07/03/2024

Número: **0815869-85.2023.4.05.0000**

Classe: **AGRAVO DE INSTRUMENTO**

Partes	
Tipo	**Nome**
ADVOGADO	**ERICKSON LOURENCO DANTAS**
AGRAVADO	**CONSELHO REGIONAL DE MEDICINA DO ESTADO DE ALAGOAS**
AGRAVANTE	**ANAJARA NERES DA SILVA**
ADVOGADO	**YVES MAIA DE ALBUQUERQUE**
CUSTOS LEGIS	**MINISTÉRIO PÚBLICO FEDERAL**

Documentos			
Id.	**Data/Hora**	**Documento**	**Tipo**
40500000.41970574	15/12/2023 08:12	AGRAVO DE INSTRUMENTO - LIMINAR	Petição Inicial
4050000.41970710	15/12/2023 08:12	ContratoSocial Requerimento do Empresario ALB2300046225 09052023165334 (1)	Documento de Comprovação
4050000.41970712	15/12/2023 08:12	GUIA CUSTAS.AG.INST.	Documento de Comprovação
4050000.41970713	15/12/2023 08:12	COMPROVANTE PGTO CUSTAS AG.INST.	Documento de Comprovação
4050000.41970714	15/12/2023 08:12	DOCS. PROCESSO DE ORIGEM 1 GRAU.	Documento de Comprovação
4050000.41970756	15/12/2023 08:12	RELAÇÃO MATRICULADOS CURSO TM FISIOTERAPIA	Documento de Comprovação
4050000.41970764	15/12/2023 08:12	ANÚNCIO CURSO TM FISIOTERAPIA	Documento de Comprovação
4050000.41970771	15/12/2023 08:12	HORÁRIO INÍCIO DO CURSO TM FISIOTERAPIA	Documento de Comprovação
4050000.41971623	15/12/2023 10:28	Decisão	Decisão
4050000.41972134	15/12/2023 10:35	Intimação	Expediente
4050000.41972584	15/12/2023 11:08	Certidão de Intimação	Certidão de Intimação
4050000.41973105	15/12/2023 11:56	Certidão de Distribuição	Certidão
4050000.42016809	18/12/2023 01:53	AMICUS CURIAE	Petição (3º Interessado)
4050000.42016810	18/12/2023 01:53	AMICUS CURIAE CREFITO1	Documento de Comprovação
4050000.42016826	18/12/2023 01:53	Doc. 1 PROCURACAO	Documento de Comprovação
4050000.42016832	18/12/2023 01:53	Doc. 2 Sentenca USG	Documento de Comprovação
4050000.42016836	18/12/2023 01:53	Doc. 3 nota tecnica	Documento de Comprovação
4050000.42016834	18/12/2023 01:53	Doc. 4 art cientifico compressed-1-60	Documento de Comprovação
4050000.42016835	18/12/2023 01:53	Doc. 4 art cientifico compressed-61-120	Documento de Comprovação
4050000.42019202	18/12/2023 09:58	EMENDA	Petição (3º Interessado)
4050000.42019203	18/12/2023 09:58	AMICUS CURIAE CREFITO1 EMENDA	Documento de Comprovação

4050000.42021683	18/12/2023 15:05	Decisão	Decisão
4050000.42023751	18/12/2023 15:16	Intimação	Expediente
4050000.42025110	18/12/2023 16:04	Certidão de Intimação	Certidão de Intimação
4050000.42046399	19/12/2023 08:52	Certidão de Intimação	Certidão de Intimação
4050000.42178330	29/12/2023 00:12	Certidão de Intimação	Certidão de Intimação
4050000.42050458	06/02/2024 22:57	Ciência (MPF)	Cota

EXCELENTÍSSIMO SENHOR DOUTOR DESEMBARGADOR FEDERAL PLANTONISTA DO TRIBUNAL REGIONAL FEDERAL DA 5ª REGIÃO.

URGÊNCIA. MATÉRIA DE PLANTÃO

Origem : **Juízo da 13ª Vara Federal - Seção Judiciária de Alagoas**

Processo nº 0814457-78.2023.4.05.8000

AUTOR: CONSELHO REGIONAL DE MEDICINA DO ESTADO DE ALAGOAS

RÉU: ANAJARA NERES DA SILVA e OUTRO

AGRAVANTE : **ANAJARA NERES DA SILVA**

AGRAVADO : CONSELHO REGIONAL DE MEDICINA DO ESTADO DE ALAGOAS

ANAJARA NERES DA SILVA (CLÍNICA TM FISIOTERAPIA) , pessoa jurídica de direito privado registrado sob o CNPJ nº 50.633.927/0001-37, com o representante legal, situado na Rua José Tomaz da Silva Nono, 586, José Áulino, CEP 57690-000, Atalaia/AL, por seu representante legal, conforme procuração anexada, com endereço profissional situado na Av. da Paz, Edf. Empresarial Avenue Center, n. 1388, Sala 207 - CEP: 57.020-440 - Maceió/AL, local onde deverá receber as intimações, vem, à presença de Vossa Excelência, propor, inconformado com a Decisão Interlocutória dos autos originários **nº 0814457-78.2023.4.05.8000** proferida pelo MM. **Juízo da 13ª Vara Federal - Seção Judiciária de Alagoas** , interpor o presente recurso de

AGRAVO DE INSTRUMENTO COM PEDIDO LIMINAR *INAUDITA ALTERA PARS* E EFEITO SUSPENSIVO

Tudo na forma do que dispõem os artigos 1.015 e ss. do CPC, mediante as razões em anexo, requerendo, para tanto, que, após a análise dos argumentos de fato e de direito a seguir aduzidos, V. Exa. se digne a reformar a Decisão proferida pelo Juízo de 1º Grau proferida em 14 de dezembro de 2023.

De acordo com o artigo 1.017, diploma processual civil, "a petição de agravo de instrumento será instruída obrigatoriamente, com cópias da petição inicial, da contestação, da petição que ensejou a decisão agravada, da própria decisão agravada, da certidão da respectiva intimação ou outro documento oficial que comprove a tempestividade e das procurações outorgadas aos advogados da agravante e da agravada".

Todavia, vale ressaltar que, no caso em tela, há a incidência do parágrafo 5º do referido artigo, que nos diz que "Sendo eletrônicos os autos do processo, dispensam-se as peças referidas nos incisos I e II do caput, facultando-se ao agravante anexar outros documentos que entender úteis para a compreensão da controvérsia"

Isto posto, estando preenchidos os requisitos objetivos e subjetivos para a interposição do presente recurso de Agravo de Instrumento, requer a Agravante seja o mesmo processado na forma legal para, no mérito, dar-lhe inteiro provimento, reformando a decisão ora hostilizada na sua inteireza.

Nestes termos, pede e espera deferimento.

Maceió/AL, 15 de dezembro de 2023.

ERICKSON LOURENÇO DANTAS

OAB/AL 11.831

EGRÉGIO TRIBUNAL REGIONAL FEDERAL DA 5ª REGIÃO

ÍNCLITO DESEMBARGADOR PLANTONISTA,

1. DA TEMPESTIVIDADE

No que diz respeito à tempestividade do presente recurso não restam dúvidas em razão da intimação do Agravante ter sido realizada no dia 14.12.2023, quinta-feira, sendo, pois, interposto o referido recurso na data seguinte, qual seja, 15.12.2023 (sexta-feira), em sede de plantão, em razão da urgência do caso em testilha.

Dito isto, comprova-se que tempestivo é o presente recurso, em razão do seu protocolo ter sido realizado nesta referida data, em 15.12.2023.

2. DO PREPARO

Em se tratando do recolhimento das custas do referido recurso, cumpre destacar que a Agravante realizou a referida diligência, haja vista o comprovante de recolhimento do referido recurso, cujo documento comprobatório segue **em anexo** .

3. DA MATÉRIA DE PLANTÃO - URGÊNCIA

Excelentíssimo Senhor Desembargador Plantonista, cumpre destacar que em razão da urgência do caso em testilha não restam dúvidas, razão pela qual a parte Agravante se insurge contra decisão interlocutória proferida na data de ontem, 14.12.2023 (quinta-feira) e em razão do prazo exíguo para a reforma da referida decisão vergastada, pois nesta data de 15.12.2023 (sexta-feira), ocorrerá a ministração do Curso de Ultrassonongrafia Cinesiológica Musculoesquelética para Fisioterapeutas, a ser realizado pela parte Agravante, na ministração do Professor Wagner Huan, conforme documentação em anexo.

Dessa forma, em razão da intimação da parte agravante ter sido realizada na data de ontem, **14.12.2023** e o referido curso ser ministrado no dia seguinte, em **15.12.2023, a partir das 08h30** , não há como a parte recorrente aguardar o expediente forense normal em busca de sua pretensão, tendo em vista que o **início do Curso de Ultrassonongrafia Cinesiológica Musculoesquelética para Fisioterapeutas ocorrer nesta presente data** , estando, pois comprovada a urgência do manejo do presente viés em sede de Plantão, buscando a revogação da decisão interlocutória ora recorrida.

Assim sendo, é cabível o presente recurso em sede de plantão pela urgência do caso em tela, conforme aduzido.

4. DOS FATOS

Inicialmente cumpre destacar que a parte agravada interpôs a referida Ação Civil Pública em desfavor da parte agravante onde fora proferida a decisão interlocutória ora recorrida oriunda do juízo da 13ª Vara Federal - Seção Judiciária de Alagoas que deferiu o pedido da parte agravada em relação a não realização do **Curso de Ultrassonongrafia Cinesiológica Musculoesquelética para Fisioterapeutas designado para seu início em 15.12.2023, às 08h30, sendo dado continuidade ao mesmo nos dias 16.12.2023 e 17.12.2023.**

Pois bem, na data de 14.12.2023, nos autos originários de nº **0814457-78.2023.4.05.8000,** assim fora proferida a decisão ora recorrida, a saber:

"(...) 13. Afora isso, pontuou o demandante que a "ultrassonografia" é uma especialidade médica tanto que "para o médico obter registro e poder se anunciar como especialista em radiologia e diagnóstico por imagem, é necessária a realização de residência médica, em período não inferior a 03 (três anos) ou por meio de concurso realizado pela Associação Médica Brasileira/Colégio Brasileiro de Radiologia e Diagnóstico por Imagem", ao passo que o curso em questão , destinado a não médicos, tem duração de apenas 03 (três) dias.

14.Sendo assim, a partir de uma análise perfunctória do caso, própria do atual estágio processual, e considerando os fundamentos apresentados, entendo que o pleito liminar atende satisfatoriamente ao requisito da probabilidade do direito *(fumus boni iuris).*

15. Quanto ao requisito do *periculum in mora* **,** entendo-o manifesto, já que o multicitado curso está marcado para se iniciar no dia de amanhã (15.12.2023), não havendo sequer tempo hábil para o exercício do contraditório.

16. Isto posto, **DEFIFO** a tutela de urgência requestada."

Maceió, 14 de dezembro de 2023.

RAIMUNDO ALVES DE CAMPOS JR.

Juiz Federal - 13ª Vara/AL

Nesse sentido, em sede de plantão em razão da urgência do caso em tela, a parte Agravante interpõe o presente recurso, em virtude do tempo exíguo, tendo em vista a iminência da realização do **Curso de Ultrassonongrafia Cinesiológica Musculoesquelética para Fisioterapeutas designado para seu início em 15.12.2023, às 08h30, sendo dado continuidade ao mesmo nos dias 16.12.2023 e 17.12.2023, requerendo, para tanto, a reforma da decisão ora recorrida, pelos fatos e fundamentos que seguem.**

Logo, outro caminho não há, a não ser a interposição do referido viés ser **realizado em sede de Plantão** , tendo em vista que sequer, ao menos, for dada oportunidade para a parte agravante se manifestar antes da realização do referido curso que terá seu início nesta data, 15.12.2023, a partir das 08h30, a ser realizado na cidade de Maceió-AL, com 12 inscrições já efetuadas, conforme **documentação comprobatória em anexo.**

Em síntese, Nobre Desembargador Plantonista, esses são os fatos ora ocorridos.

5. DO PEDIDO LIMINAR EM SEDE DE AGRAVO DE INSTRUMENTO

O Código de Processo Civil (CPC) determina a concessão do pedido de antecipação de tutela nos casos em que estiverem presentes o ***fumus boni iuris*** e o ***periculum in mora*** , como se depreende da melhor interpretação do *caput* do art. 300 da lei codificada em pauta:

Art. 300 CPC - A tutela de urgência será concedida quando houver elementos que evidenciem a probabilidade do direito e o perigo de dano ou o risco ao resultado útil do processo.

In casu, a Agravante preenche corretamente os requisitos ensejadores para a concessão de tal medida, senão vejamos:

Vale dizer: os provimentos cautelares nunca são um fim em si mesmos, e surgem sempre " *da existência de um **perigo de dano jurídico** , derivado do atraso de um provimento jurisdicional definitivo (**periculum in mora**)* ".

Pois bem, em se tratando do ***fumus boni iuris*** , não há dúvidas, uma vez que recentemente, o Superior Tribunal de Justiça - STJ, já se posicionou sobre o caso em testilha, tendo em vista não ser atribuição exclusiva ao médico tal procedimento, conforme decisão proferida nos autos do **EDcl noREsp n. 1.592.450/RS, relator Ministro Gurgel de Faria, Primeira Turma, julgado em 22.11.2022, DJe de 31/1/2023):**

PROCESSUAL CIVIL E ADMINISTRATIVO. AÇÃO CIVIL PÚBLICA. CONTROLE DE LEGALIDADE. DECLARAÇÃO DE NULIDADE DE NORMA INFRALEGAL. POSSIBILIDADE. RESOLUÇÕES NORMATIVAS. CONSELHO DE FISIOTERAPIA E TERAPIA OCUPACIONAL. AUTORIZAÇÃO. ATO RESERVADO A MÉDICOS. IMPOSSIBILIDADE. 1. Embora não caiba a este Tribunal examinar o pedido de inconstitucionalidade de norma em face da Constituição, é possível promover o exame da legalidade das resoluções normativas que eventualmente tenham contrariado o Decreto-lei n. 938/1969. 2. No caso, como o pedido da inicial foi deduzido de ambas as maneiras (declaração de ilegalidade e inconstitucionalidade), a ação civil pública é viável, ao menos em relação ao primeiro pleito, sendo os autores partes legítimas para deduzi-lo. 3. O exercício das profissões de fisioterapeuta e terapeuta ocupacional se desenvolve de acordo com os parâmetros dispostos Decreto-lei n. 938/1969 (art. 1º), que, em seus arts. 3º e 4º, expressamente reservou aos profissionais a atividade de executar métodos e técnicas fisioterápicos, terapêuticos e recreacionais. 4. Não há, na norma de caráter primário, autorização para que os fisioterapeutas e terapeutas ocupacionais desempenhem atividades como as de receber demanda espontânea, realizar diagnóstico, prescrever ou realizar exames sem assistência médica, ordenar tratamento e dar alta terapêutica, atividades reservadas aos médicos. 5. O STF, no julgamento da Representação 1.056/DF, considerou constitucionais os arts. 3º e 4º do Decreto-lei n. 938/1969 e o art. 12 da Lei n. 6.316/1975 e bem delimitou as atividades do fisioterapeuta e do terapeuta ocupacional: a) ao médico cabe a tarefa de diagnosticar, prescrever tratamentos, avaliar resultados; b) ao fisioterapeuta e ao terapeuta ocupacional, diferentemente, cabe a execução das técnicas e métodos prescritos (STJ, REsp 693.454/RS, Rel. Ministra ELIANA CALMON, Segunda Turma, julgado em 03/11/2005, DJ 14/11/2005, p. 267). 6. Hipótese em que a interpretação sistemática entre os arts. 1º, 3º e 4º do Decreto-lei n. 938/1969 e os arts. 1º, 2º, parágrafo único, II, 4º, X, XI e XIII e §§ 1º e 7º, da Lei n. 12.842/2013 reforça as conclusões antes adotadas por esta Corte e pelo Supremo. 7. Deve ser mantida a possibilidade da prática da acupuntura, quiropraxia, osteopatia e fisioterapia e terapia ocupacional do trabalho pelos fisioterapeutas e terapeutas ocupacionais, porque, quanto a elas, não há comando secundário em abstrato que, pela só existência, vulnere os preceitos normativos primários que disciplinam as atividades de fisioterapeutas, terapeutas ocupacionais, ou mesmo médicos. 8. Recurso especial parcialmente provido.

(STJ - REsp: 1592450 RS 2016/0072200-2, Data de Julgamento: 21/06/2022, T1 - PRIMEIRA TURMA, Data de Publicação: DJe 30/06/2022).

Logo, Exelência, patente a existência do ***fumus boni iuris*** tendo em vista não ser atribuição exclusiva do médico tal atribuição, conforme comprovado em decisão do STJ acima transcrita.

Já a respeito do ***periculum in mora*** , está nitidamente comprovado **,** uma vez que o perigo da demora poderá ensejar o cancelamento do **Curso de Ultrassonongrafia Cinesiológica Musculoesquelética para Fisioterapeutas designado para seu início em 15.12.2023 (nesta data, sexta-feira, às 08h30), sendo dado continuidade ao mesmo nos dias 16.12.2023 (sábado) e 17.12.2023 (domingo).**

Dessa forma, estando presentes os requisitos ensejadores para deferimento da presente tutela requestada, requer o deferimento da tutela antecipada ***inaudita altera pars*** no sentido de que seja determinada a realização do **Curso de Ultrassonongrafia Cinesiológica Musculoesquelética para Fisioterapeutas designado para seu início na cidade de Maceió-AL, em 15.12.2023 (nesta data, sexta-feira, às 08h30), sendo dado continuidade ao mesmo nos dias 16.12.2023 (sábado) e 17.12.2023 (domingo), devendo, pois, ser intimada, em caráter de urgência, a parte Agravada CONSELHO REGIONAL DE MEDICINA DO ESTADO DE ALAGOAS para cumprir tal determinação judicial, sob pena de aplicação de multa diária no valor de R$ 2.000,00 (dois mil reais), em caso de descumprimento.**

6. DO EFEITO SUSPENSIVO

A respeito do pedido de efeito suspensivo, o próprio artigo 1.019 do Código de Processo Civil aborda a possibilidade de atribuição do efeito suspensivo ao agravo pelo Relator, segundo a redação de seu inciso I, *in verbis* :

"Art. 1.019. Recebido o agravo de instrumento no tribunal e distribuído imediatamente, se não for o caso de aplicação do art. 932, incisos III e IV, o relator, no prazo de 5 (cinco) dias:

I - poderá atribuir efeito suspensivo ao recurso ou deferir, em antecipação de tutela, total ou parcialmente, a pretensão recursal, comunicando ao juiz sua decisão"

Faz-se ainda necessário, então, requerer que seja aplicado o efeito suspensivo ao cumprimento da referida decisão, até o pronunciamento definitivo da respectiva Câmara, conforme se expõe.

Eminente Desembargador Plantonista, a Agravante requer seja atribuído efeito suspensivo no presente recurso em relação ao andamento principal do processo originário para que sejam evitadas decisões contraditórias e insegurança jurídica.

Dessa forma, requer seja deferido o pedido de efeito suspensivo do presente recurso, determinando o sobrestamento do processo originário de nº **0814457-78.2023.4.05.8000,** em trâmite na 13ª Vara Federal - Seção Judiciária de Alagoas, até o julgamento do mérito do referido recurso de Agravo de Instrumento ora interposto.

7. DA REVOGAÇÃO DA DECISÃO INTERLOCUTÓRIA

A *priori*, com todas as devidas *vênias*, cumpre destacar que a referida Decisão do Douto Magistrado da 13ª Vara Federal - Seção Judiciária de Alagoas merece ser reformada, uma vez que houve **não há que se falar em proibição** na realização do referido curso a ser realizado pela parte Agravante, uma vez que **não há que se falar em atribuição exclusiva de profissional médico, conforme já decidido pelo STJ,** nos autos do **REsp: 1592450 RS 2016/0072200-2** , conforme decisão transcrita no pedido liminar ora requerido pela parte Agravante.

Ademais, é de grande relevância destacar que a parte Agravada passou a se insurgir contra a realização do curso a ser realizado pela Agravante em relação ao **Curso de Ultrassononografia Cinesiológica Musculoesquelética para Fisioterapeutas designado para seu início na cidade de Maceió-AL, em 15.12.2023 (nesta data, sexta-feira, às 08h30), sendo dado continuidade ao mesmo nos dias 16.12.2023 (sábado) e 17.12.2023 (domingo), aduzindo que** se trataria de atribuição exclusiva do profissional médico, de acordo com a Lei nº 12.842, de 10 de julho de 2013.

Contudo, Excelência, na lista das atividades privativas do médico, conforme consta no §7º do art. 4º da Lei nº 12.842/2013 ressalva que:

§ 7º O disposto neste artigo será aplicado de forma que sejam resguardadas as competências próprias das profissões de assistente social, biólogo, biomédico, enfermeiro, farmacêutico, ***fisioterapeuta*** *, fonoaudiólogo, nutricionista, profissional de educação física, psicólogo, terapeuta ocupacional e técnico e tecnólogo de radiologia.*

Grifamos!

Nesse jaez, o referido artigo **JAMAIS** pode servir de fundamento para inibir os profissionais fisioterapeutas de exercer de forma ampla sua competência, utilizando para tanto as ferramentas que tenham disponíveis.

Ainda sobre o tema em foco, a Seção Judiciária do Distrito Federal também tem se posicionado sobre a matéria, uma vez que fora **NEGADO** o pedido liminar formulado pelo **Conselho Federal de**

Medicina (CFM) , sendo mantidas as resoluções do Conselho Federal de Fisioterapia e Terapia Ocupacional (Coffito) quanto à **ultrassom,** uma vez que os Fisioterapeutas têm autonomia e conhecimento para solicitar, realizar e interpretar exame ultrassonografia cinesiológica, cuja decisão fora proferida nos autos da **Ação Civil Pública nº 1043821-22.2021.4.01.3400 tramitada na 20ª Vara Federal Cível da SJDF, a saber:**

"(...) Aparentemente, as resoluções do COFFITO apenas ampliaram as ferramentas de que os fisioterapeutas podem se utilizar ao exercer sua competência, permitindo a realização de exames, bem como sua respectiva interpretação, por meio de laudo. Nesse sentido, manifestou-se o COFFITO (ID 613586355 - Pág. 20):

"(...) a ultrassonografia cinesiológica é utilizada com a finalidade de estabelecer o diagnóstico funcional (fisioterapêutico), visando auxiliar no tratamento e prognóstico funcional (fisioterapêutico), pois constitui importante processo avaliativo se o tratamento fisioterapêutico é eficaz ou não, bem como a necessidade de ajustes no interesse da maior eficácia possível para o paciente. A diversificação e variabilidade das técnicas ou métodos fisioterapêuticos, a serem empregados no futuro podem ser medidas com o uso da ultrassonografia."

Ante a presunção de legalidade do ato administrativo, presume-se que o mencionado Conselho ponderou a necessidade de previsão desta atribuição, bem como a capacidade do profissional fisioterapeuta de exercê-la, de acordo com a sua formação.

A própria entidade autora afirma que o fisioterapeuta "na eventual hipótese de constatar situação grave, deverá remeter o caso ao médico responsável".

Ora, permitir que o profissional fisioterapeuta realize e interprete os exames que entende pertinentes, em tese, apenas o auxiliará na constatação da gravidade do caso e contribuirá para o encaminhamento do paciente para o tratamento pertinente.

Destaque-se que não se pode supor (uma vez que a má-fé não se presume) que os fisioterapeutas agirão de modo a extrapolar suas funções, requisitando exames que não estão capacitados a realizar/interpretar e que deixarão de realizar os encaminhamentos pertinentes ao constatarem a necessidade de acompanhamento do caso por profissional médico. De todo modo, caso se verifique que os profissionais extrapolaram suas funções, estes estarão sujeitos às sanções previstas no ordenamento jurídico.

Saliento ainda que as resoluções do COFFITO de modo algum inibem a população de procurar o auxílio médico diretamente, apenas asseguram que os profissionais fisioterapeutas tenham uma ferramenta a mais para o exercício de suas funções.

Além da ausência de verossimilhança, destaco que não restou demonstrada a urgência que justifique a concessão de tutela provisória, uma vez que são impugnadas resoluções editadas nos anos de 2011 e 2017, tendo o presente feito sido ajuizado apenas em 2021. Ademais, apesar do tempo decorrido desde as resoluções combatidas, a autora aponta apenas potencial dano em decorrência destas, sem apontar qualquer caso concreto em que efetivamente tenha havido dano à saúde de algum paciente em virtude do exercício pelos fisioterapeutas das atribuições previstas nas resoluções do COFFITO, o que corrobora a ausência de periculum in mora. INDEFIRO, pois, a liminar.

Cite-se.

Após, vista ao autor para réplica e para que requeira a produção das provas que entender pertinentes.

Em seguida, vista à ré para especificação de provas.

Brasília, data da assinatura

datado e assinado eletronicamente)

Liviane Kelly Soares Vasconcelos

Juíza Federal Substituta da 20ª Vara/SJDF

Assim, assiste razão à Agravante para o deferimento do presente recurso, tendo em vista que tal decisão também fora confirmada na decisão de mérito, sendo, pois **JULGADA TOTALMENTE IMPROCEDENTE** a Ação Civil Pública de **nº 1043821-22.2021.4.01.3400 tramitada na 20ª Vara Federal Cível da SJDF que fora ajuizada pelo Conselho Federal de Medicina (CFM).**

Dessa forma, fica nítida a necessidade da reforma da Decisão Interlocutória ora recorrida para que se preserve o princípio da segurança jurídica nas referidas decisões, sobretudo, em relação ao princípio da coisa julgada.

7. DOS PEDIDOS

Diante do exposto, requer seja conhecido e provido o presente Agravo de Instrumento, da seguinte forma:

a) Seja, LIMINARMENTE, em sede de plantão pela urgência do caso em tela, deferido o pedido liminar de tutela antecipada *inaudita altera pars* com fundamento no art. 300 do CPC, tendo em vista a existência dos requisitos ensejadores do ***periculum in mora*** **e** ***fumus boni iuris*** , sendo **REVOGADA** a decisão ora recorrida proferida nos autos originários nº **0814457-78.2023.4.05.8000,** em trâmite na 13ª Vara Federal - Seção Judiciária de Alagoas, no sentido de que seja ralizado por parte da Agravante o **Curso de Ultrassononografia Cinesiológica Musculoesquelética para Fisioterapeutas designado para seu início na cidade de Maceió-AL, em 15.12.2023 (nesta data, sexta-feira, às 08h30), sendo dado continuidade ao mesmo nos dias 16.12.2023 (sábado) e 17.12.2023 (domingo), sendo arbitrada multa diária de R$ 2.000,00 (dois mil reais), em caso de descumprimento da parte Agravada;**

b) Seja deferido o pedido de efeito suspensivo no presente recurso, determinando a suspensão do andamento do feito do juízo de origem para que sejam evitadas decisões contraditórias até o pronunciamento final do TRF - 5ª Região;

c) Seja intimada a parte Agravada **CONSELHO REGIONAL DE MEDICINA DO ESTADO DE ALAGOAS, autarquia federal, inscrita no CNPJ sob o nº 10.884.377/0001-04, com sede na Rua Fausto Correia Wanderly, nº 90, Pinheiro, Maceió-AL, na pessoa de seu procurador legalmente habilitado, YVES MAIA DE ALBUQUERQUE (082 - 99969-7951/ 082 - 3313-4346), inscrito na OAB-AL 3.367,** para, querendo, apresentar as devidas contrarrazões no prazo legal;

d) Seja, no mérito, reformada a Decisão Interlocutória ora recorrida no sentido de ser mantida a realização do **Curso de Ultrassonongrafia Cinesiológica Musculoesquelética para Fisioterapeutas designado para seu início na cidade de Maceió-AL, em 15.12.2023 (nesta data, sexta-feira, às 08h30), sendo dado continuidade ao mesmo nos dias 16.12.2023 (sábado) e 17.12.2023 (domingo);**

e) Seja intimado o Ministério Público Federal para oferecer parecer;

f) Seja, no mérito, conhecido e provido o referido recurso pelos fatos e fundamentos comprovados no presente viés.

Nestes termos, pede e espera deferimento.

Maceió/AL, 15 de dezembro de 2023.

ERICKSON LOURENÇO DANTAS

OAB/AL 11.831

INSTRUMENTO DE INSCRIÇAO DE EMPRESARIO INDIVIDUAL

ANAJARA NERES DA SILVA

Pelo presente instrumento particular de Ato Constitutivo:

ANAJARA NERES DA SILVA, BRASILEIRA , SOLTEIRA, EMPRESÁRIA, nascido(a) em 16/03/1998, n° do CPF 118.926.494-38, residente e domiciliada na cidade de Atalaia - AL, na LOTEAMENTO JARDIM I, nº SN, JOSÉ PAULINO, CEP: 57690-000.

Resolve constituir como empresário individual, mediante as seguintes cláusulas **(art. 968, I, CC)**:

CLÁUSULA I - DO NOME EMPRESARIAL (art. 968, II, CC)
A empresário individual adotará como nome empresarial: **ANAJARA NERES DA SILVA**, e usará a expressão Clinica TM Fisioterapia como nome fantasia.

CLÁUSULA II - DO CAPITAL (art. 968, III, CC)
O capital destacado em moeda corrente é de R$ 40.000,00 (quarenta mil reais).

CLÁUSULA III - DA SEDE (art. 968, IV, CC)
O Empresário Individual terá sua sede no seguinte endereço: RUA JOSÉ TOMAZ DA SILVA NONO, nº 586, JOSÉ ÁULINO, Atalaia - AL, CEP: 57690000.

CLÁUSULA IV - DO OBJETO (art. 968, IV, CC)
O Empresário Individual terá por objeto o exercício das seguintes atividades econômicas: 8650-0/04 - ATIVIDADES DE FISIOTERAPIA, 8599-6/04 - TREINAMENTO EM DESENVOLVIMENTO PROFISSIONAL E GERENCIAL, 8630-5/06 - SERVIÇOS DE VACINAÇÃO E IMUNIZAÇÃO HUMANA, 8650-0/99 - ATIVIDADES DE PROFISSIONAIS DA ÁREA DE SAÚDE NÃO ESPECIFICADAS ANTERIORMENTE, 8690-9/99 - OUTRAS ATIVIDADES DE ATENÇÃO À SAÚDE HUMANA NÃO ESPECIFICADAS ANTERIORMENTE, 9313-1/00 - ATIVIDADES DE CONDICIONAMENTO FÍSICO

Parágrafo único. Em estabelecimento eleito como Sede (Matriz) será(ão) exercida(s) a(s) atividade(s) de 8650-0/04 - ATIVIDADES DE FISIOTERAPIA, 8599-6/04 - TREINAMENTO EM DESENVOLVIMENTO PROFISSIONAL E GERENCIAL, 8630-5/06 - SERVIÇOS DE VACINAÇÃO E IMUNIZAÇÃO HUMANA, 8650-0/99 - ATIVIDADES DE PROFISSIONAIS DA ÁREA DE SAÚDE NÃO ESPECIFICADAS ANTERIORMENTE, 8690-9/99 - OUTRAS ATIVIDADES DE ATENÇÃO À SAÚDE HUMANA NÃO ESPECIFICADAS ANTERIORMENTE, 9313-1/00 - ATIVIDADES DE CONDICIONAMENTO FÍSICO.

E exercerá as seguintes atividades:

CNAE Nº 8650-0/04 - Atividades de fisioterapia
CNAE Nº 8599-6/04 - Treinamento em desenvolvimento profissional e gerencial
CNAE Nº 8630-5/06 - Serviços de vacinação e imunização humana
CNAE Nº 8650-0/99 - Atividades de profissionais da área de saúde não especificadas anteriormente
CNAE Nº 8690-9/99 - Outras atividades de atenção à saúde humana não especificadas anteriormente
CNAE Nº 9313-1/00 - Atividades de condicionamento físico

CLÁUSULA V - DECLARAÇÃO DE DESIMPEDIMENTO (art. 37, II, Lei n° 8.934, de 1994)
O empresário declara, sob as penas da lei, inclusive que são verídicas todas as informações prestadas neste instrumento e quanto ao disposto no artigo 299 do Código Penal, não estar impedido de exercer atividade empresária e não possuir outro registro como Empresário Individual no País.

CLÁUSULA VI - DO INÍCIO DAS ATIVIDADES E PRAZO DE DURAÇÃO (art. 53, III, F, Decreto n° 1.800/96)
A Empresa iniciará suas atividades em 09/05/2023 e seu prazo de duração será por tempo indeterminado.

INSTRUMENTO DE INSCRIÇAO DE EMPRESARIO INDIVIDUAL

ANAJARA NERES DA SILVA

CLAUSULA VII - PORTE EMPRESARIAL
O empresário declara que a empresa se enquadra como Microempresa - ME, nos termos da Lei Complementar nº 123, de 14 de dezembro de 2006, e que não se enquadra em qualquer das hipóteses de exclusão relacionadas no § 4º do art. 3º da mencionada lei. (art. 3º, I, LC nº 123, de 2006)

E, por estar assim constituído, assino o presente instrumento.

Atalaia - AL, 09 de maio de 2023

____
ANAJARA NERES DA SILVA
Empresário

SR. CONTRIBUINTE: ESTA GUIA NÃO PODERÁ SER LIQUIDADA COM CHEQUE

MINISTÉRIO DA ECONOMIA SECRETARIA DO TESOURO NACIONAL Guia de Recolhimento da União GRU JUDICIAL	Código de Recolhimento	**18720-8**
	Número do Processo	**08144577820234058000**
	Competência	**12/2023**
	Vencimento	**15/12/2023**
Nome do Contribuinte / Recolhedor : **ANAJARA N. DA SILVA CLÍNICA TM FISIOTERAPIA**	CNPJ ou CPF do Contribuinte	**50.633.927/0001-37**
Nome da Unidade Favorecida: **TRIBUNAL REGIONAL FEDERAL DA 5A.REGIAO**	UG / Gestão	**090031 / 00001**
Nome do Requerente / Autor:	(=) Valor do Principal	**100,00**
CNPJ/CPF do Requerente / Autor:	(-) Desconto/Abatimento	
Seção Judiciária: Vara: Classe:	(-) Outras deduções	
Base de Cálculo:	(+) Mora / Multa	
Instruções: As informações inseridas nessa guia são de exclusiva responsabilidade do contribuinte, que deverá, em caso de dúvidas, consultar a Unidade Favorecida dos recursos.	(+) Juros / Encargos	
	(+) Outros Acréscimos	
SR. CAIXA: NÃO RECEBER EM CHEQUE Pagamento exclusivo na Caixa Econômica Federal [STNDD37B99709BFF49CC80E8F1E48D4867D]	(=) Valor Total	**100,00**

85880000001-6 00000281187-1 20001512506-0 33927000137-3

SR. CONTRIBUINTE: ESTA GUIA NÃO PODERÁ SER LIQUIDADA COM CHEQUE

MINISTÉRIO DA ECONOMIA SECRETARIA DO TESOURO NACIONAL Guia de Recolhimento da União GRU JUDICIAL	Código de Recolhimento	**18720-8**
	Número do Processo	**08144577820234058000**
	Competência	**12/2023**
	Vencimento	**15/12/2023**
Nome do Contribuinte / Recolhedor: **ANAJARA N. DA SILVA CLÍNICA TM FISIOTERAPIA**	CNPJ ou CPF do Contribuinte	**50.633.927/0001-37**
Nome da Unidade Favorecida: **TRIBUNAL REGIONAL FEDERAL DA 5A.REGIAO**	UG / Gestão	**090031 / 00001**
Nome do Requerente / Autor:	(=) Valor do Principal	**100,00**
CNPJ/CPF do Requerente / Autor:	(-) Desconto/Abatimento	
Seção Judiciária: Vara: Classe:	(-) Outras deduções	
Base de Cálculo:	(+) Mora / Multa	
Instruções: As informações inseridas nessa guia são de exclusiva responsabilidade do contribuinte, que deverá, em caso de dúvidas, consultar a Unidade Favorecida dos recursos.	(+) Juros / Encargos	
	(+) Outros Acréscimos	
SR. CAIXA: NÃO RECEBER EM CHEQUE Pagamento exclusivo na Caixa Econômica Federal [STNDD37B99709BFF49CC80E8F1E48D4867D]	(=) Valor Total	**100,00**

85880000001-6 00000281187-1 20001512506-0 33927000137-3

Comprovante de pagamento de IPVA

Valor	Data
R$ 100,00	**15/12/23** 06:14

Operação realizada com sucesso!

Dados do Pagamento

Código de barras

858800000016000002811871200015125060339270001373

Conta de débito

03545 | 1288 | 000856616763-3

Convênio

GRU JUDICIAL-EXCLUSI

Valor

100,00

Data de vencimento

15/12/2023

Data de débito

15/12/2023

Código da operação

97559694

Chave de segurança

R9GU2HQ1HGRPQT48

Você poderá consultar futuramente essa e outras transações no menu de consultas.

Em caso de dúvidas entre em contato através dos nossos canais de atendimento, e informe o ID da transação presente neste comprovante.

Alô CAIXA: 4004 0104 (Capitais e reg. metropolitanas)
Alô CAIXA: 0800 104 0 104 (Demais regiões)
Pessoas com deficiência auditiva: 0800 726 2492
SAC CAIXA: 0800 726 0101
Ouvidoria: 0800 725 7474

14/12/2023

Número: **0814457-78.2023.4.05.8000**

Classe: **AÇÃO CIVIL PÚBLICA**

Partes	
Tipo	**Nome**
ADVOGADO	**YVES MAIA DE ALBUQUERQUE**
AUTOR	**CONSELHO REGIONAL DE MEDICINA DO ESTADO DE ALAGOAS**
RÉU	**WAGNER CRUZ HAUN**
RÉU	**ANAJARA NERES DA SILVA**

Documentos			
Id.	**Data/Hora**	**Documento**	**Tipo**
4058000.14116385	14/12/2023 15:51	Decisão	Decisão
4058000.14099450	12/12/2023 13:51	ACP	Documento de Comprovação
4058000.14117401	14/12/2023 16:31	Intimação	Expediente

PROCESSO Nº: 0814457-78.2023.4.05.8000 **- AÇÃO CIVIL PÚBLICA**
AUTOR: CONSELHO REGIONAL DE MEDICINA DO ESTADO DE ALAGOAS
ADVOGADO: Yves Maia De Albuquerque
RÉU: ANAJARA NERES DA SILVA e outro
13ª VARA FEDERAL - AL (JUIZ FEDERAL TITULAR)

D E C I S Ã O

Vistos etc.

1. Trata-se de ação civil pública ajuizada pelo **CONSELHO REGIONAL DE MEDICINA DE ALAGOAS - CREMAL** em face de **WAGNER CRUZ HAUN** e **CLÍNICA TM FISIOTERAPIA** , ambos qualificados na inicial, com o escopo de auferir provimento judicial que, em sede de tutela de urgência, determine a suspensão do curso intitulado *"CURSO DE ULTRASSONOGRAFIA MUSCOESQUELÉTICA"* , marcado para ocorrer nos dias 15, 16 e 17 de dezembro de 2023, sob pena de multa diária de R$ 1.000,00 (mil reais) por aluno do referido curso.

2. Segundo o demandante, em síntese, o curso em questão ofende o disposto na Lei nº 12.842/13 (Lei do Ato Médico) e na Resolução do Conselho Federal de Medicina - CFM nº 1.361/92, na medida em que o respectivo conteúdo programático e as práticas a serem disseminadas são privativas de quem possui graduação em Medicina, e não em Fisioterapia. Destarte, o indigitado curso não poderia ser ministrado pelo corréu **WAGNER CRUZ HAUN** (Fisioterapeuta) e nem para profissionais fisioterapeutas.

3. Anexou documentos eletronicamente.

4. O feito foi distribuído inicialmente para a 4ª Vara Federal, cujo Juízo declinou da competência para esta 13ª Vara Federal/AL, por conexão e prevenção (cf. id. 14104047).

5. **Relatei. Decido.**

6. A concessão de liminar, em se tratando de ação civil pública, encontra assento legal no art. 12 da Lei nº 7.347/85, possibilitando, em juízo preambular, a antecipação da tutela pretendida nos moldes do art. 300 do novo Código de Processo Civil, que assim dispõe: "a *tutela de urgência será concedida quando houver elementos que evidenciem a probabilidade do direito e o perigo de dano ou o risco ao resultado útil do processo* ".

7. Vê-se, pois, que houve a unificação dos requisitos para concessão da tutela de urgência, seja ela cautelar ou antecipada. São exigidos em ambos os casos: a probabilidade do direito e o perigo de dano ou

o risco ao resultado útil do processo.

8. O Enunciado 143 do Fórum Permanente de Processualistas Civis assim dispôs acerca da redação do art. 300 do Código de Processo Civil:

> *143. (art. 300, caput) A redação do art. 300, caput, superou a distinção entre os requisitos da concessão para a tutela cautelar e para a tutela satisfativa de urgência, erigindo a probabilidade e o perigo na demora a requisitos comuns para a prestação de ambas as tutelas de forma antecipada. 59 (Grupo: Tutela Antecipada).*

9. Logo, a concessão da tutela de urgência depende, em primeiro lugar, da preponderância dos fatores convergentes à aceitação do direito alegado na exordial. Em seguida, também se faz necessária a presença de fundado receio de sofrer dano irreparável ou de difícil reparação.

10. É necessário, ainda, que a providência adotada antes do pronunciamento definitivo não esgote o objeto da ação. A reversibilidade, como visto, é nota marcante a influenciar o magistrado quando esse aprecia medidas de cunho liminar, sob pena de converter o pleito em julgamento antecipado e, pior, sem observância do contraditório e da ampla defesa.

11. No caso dos autos, pretende o Conselho autor impedir a realização do *" "CURSO DE ULTRASSONOGRAFIA MUSCOESQUELÉTICA"* , a ser ministrado pelo réu **WAGNER CRUZ HAUN** em parceria com a **Clínica TM Fisioterapia** , marcado para ocorrer nos dias 15, 16 e 17 de dezembro de 2023.

12. Pois bem. Considerando o teor do art. 1º da Resolução CFM n. 1.361/1992: *"É da exclusiva competência do médico a execução e a interpretação do exame ultra-sonográfico em seres humanos, assim como a emissão do respectivo laudo".* Ademais, o art. 4º da Lei n. 12.842/2013 (Lei do Ato Médico) confere privativamente aos profissionais da Medicina, dentre outras atribuições: a emissão de laudo dos exames de imagem e a determinação do prognóstico relativo ao diagnóstico nosológico (art. 4º, alíneas "f" e "g").

13. Afora isso, pontuou o demandante que a *"ultrassonografia"* é uma especialidade médica, tanto que *"para o médico obter registro e poder se anunciar como especialista em radiologia e diagnóstico por imagem, é necessária a realização de residência médica, em período não inferior a 03 (três anos) ou por meio de concurso realizado pela Associação Medica Brasileira/Colégio Brasileiro de Radiologia e Diagnóstico por Imagem"* , ao passo que o curso em questão, destinado a não-médicos, tem duração de apenas 03 (três) dias.

14. Sendo assim, a partir de uma análise perfunctória do caso, própria do atual estágio processual, e considerando os fundamentos apresentados, entendo que o pleito liminar atende satisfatoriamente ao requisito da probabilidade do direito (*fumus boni iuris*).

15. Quanto ao requisito do *periculum in mora* , entendo-o manifesto, já que o multicitado curso está marcado para se iniciar no dia de amanhã (15.12.2023), não havendo sequer tempo hábil para o exercício do contraditório.

16. Isto posto, **DEFIRO** a tutela de urgência requestada.

17. **Intimem-se** os réus da presente decisão, da forma mais expedita possível, inclusive através do Oficial de Justiça Plantonista, caso necessário, assim como proceda-se, na mesma oportunidade, à citação dos mesmos para, no prazo legal, oferecerem resposta e especificarem as provas que pretendam produzir.

18. **Intime-se** o Ministério Público Federal para, no prazo de 10 (dez) dias, manifestar seu interesse em integrar o polo ativo da presente ação. Caso pretenda integrar o polo ativo, o MPF deve, no mesmo prazo, ratificar ou complementar a petição inicial.

19. Sendo requerido pelo MPF o ingresso no polo ativo, voltem os autos conclusos.

20. Intimações devidas. Providências necessárias, **<u>com urgência</u>** **.**

Maceió, 14 de dezembro de 2023.

RAIMUNDO ALVES DE CAMPOS JR.

Juiz Federal - 13ª Vara/AL

1-Mary kyrze Guimarães Batista

2- Marco Aurélio Albieri Dominato

3- Valéria Gonzalez Dominato

4- Rafael Mota Moitinho

5- Juan Fernandes Alves

6- Fátima Maria de Souza

7- Fabrício Arruda da Silva

8- Alexsandro Dos Santos Lima

9- Flávio Carlos Souza Ribeiro

10- Jânio Glauco Beserra

11- Gustavo Henrique Albuquerque de Mendonça

12- Antonio Moreira de Almeida Neto


PROFESSOR
WAGNER HAUN
ALÔ MACEIÓ-AL
CURSO CONFIRMADO
ULTRASSONOGRAFIA
CINESIOLÓGICA
MUSCULOESQUELÉTICA
PARA FISIOTERAPEUTAS
15-16-17
DEZEMBRO
2023
Hotel Intercity
Jatiúca-Maceió
MAIS INFORMAÇÕES
(82) 99183-4345

Esse é o aparelho 10:38

Vai ter uma apresentação dentro do curso 10:39

~ Dr Alexsandro Li... +55 87 98118-7092
Vai ser top 👏 11:35

Vai sim 11:37

Fisio Gustavo Pilar
Boa tarde! Na sexta qual horário previsto para inicio e término? 12:33

Boa tarde Dr Gustavo, 8:30às 18:00 paramos para almoço e para o coffee 12:36

Na parte da tarde! 12:36

Fisio Gustavo Pilar
👍

PROCESSO Nº: 0815869-85.2023.4.05.0000 **- AGRAVO DE INSTRUMENTO**
AGRAVANTE: ANAJARA NERES DA SILVA
ADVOGADO: Erickson Lourenco Dantas
AGRAVADO: CONSELHO REGIONAL DE MEDICINA DO ESTADO DE ALAGOAS
RELATOR(A): Desembargador(a) Federal Nenhum -
JUIZ PROLATOR DA SENTENÇA (1° GRAU): Juiz(a) Federal

DECISÃO

Recebido no plantão.

Trata-se de agravo de instrumento interposto por ANAJARA NERES DA SILVA (CLÍNICA TM FISIOTERAPIA) contra decisão proferida pelo juízo da 13ª Vara da Seção Judiciária de Alagoas, em ação civil pública proposta pelo Conselho Regional de Medicina de Alagoas, deferiu a tutela de urgência para determinar a suspensão do curso intitulado *"CURSO DE ULTRASSONOGRAFIA MUSCOESQUELÉTICA"* , marcado para ocorrer nos dias 15, 16 e 17 de dezembro de 2023.

Sustenta a agravante, em síntese, que se trataria de matéria de plantão sob o fundamento de suposta urgência em razão de: a) a intimação da parte agravante ter sido realizada na data de ontem, 14.12.2023 e o curso, que ora se pretende a realização, teria início hoje, em 15.12.2023, a partir das 08h30; b) não haveria como aguardar o expediente forense normal em busca de sua pretensão, tendo em vista que o início do Curso de Ultrassonongrafia Cinesiológica Musculoesquelética para Fisioterapeutas ocorrer nesta presente data, estando, pois comprovada a urgência do manejo do presente viés em sede de Plantão, buscando a revogação da decisão interlocutória ora recorrida.

É o relatório.

Os presentes autos vieram-me conclusos em face do art. 1º, § 1º, da Resolução nº 13/2009 deste TRF, que atribui ao Desembargador Federal Plantonista a prévia avaliação da urgência que mereça atendimento, desde que vinculada à tutela ou medida premente e a definição da sua adequação à apreciação em regime de plantão.

Entretanto, a hipótese dos autos não se enquadra nos termos do dispositivo citado, pois o regime de plantão traduz exceção ao princípio do Juiz Natural (art. 5º, LII e XXXVII, CF/88), sendo certo que a urgência a provocar a atuação do plantonista há que ser maior e mais exigente do que a que norteia atividade do relator.

Se a mera possibilidade de dano de difícil reparação ou o abuso do direito de defesa autoriza a atuação do relator natural, a intervenção do plantonista somente deve ter lugar quando constatado, a um só tempo, que a necessidade da proteção jurisdicional tenha surgido no plantão ou nos dias imediatamente anteriores e que o provimento perseguido tenha de se realizar dentro do mesmo lapso temporal.

No caso em exame, não há demonstração de perecimento do direito que justifique a apreciação da medida no plantão judiciário. Destaque-se que o expediente forense se inicia hoje, às 9h, e, por sua vez, a parte interpôs o recurso, às 8h12, objetivando que seja proferida tutela a fim de assegurar o início do curso descrito nas razões recursais às 8h30. Ocorre que, diante da iminência do início do expediente, não estaria caracterizada a urgência a justificar a manifestação do juízo plantonista.

Ademais, se reconhecido pelo juiz natural o direito à realização do curso em questão, este poderá ser ministrado hoje ou nos dias seguintes, inexistindo, assim, prejuízo para a parte recorrente diante da livre distribuição do recurso. Nesse contexto, aguarde-se o pronunciamento do Juiz Natural da demanda, o qual - caso assim entenda -, poderá conceder a medida de urgência pleiteada.

Este o quadro, remetam-se os autos ao Gabinete do Desembargador Federal Relator, a quem couber por distribuição, para oportuna análise da pretensão.

Expedientes necessários.

Intime-se.

Recife (PE), data da assinatura eletrônica.

Leonardo Augusto Nunes Coutinho

Desembargador Federal Plantonista

PROCESSO Nº: 0815869-85.2023.4.05.0000 **- AGRAVO DE INSTRUMENTO**
AGRAVANTE: ANAJARA NERES DA SILVA
ADVOGADO: Erickson Lourenco Dantas
AGRAVADO: CONSELHO REGIONAL DE MEDICINA DO ESTADO DE ALAGOAS
RELATOR(A): Desembargador(a) Federal Nenhum -
JUIZ PROLATOR DA SENTENÇA (1° GRAU): Juiz(a) Federal

DECISÃO

Recebido no plantão.

Trata-se de agravo de instrumento interposto por ANAJARA NERES DA SILVA (CLÍNICA TM FISIOTERAPIA) contra decisão proferida pelo juízo da 13ª Vara da Seção Judiciária de Alagoas, em ação civil pública proposta pelo Conselho Regional de Medicina de Alagoas, deferiu a tutela de urgência para determinar a suspensão do curso intitulado *"CURSO DE ULTRASSONOGRAFIA MUSCOESQUELÉTICA"* , marcado para ocorrer nos dias 15, 16 e 17 de dezembro de 2023.

Sustenta a agravante, em síntese, que se trataria de matéria de plantão sob o fundamento de suposta urgência em razão de: a) a intimação da parte agravante ter sido realizada na data de ontem, 14.12.2023 e o curso, que ora se pretende a realização, teria início hoje, em 15.12.2023, a partir das 08h30; b) não haveria como aguardar o expediente forense normal em busca de sua pretensão, tendo em vista que o início do Curso de Ultrassonongrafia Cinesiológica Musculoesquelética para Fisioterapeutas ocorrer nesta presente data, estando, pois comprovada a urgência do manejo do presente viés em sede de Plantão, buscando a revogação da decisão interlocutória ora recorrida.

É o relatório.

Os presentes autos vieram-me conclusos em face do art. 1º, § 1º, da Resolução nº 13/2009 deste TRF, que atribui ao Desembargador Federal Plantonista a prévia avaliação da urgência que mereça atendimento, desde que vinculada à tutela ou medida premente e a definição da sua adequação à apreciação em regime de plantão.

Entretanto, a hipótese dos autos não se enquadra nos termos do dispositivo citado, pois o regime de plantão traduz exceção ao princípio do Juiz Natural (art. 5º, LII e XXXVII, CF/88), sendo certo que a urgência a provocar a atuação do plantonista há que ser maior e mais exigente do que a que norteia atividade do relator.

Se a mera possibilidade de dano de difícil reparação ou o abuso do direito de defesa autoriza a atuação do relator natural, a intervenção do plantonista somente deve ter lugar quando constatado, a um só tempo, que a necessidade da proteção jurisdicional tenha surgido no plantão ou nos dias imediatamente anteriores e que o provimento perseguido tenha de se realizar dentro do mesmo lapso temporal.

No caso em exame, não há demonstração de perecimento do direito que justifique a apreciação da medida no plantão judiciário. Destaque-se que o expediente forense se inicia hoje, às 9h, e, por sua vez, a parte interpôs o recurso, às 8h12, objetivando que seja proferida tutela a fim de assegurar o início do curso descrito nas razões recursais às 8h30. Ocorre que, diante da iminência do início do expediente, não estaria caracterizada a urgência a justificar a manifestação do juízo plantonista.

Ademais, se reconhecido pelo juiz natural o direito à realização do curso em questão, este poderá ser ministrado hoje ou nos dias seguintes, inexistindo, assim, prejuízo para a parte recorrente diante da livre distribuição do recurso. Nesse contexto, aguarde-se o pronunciamento do Juiz Natural da demanda, o qual - caso assim entenda -, poderá conceder a medida de urgência pleiteada.

Este o quadro, remetam-se os autos ao Gabinete do Desembargador Federal Relator, a quem couber por distribuição, para oportuna análise da pretensão.

Expedientes necessários.

Intime-se.

Recife (PE), data da assinatura eletrônica.

Leonardo Augusto Nunes Coutinho

Desembargador Federal Plantonista

TRIBUNAL REGIONAL FEDERAL DA 5ª REGIÃO
PROCESSO: **0815869-85.2023.4.05.0000 - AGRAVO DE INSTRUMENTO**

Polo ativo	
ANAJARA NERES DA SILVA	AGRAVANTE
ERICKSON LOURENCO DANTAS	ADVOGADO

Polo passivo	
CONSELHO REGIONAL DE MEDICINA DO ESTADO DE ALAGOAS	AGRAVADO
YVES MAIA DE ALBUQUERQUE	ADVOGADO

Outros participantes
Sem registros

CERTIDÃO

CERTIFICO que, em 15/12/2023 11:08, o(a) ANAJARA NERES DA SILVA foi intimado(a) acerca de Decisão registrado em 15/12/2023 10:28 nos autos judiciais eletrônicos especificados na epígrafe.

1 - Esta Certidão é válida para todos os efeitos legais, havendo sido expedida através do Sistema Processo Judicial Eletrônico - PJe.

2 - A autenticidade desta Certidão poderá ser confirmada no endereço https://pje.trf5.jus.br/pje/Processo/ConsultaDocumento/listView.seam , através do código de autenticação nº 23121510342808800000042039949 .

3 - Esta Certidão foi emitida gratuitamente em 15/12/2023 11:08 - Tribunal Regional Federal 5ª Região.

TRIBUNAL REGIONAL FEDERAL 5ª REGIÃO
PROCESSO Nº: **0815869-85.2023.4.05.0000**
CLASSE: **AGRAVO DE INSTRUMENTO**
ADVOGADO: **ERICKSON LOURENCO DANTAS**
AGRAVANTE: **ANAJARA NERES DA SILVA**
AGRAVADO: **CONSELHO REGIONAL DE MEDICINA DO ESTADO DE ALAGOAS**
ADVOGADO: **YVES MAIA DE ALBUQUERQUE**
RELATOR(A): **DESEMBARGADOR(A) FEDERAL ROBERTO WANDERLEY NOGUEIRA - 1ª TURMA**

Certidão de Distribuição

Tipo da Distribuição: Automática.
Concorreu(ram): 1ª Turma: Gab 9 - Des. ÉLIO SIQUEIRA, Gab 14 - Des. EDVALDO BATISTA, Gab 1 - Des. ROBERTO WANDERLEY. 2ª Turma: Gab 6 - Des. PAULO CORDEIRO, Gab 7 - Des. PAULO ROBERTO, Gab 15 - Des. EDILSON NOBRE. 3ª Turma: Gab 2 - Des. ALEXANDRE LUNA FREIRE, Gab 3 - Des. CID MARCONI, Gab 13 - Des. ROGÉRIO FIALHO MOREIRA. 4ª Turma: Gab 10 - Des. RUBENS CANUTO, Gab 11 - Des. MANOEL ERHARDT, Gab 12 - Des. VLADIMIR CARVALHO. 5ª Turma: Gab 16 - Des. FRANCISCO ALVES, Gab 19 - Desa. JOANA CAROLINA, Gab 24 - Desa. CIBELE BENEVIDES. 6ª Turma: Gab 17 - Des. SEBASTIÃO VASQUES, Gab 20 - Des. LEONARDO RESENDE, Gab 23 - Des. RODRIGO TENÓRIO. 7ª Turma: Gab 5 - Des. ROBERTO MACHADO, Gab 22 - Des. LEONARDO COUTINHO, Gab 21 - Des. FREDERICO DANTAS.
Impedido(s): -
Distribuído para: 1ª Turma: Gab 1 - Des. ROBERTO WANDERLEY.

Excelentíssimo Senhor Desembargador Relator

Dr. Roberto Wanderley

Ref. Agravo de Instrumento de nº 0815869-85.2023.4.05.0000

CONSELHO REGIONAL DE FISIOTERAPIA E TERAPIA OCUPACIONAL DA 1ª REGIÃO (CREFITO-1) , autarquia pública federal, inscrita no CNPJ sob o nº 11.425.519/0001-38, com sede na Rua Henrique Dias, nº 303, Boa Vista, Recife/PE, CEP: 50.070-140, por seu procurador *in fine* , devidamente constituído por meio do instrumento procuratório em anexo ***(doc. 1)*** , vem, à presença de V.Exa., com fulcro nos artigos 119 e seguintes do CPC, **requerer habilitação nos presentes autos na qualidade de AMICUS CURIAE** , o que faz pelos fatos e fundamentos expostos na petição anexa.

Data e assinatura registradas eletronicamente.

Excelentíssimo Senhor Desembargador Relator

Dr. Roberto Wanderley

Ref. Agravo de Instrumento de nº 0815869-85.2023.4.05.0000

CONSELHO REGIONAL DE FISIOTERAPIA E TERAPIA OCUPACIONAL DA 1ª REGIÃO (CREFITO-1), autarquia pública federal, inscrita no CNPJ sob o nº 11.425.519/0001-38, com sede na Rua Henrique Dias, nº 303, Boa Vista, Recife/PE, CEP: 50.070-140, por seu procurador *in fine*, devidamente constituído por meio do instrumento procuratório em anexo ***(doc. 1)***, vem, à presença de V.Exa., com fulcro nos artigos 119 e seguintes do CPC, **requerer habilitação nos presentes autos na qualidade de AMICUS CURIAE**, o que faz pelos fatos e fundamentos delineados por meio dos seguintes tópicos:

1. DO CABIMENTO E DA LEGITIMIDADE

2. RESUMO DA DEMANDA E DECISÃO AGRAVADA

3. BREVES CONSIDERAÇÕES CONCEITUAIS SOBRE A ULTRASSONOGRAFIA CINESIOLÓGICA (MUSCULOESQUELETICA) E A AUSÊNCIA DE DANO CONCRETO OU RISCO POTENCIAL À SAÚDE DA POPULAÇÃO

1. DO CABIMENTO E DA LEGITIMIDADE

1. O Código de Processo Civil assegura, em seu artigo 138, que, considerando a **relevância da matéria**, a **especificidade do tema objeto da demanda** ou a **repercussão social da controvérsia**, o juiz ou o relator poderá admitir a participação de pessoa natural ou jurídica, órgão ou entidade especializada no processo, na condição de "*amicus curiae*":

> *Art. 138. O juiz ou o relator, considerando a relevância da matéria, a especificidade do tema objeto da demanda ou a repercussão social da controvérsia, poderá, por decisão irrecorrível, de ofício ou a requerimento das partes ou de quem pretenda manifestar-se, solicitar ou admitir a participação de pessoa natural ou jurídica, órgão ou entidade especializada, com representatividade adequada, no prazo de 15 (quinze) dias de sua intimação.*

> *§ 1º A intervenção de que trata o caput não implica alteração de competência nem autoriza a interposição de recursos, ressalvadas a oposição de embargos de declaração e a hipótese do § 3º.*
>
> *§ 2º Caberá ao juiz ou ao relator, na decisão que solicitar ou admitir a intervenção, definir os poderes do amicus curiae .*
>
> *§ 3º O amicus curiae pode recorrer da decisão que julgar o incidente de resolução de demandas repetitivas.*

2. Para Cassio Scarpinella Bueno[1], "*o amicus curiae não atua, assim, em defesa de um indivíduo ou de uma pessoa, como faz o assistente, em prol de um direito de alguém.* ***Ele atua em prol de um interesse, que pode, até mesmo, não ser titularizado por ninguém, embora seja partilhado difusa ou coletivamente por um grupo de pessoas e que tende a ser afetado pelo que vier a ser decidido no processo***". (Grifado).

3. Segundo, ainda, o mesmo doutrinador, o Amicus Curiae, desempenha, nessa ordem de ideias, "*melhorar o debate processual e contribuir a uma decisão mais justa e fundamentada*" e legitimar "*democraticamente a formação de precedente judicial, de jurisprudência dominante ou de súmula, o que é levado a efeito por meio da pluralização do diálogo processual para com locos, grupos, classes ou estratos da sociedade ou, ainda, para com órgãos, instituições, potências públicas ou próprio Estado*" de cujos interesses momentaneamente se torna adequado representante, em juízo.

4. No presente caso, é evidente a relevância da matéria, a especificidade do tema objeto da demanda e, acima de tudo, a repercussão social da controvérsia.

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[1] BUENO, Cassio Scarpinella. Curso sistematizado.

5. A decisão combatida por meio do presente agravo de instrumento determinou a suspensão de curso oferecido por profissional fisioterapeuta intitulado CURSO DE ULTRASSONOGRAFIA MÚSCULO ESQUELÉTICA, sob o equivocado argumento de que ultrassonografia músculo esquelética seria ATO MÉDICO, de forma que o resultado da presente demanda, assim como da demanda de origem, **implicará diretamente na atividade fiscalizatória do requerente sobre os profissionais inscritos em sua circunscrição**.

6. É que o CREFITO-1, autarquia pública federal, instituída pela Lei 6.316/75, tem a incumbência de **fiscalizar o exercício profissional de fisioterapeutas e terapeutas**, profissões devidamente regulamentadas pelo Decreto-Lei 938/69, e diante da propositura da presente demanda, há a real possibilidade desse r. Poder Judiciário considerar, equivocadamente (com todas as vênias), que profissionais fisioterapeutas estariam desautorizados a realizar o procedimento de ultrassonografia cinesiológica.

7. Assim, propõe-se seja o CREFITO-1 admitido nos presentes autos, na condição de *AMICUS CURIAE*, nos termos do art. 138 do CPC.

8. Caso se entenda por tal admissão, passa-se a expor razões de direito com o intuito de melhorar o debate processual e contribuir para a uma decisão mais justa.

2. RESUMO DA DEMANDA E DECISÃO AGRAVADA

9. Na origem, o Conselho Regional de Medicina do Estado de Alagoas (CREMAL) propôs Ação Civil Pública em face do fisioterapeuta/professor WAGNER CRUZ HAUN, devidamente inscrito no CREFITO sob o nº 161960-F, e da CLÍNICA TM FISIOTERAPIA, buscando – **liminarmente** – que os demandados se abstivessem de realizar o CURSO DE ULTRASSONOGRAFIA MUSCOESQUELÉTICA nos dias 15 a 17 de dezembro de 2023, na cidade Maceió, sob o argumento de que o exame de ultrassonografia musculoesquelética seria ato privativo de medicina, e – **no mérito** – seja reconhecida a ilegalidade do referido curso, com fundamento no inciso III do §4º do art. 4º da Lei 12.842/2013, assim como "*nos incisos III do artigo 1º, no caput do artigo 5º, no caput do artigo 37 e no caput do artigo 196 todos da Major Lex*" (sic).

10. No dia 14/12/2023, o r. Juízo de origem deferiu o pedido liminar em decisão assim proferida:

> *11. No caso dos autos, pretende o Conselho autor impedir a realização do " "CURSO DE ULTRASSONOGRAFIA MUSCOESQUELÉTICA" , a ser ministrado pelo réu WAGNER CRUZ HAUN em parceria com a Clínica TM Fisioterapia , marcado para ocorrer nos dias 15, 16 e 17 de dezembro de 2023.*
> *12. Pois bem. **Considerando o teor do art. 1º da Resolução CFM n. 1.361/1992: "É da exclusiva competência do médico a execução e a interpretação do exame ultra-sonográfico em seres humanos, assim como a emissão do respectivo laudo". Ademais, o art. 4º da Lei n. 12.842/2013 (Lei do Ato Médico) confere privativamente aos profissionais da Medicina, dentre outras atribuições: a emissão de laudo dos exames de imagem e a determinação do prognóstico relativo ao diagnóstico nosológico (art. 4º, alíneas "f" e "g").***
> *13. Afora isso, pontuou o demandante que a **"ultrassonografia" é uma especialidade médica, tanto que "para o médico obter registro e poder se anunciar como especialista em radiologia e diagnóstico por imagem, é necessária a realização de***

> ***residência médica, em período não inferior a 03 (três anos) ou por meio de concurso realizado pela Associação Medica Brasileira/Colégio Brasileiro de Radiologia e Diagnóstico por Imagem", ao passo que o curso em questão, destinado a não-médicos, tem duração de apenas 03 (três) dias.***
>
> *14. Sendo assim, a partir de uma análise perfunctória do caso, própria do atual estágio processual, e considerando os fundamentos apresentados, entendo que o pleito liminar atende satisfatoriamente ao requisito da probabilidade do direito (fumus boni iuris).*
>
> *15. Quanto ao requisito do periculum in mora , entendo-o manifesto, já que o multicitado curso está marcado para se iniciar no dia de amanhã (15.12.2023), não havendo sequer tempo hábil para o exercício do contraditório.*
>
> *16. Isto posto, DEFIRO a tutela de urgência requestada.*

11. Com o devido respeito, há graves erros na decisão agravada, sendo sua revogação, por meio do presente agravo de instrumento, medida de justiça.

3. BREVES CONSIDERAÇÕES CONCEITUAIS SOBRE A ULTRASSONOGRAFIA CINESIOLÓGICA (MUSCULOESQUELETICA) E A AUSÊNCIA DE DANO CONCRETO OU RISCO POTENCIAL À SAÚDE DA POPULAÇÃO

12. De início, faz-se imperioso esclarecer que a ultrassonografia cinesiológica (ou musculoesquelética) é **"um procedimento usado por fisioterapeutas para avaliar a morfologia e função muscular e dos tecidos moles relacionados durante o exercício e tarefas físicas e é usado para auxiliar na aplicação de intervenções terapêuticas destinadas a melhorar a função muscular"[2].**

[2] TEYHEN D, S. Rehabilitative Ultrasound Imaging Symposium San Antonio, TX. Journal of Orthopaedic Sports and Physical Therapy, v.36:A1-3, Maio 2006.

13. Conforme é possível se extrair da NOTA TÉCNICA/2021/PROJUR/GT/SJDF/1043821-22 (doc. 3), acompanhada de inúmeras referências bibliográficas, o uso dessa técnica no âmbito da fisioterapia tem sido crescente ao longo dos últimos 30 anos, o que foi possível a partir do trabalho de pesquisadores que demonstraram os ganhos possíveis com a utilização do exame ultrassonográfico nas rotinas de tratamento e diagnóstico fisioterapêutico.

14. Foi a partir da década de 1990 que o uso da ultrassonografia cinesiológica ganhou o apreço dos fisioterapeutas, com a publicação de uma gama de estudos que comprovaram a segurança, a viabilidade e a precisão desta ferramenta.

15. Já nos anos 2000 (2006), foi realizado o primeiro simpósio sobre o tema, o qual fora promovidopela faculdade de fisioterapia da Army-Baylor University, localizada nos Estados Unidos, quando o exame de imagem na fisioterapia recebeu o nome de ultrassonografia reabilitativa ou cinesiológica, como é conhecida no Brasil.

16. Com a realização do simpósio, estabeleceu-se que a ultrassonografia cinesiológica é ferramenta apta ao fisioterapeuta, **a fim de avaliar a melhoria da função neuromuscular do paciente em tratamento fisioterapêutico**, sendo possível identificar com maior certeza a presença de qualquer alteração morfofuncional, bem como o nível de evolução do tratamento.

17. **Diferente do que o CREMAL alega, trata-se, na verdade, de método não invasivo, que não se utiliza de radiação, não oferecendo nenhum risco à saúde do paciente.**

18. O exame possibilita ao fisioterapeuta, profissional devidamente habilitado, a chegar a diagnósticos funcionais e avaliar a resposta morfofuncional ao tratamento, quando o profissional de fisioterapia poderá precisamente definir possíveis ajustes e prognóstico do combalido.

19. Dentre as vantagens dessa avaliação à resposta morfofuncional do tratamento, tem-se a possibilidade de detectar, no músculo, alterações no comprimento, espessura, diâmetro, área de secção transversa, volume, comprimento do fascículo e ângulo de penação, alterações funcionais neurofisiológicas; presença de edema/inflamação neuromusculares e em tecidos moles; para avaliar a diminuição da capacidade contrátil ede estiramento, promovendo um melhor feedback para pacientes que estão passando por reaprendizado motor.

20. A fim de melhor ilustrar como ocorre o exame sob discussão,colaciona-se fotografia de um estudo clínico retirado do artigo "**Ultrassonografia Musculoesquelética – Bases Teóricas para Avaliação da Arquitetura Muscular em Pacientes Criticamente Enfermos**" (doc. 4 - Pág. 89), bem como do aparelho geralmente utilizado:

21. Como se vê, trata-se de procedimento relativamente simples e de grande valia no acompanhamento e direcionamento do tratamento e evolução do paciente.

22. Importante frisar que, no âmbito da fisioterapia, o exame de ultrassonografia cinesiológica é complementar ao tratamento de reabilitação motora, a partir do diagnóstico fisioterapêutico.

23. **Não se pretende com exames feito por fisioterapeutas realizar diagnóstico de doenças, mas quantificar, qualificar e descrever limitação funcional, que é alvo e finalidade da fisioterapia.**

24. O fisioterapeuta não entrega ao paciente o diagnóstico médico, mas o diagnóstico fisioterapêutico (também denominado de cinético-funcional, cinesiofuncional ou simplesmente funcional) se utilizando em sua avaliação da Classificação Internacional de Funcionalidade (CIF)[3], **escala criada pela OrganizaçãoMundial de Saúde (OMS).**

25. Conforme se demonstra nos tópicos seguintes, a alegação de que a elaboração de diagnóstico e prognóstico é atividade exclusiva do profissional da medicina é infundada, porquanto **tais termos não são privativos de uma profissão, mas "instrumentos de avaliação complementares para análise semiológica", que no âmbito da fisioterapia têm *"o propósito de quantificar e qualificar as deficiências cinético-funcionais".***

26. Conclui-se que de fato a ULTRASSONOGRAFIA CINESIOLÓGICA é um exame **SIMPLES, MULTIDISCIPLINAR E NÃO INAVISO**, COM DIFERENTES FINALIDADES A DEPENDER DO PROFISSIONAL DE SAÚDE QUE APLICA, INTERPRETA E LAUDA O REFERIDO EXAME E, QUE NÃO IMPÕE RISCOS AOS PACIENTES.

27. Assim, ficou fácil perceber que os riscos alardeados pelo CREMAL não passam de argumentos genéricos e sem nenhuma comprovação.

[3] Classificação Internacional de Funcionalidade – Organização Mundial da Saúde

4. FUNDAMENTAÇÃO JURÍDICA

4.1. PRELIMINAR – INÉPCIA DA INICIAL DA AÇÃO DE ORIGEM

28. Antes de adentrar no mérito, é importante registrar que o Juízo de origem, infelizmente, não se deu conta de que **a petição inicial da ação de origem é completamente inepta**, pois que há **completa desconexão** entre pedidos e causa de pedir.

29. Em petição bastante confusa, o CREMAL pretende, com a ação de origem, seja reconhecida a "ilegalidade do curso de ultrassonografia músculo esquelética". Senão, vejamos trecho dos pedidos:

> c) Que julgue procedente o presente pedido declarando no mérito e determinando com fundamento no inciso III do §4° do art. 4° da Lei 12.842 de 10 de Julho de 2013 c/c nos incisos III do artigo 1°, no *caput* do artigo 5°, no *caput* do artigo 37 e no *caput* do artigo 196 todos da *Major Lex*, que é ilegal o curso programado pelo professor e conselheiro do CREFITO/SC, **WAGNER HAUN** o primeiro demandado, nos dias 15/16 e 17 de dezembro de 2023, **CURSO DE ULTRASSONOGRAFIA MUSCOESQUELÉTICA**, confirmando por fim a liminar concedida;

30. No entanto, não apresenta, em toda petição, qualquer fundamento legal sob o qual possa amparar-se para considerar o curso em questão "ilegal".

31. Aliás, o pedido em si é muito estranho: considerar que "o curso" seja ilegal. Difícil de entender.

32. A petição nesse ponto é claramente ininteligível.

33. Ao que parece, o que o CREMAL pretende é que a realização do exame de ultrassonografia musculoesquelética seja considerada atividade privativa de profissional médico, o que é um erro grave, já que todas as atividades privativas do médico estão estabelecidas, **de forma taxativa**, no artigo 4º da lei 12.842/2013, e entre as mesmas não se encontra a realização do referido exame, como se demonstra adiante.

34. No entanto, embora o CREMAL utilize tal fundamento como causa de pedir, o que se pede é outra coisa completamente diferente, ou seja, que "o curso", e não a realização do exame, seja considerado ilegal. **Ou seja, ficou bem confuso mesmo**.

35. Em determinado trecho de sua petição, o CREMAL, como que num ato falho, acaba revelando a sua verdadeira intenção ao tentar impedir que profissionais fisioterapeutas exerçam livremente, e legitimamente, atividades econômicas, como a realização do curso em questão, ao dizer que tais atividades se dão "de forma altamente lucrativa".

> Feitas estas considerações, é fato que visa, através do ajuizamento de Ação Civil Pública em desfavor do professor que tenta disseminar de forma altamente lucrativa, atividade de fisioterapia que é exclusiva de médico pelo comando legislativo e litisconsorte com local onde se realizará curso de ultrassonografia muscoesquelética, resguardar os interesses não só da saúde dos pacientes, mas da coletividade de uma forma geral.

36. Ou seja, fica claro que o que o CREMAL pretende com a ação de origem é promover reserva de mercado para os profissionais da medicina.

37. Na alínea "c" dos pedidos como exposto no recorte acima, o CREMAL utiliza como fundamento para pedir que seja o curso reconhecido como ilegal os seguintes dispositivos normativos: *inciso III do §4º do art. 4º da Lei 12.842 de 10 de Julho de 2013 c/c nos incisos III do artigo 1º, no caput do artigo 5º, no caput do artigo 37 e no caput do artigo 196 todos da Major Lex* (sic).

38. No entanto, tais dispositivos **não guardam – minimamente – qualquer relação com eventual ilegalidade cometida pelos demandados ao realizar o curso de ultrassonografia músculo esquelética**.

39. Vejamos, na ordem apresentada pelo CREMAL.

40. O inciso III do §4º do art. 4º da Lei 12.842 de 10 de Julho de 2013 não diz outra coisa além de que a invasão dos orifícios naturais do corpo, atingindo órgãos internos são procedimentos invasivos:

> § 4º Procedimentos invasivos, para os efeitos desta Lei, são os caracterizados por quaisquer das seguintes situações:
>
> III - invasão dos orifícios naturais do corpo, atingindo órgãos internos.

41. Nem com muito esforço se consegue imaginar porque o CREMAL trouxe esse dispositivo aos autos. É impensável imaginar que a intenção seria classificar a ultrassonografia músculo esquelética como "procedimento invasivo que atinge órgãos internos".

42. Considerando que um Egrégio Conselho Regional de Medicina não cometeria tal equívoco, não se imagina outra coisa, senão, que a intenção foi mesmo confundir o juízo agravado. O que, infelizmente, se conseguiu.

43. Os dispositivos Constitucionais citados pelo CREMAL na alínea "c" dos seus pedidos também não trazem nenhuma previsão que possa servir como parâmetro para considerar o curso de ultrassonografia músculo esquelética "ilegal". Vejamos:

> Art. 1º A República Federativa do Brasil, formada pela união indissolúvel dos Estados e Municípios e do Distrito Federal, constitui-se em Estado Democrático de Direito e tem como fundamentos:
> III - a dignidade da pessoa humana;

> Art. 5º Todos são iguais perante a lei, sem distinção de qualquer natureza, garantindo-se aos brasileiros e aos estrangeiros residentes no País a inviolabilidade do direito à vida, à liberdade, à igualdade, à segurança e à propriedade, nos termos seguintes:
>
> Art. 37. A administração pública direta e indireta de qualquer dos Poderes da União, dos Estados, do Distrito Federal e dos Municípios obedecerá aos princípios de legalidade, impessoalidade, moralidade, publicidade e eficiência e, também, ao seguinte:
>
> Art. 196. A saúde é direito de todos e dever do Estado, garantido mediante políticas sociais e econômicas que visem à redução do risco de doença e de outros agravos e ao acesso universal e igualitário às ações e serviços para sua promoção, proteção e recuperação.

44. Em outro trecho da petição inicial, o CREMAL cita, como fundamento para causa de pedir, o art. 1º de uma resolução do Conselho Federal de Medicina – CFM (Resolução 1361/1992) onde, aí sim, **de forma completamente ilegal**, atribui-se ao profissional médico a competência exclusiva para realização de exame de ultrassonografia, como se o CFM tivesse poderes para atribuir competências exclusivas ou qualificações profissionais ao médico, o que, segundo o inciso XIII do artigo 5º da CF só pode ser feito por meio de LEI, sob pena de grave afronta ao Princípio da LIBERDADE DE PROFISSÃO:

> XIII - é livre o exercício de qualquer trabalho, ofício ou profissão, atendidas as qualificações profissionais **que a lei estabelecer**; (grifado)

45. E mesmo que a referida resolução do CFM pudesse estabelecer o que é e o que não é competência exclusiva do médico – mesmo assim – tal norma não poderia jamais servir como fundamento para o pedido formulado pelo CREMAL na ação de origem, ou seja, que o curso de ultrassonografia musculoesquelética seja reconhecido "ilegal".

46. O CREMAL também utiliza como causa de pedir alguns dispositivos previstos na Lei 12.842/2013, que regulamenta o exercício da medicina, no entanto, nenhum deles poderia servir como fundamento para se considerar o curso em questão como ilegal.

47. Enfim, há uma completa desconexão entre causa de pedir e pedidos. Não há qualquer fundamento na causa de pedir que mantenha a congruência com o pedido ao final requerido.

48. O Código de Processo Civil dispõe claramente que é inepta a petição inicial que não possua causa de pedir. Vejamos o que dispõe o art. 330, inciso I, do CPC:

> Art. 330. A petição inicial será indeferida quando:
> I - for inepta;
> (...)
> § 1º Considera- se inepta a petição inicial quando:
> I - lhe faltar pedido ou causa de pedir; (...).

49. O feito, nesse sentido, merece ser extinto sem resolução de mérito, conforme previsto no inciso I do artigo 485 do CPC.

> Art. 485. O juiz não resolverá o mérito quando:
> I - indeferir a petição inicial;

4.2. ULTRASSONOGRAFIA MUSCULOESQUELETICA NÃO É ATIVIDADE PRIVATIVA DE MÉDICO (ATO MÉDICO)

50. Em sua causa de pedir, que, como já dito, não mantém a mínima congruência com os pedidos apresentados, o CREMAL alega, equivocadamente, que a realização de exame de ultrassonografia cinesiológica seria "ato médico", a realização de diagnóstico é "prerrogativa" de médico.

> Segundo a Lei nº 12.842 de julho de 2013, ou Lei do Ato Médico, essa prática é claramente proibida por não médico, uma vez que a realização de procedimentos constitui como prerrogativa exclusiva do médico, visto que a realização de diagnóstico é prerrogativa e especialidade dos médicos(três anos) e não dos fisioterapeutas(três dias).

51. Ora, ato médico é a expressão popularmente usada para denominar as atividades privativas do profissional da medicina, previstas, **de forma taxativa**, no caput do artigo 4° da lei 12.842/2013:

> *Art. 4º São atividades privativas do médico:*
> *I - (VETADO);*

> *II - indicação e execução da intervenção cirúrgica e prescrição dos cuidados médicos pré e pós-operatórios;*
> *III - indicação da execução e execução de procedimentos invasivos, sejam diagnósticos, terapêuticos ou estéticos, incluindo os acessos vasculares profundos, as biópsias e as endoscopias;*
> *IV - intubação traqueal;*
> *V - coordenação da estratégia ventilatória inicial para a ventilação mecânica invasiva, bem como das mudanças necessárias diante das intercorrências clínicas, e do programa de interrupção da ventilação mecânica invasiva, incluindo a desintubação traqueal;*
> *VI - execução de sedação profunda, bloqueios anestésicos e anestesia geral;*
> *VII - emissão de laudo dos exames endoscópicos e de imagem, dos procedimentos diagnósticos invasivos e dos exames anatomopatológicos;*
> *VIII - (VETADO);*
> *IX - (VETADO);*
> *X - determinação do prognóstico relativo ao diagnóstico nosológico;*
> *XI - indicação de internação e alta médica nos serviços de atenção à saúde;*
> *XII - realização de perícia médica e exames médico-legais, excetuados os exames laboratoriais de análises clínicas, toxicológicas, genéticas e de biologia molecular;*
> *XIII - atestação médica de condições de saúde, doenças e possíveis sequelas;*
> *XIV - atestação do óbito, exceto em casos de morte natural em localidade em que não haja médico.*

52. Observe-se que, em nenhum momento, a Lei prevê que a realização do exame seria ato privativo de médico.

53. Aliás, o inciso I do art. 4º, que elencava a formulação do diagnóstico nosológico e respectiva prescrição terapêutica como atividade privativa do médico **foi vetado pela Presidência da República**, não havendo base legal para se sustentar que a formulação de qualquer diagnóstico nosológico, ou qualquer prescrição terapêutica sejam atividades privativas.

54. As razões do veto são claras em expressar a INTERDISCIPLINARIEDADE na assistência à saúde do sistema de saúde brasileiro, assim como a possibilidade de realização do diagnóstico nosológico por profissionais de outras áreas que não a médica.

> "O texto inviabiliza a manutenção de ações preconizadas em protocolos e diretrizes clínicas estabelecidas no Sistema Único de Saúde e em rotinas e protocolos consagrados nos estabelecimentos privados de saúde. Da forma como foi redigido, o inciso I impediria a continuidade de inúmeros programas do Sistema Único de Saúde que funcionam a partir da **atuação integrada dos profissionais de saúde, contando, inclusive, com a realização do diagnóstico nosológico por profissionais de outras áreas que não a médica**. É o caso dos programas de prevenção e controle à malária, tuberculose, hanseníase e doenças sexualmente transmissíveis, dentre outros. Assim, a sanção do texto poderia comprometer as políticas públicas da área de saúde, além de introduzir elevado risco de judicialização da matéria." (Grifado)

55. Considerando que o exame de ultrassonografia musculoesquelética é utilizado como recurso para formulação de diagnóstico (fisioterapêutico, e não médico), conclui-se que não pode ser considerado atividade privativa do médico, em razão do veto presidencial implementado pela Presidência da República, que, inclusive, buscou resguardar a possibilidade de formulação de diagnóstico por outros profissionais de saúde.

56. Alinha-se a essa interpretação do veto o texto do § 7º do mesmo artigo, que resguarda, de forma expressa, as competências próprias de várias profissões na aplicação do art. 4º, entre as mesmas, a do fisioterapeuta:

> § 7º O disposto neste artigo será aplicado de forma **que sejam resguardadas as competências próprias das profissões** de assistente social, biólogo, biomédico, enfermeiro, farmacêutico, **fisioterapeuta**, fonoaudiólogo, nutricionista, profissional de educação física, psicólogo, terapeuta ocupacional e técnico e tecnólogo de radiologia.
> (Grifado)

57. Além do mais, não há uma única norma vigente no ordenamento jurídico brasileiro que proíba ao fisioterapeuta a elaboração de diagnóstico por meio ultrassonografia musculoesquelética, dentro da sua atuação profissional, o que, do contrário, resultaria em restrição arbitrária da liberdade do exercício profissional do fisioterapeuta.

58. Nessa perspectiva, intentar uma restrição sem previsão legal prévia constitui a só tempo ofensa aos princípios constitucionais insculpidos no art. 5º, inciso II (Princípio da Reserva Legal) e XIII (Liberdade de Ofício), ambas cláusulas pétreas da Constituição Federal, assim como ao Princípio da Livre Iniciativa prevista no art. 170.

59. O art. 5º, inciso II da CRFB dispõe acerca do Princípio Constitucional da Reserva Legal, no sentido de que qualquer vedação ao exercício de prática, ofício, atividade ou trabalho é permitida, ressalvada a proibição legal neste sentido.

60. Sendo assim, se não há Lei no sentido formal proibindo uma atividade, não é dado à administração ou ao próprio Poder Judiciário fazê-lo, o que claramente se aplica ao exame de ultrassonografia musculoesquelética.

61. Acerca do Princípio da Reserva Legal importa registrar que a interpretação deve ser sempre no sentido inverso do que pretende o CREMAL.

62. Ou seja, não havendo proibição expressa em Lei, não é possível imputar a restrição ao particular, definindo o Constituinte Originário em cláusula pétrea que "**ninguém será obrigado a fazer ou deixar de fazer alguma coisa senão em virtude de lei**".

63. Quanto à pretensão do CREMAL na ação de origem, outro importante postulado constitucional deve impedir o sucesso de sua empreitada, visto que a limitação pretendida busca limitar o exercício de trabalho, ofício, que não fora restringido em lei.

64. É necessária uma análise do tema sob o duplo enfoque: (i) ausência de norma proibitiva; (ii) da liberdade de trabalho, profissão, arte ou ofício.

65. A Constituição da República Federativa do Brasil garante a todos os brasileiros o exercício de qualquer trabalho, ofício ou profissão. A liberdade do exercício profissional é Direito Fundamental com previsão no artigo 5º, inciso XIII do texto constitucional:

> *Art. 5º [...]*
>
> *XIII – é livre o exercício de qualquer trabalho, ofício ou profissão, atendidas as qualificações profissionais que a lei estabelecer*

66. A segunda parte do inciso XIII do artigo 5º da Constituição prevê

que, para o exercício do direito de liberdade profissão, qualificações profissionais devem ser estabelecidas por lei.

67. Entende-se assim que todo brasileiro pode exercer profissão de sua escolha, tendo como *único limite* para o exercício desse direito, conforme disposto na segunda parte do inciso, "*as qualificações profissionais que a lei estabelecer*".

68. Essa restrição constitui-se como **reserva legal** qualificada ao direito fundamental.

69. Segundo Gilmar Mendes (2008, p.309)[4]: "[t]em-se uma **reserva legal** ou restrição legal qualificada quando a Constituição não se limita a exigir que eventual restrição ao âmbito de proteção de determinado direito seja prevista em lei, estabelecendo também, as condições especiais, os fins a serem perseguidos ou os meios a serem utilizados." (Grifado).

70. E nesse sentido, as condições especiais para o exercício da profissão de Fisioterapeuta estão delineadas na legislação ordinária, conforme se expõe no próximo tópico.

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[4] MENDES, Gilmar Ferreira; COELHO, Inocêncio Mártires; BRANCO, Paulo Gustavo Gonet. Curso de direito constitucional. 3. ed., São Paulo: Saraiva, 2008, p. 309

4.3. DAS COMPETÊNCIAS LEGAIS DO FISIOTERAPEUTA PARA REALIZAR O EXAME DE ULTRASSONOGRAFIA MUSCULOESQUELÉTICA

71. A profissão da fisioterapia foi regulamentada pelo Decreto-Lei 938/69, que assim estabelece em seu artigo 3º:

> *"É atividade privativa do fisioterapeuta executar métodos e técnicas fisioterápicos com a finalidade de **restaurar, desenvolver e conservar** a capacidade física do ciente".* (Grifado)

15. Assim, a elaboração de diagnóstico e laudos decorrentes de ultrassonografia voltada a restaurar, desenvolver e conservar a capacidade física do paciente é lícita ao fisioterapeuta, cabendo ao Conselho Federal de Fisioterapia e Terapia Ocupacional exercer função normativa, editando os atos necessários à interpretação e execução do quanto disposto na Lei 6.316/1975 e à fiscalização profissional (art. 5º, II, da Lei 6.316/1975).

> *Art. 5º Compete ao Conselho Federal:*
>
> *I - eleger, dentre os seus membros, por maioria absoluta, o seu Presidente e o Vice-Presidente;*
>
> *II - **exercer função normativa**, baixar atos necessários à interpretação e execução do disposto nesta Lei e à fiscalização do exercício profissional, adotando providências indispensáveis à realização dos objetivos institucionais;*

16. E, nesse sentido, amparado pela atribuição conferida pela Lei 6.316/75, ou seja, de exercer função normativa, o COFFITO publicou a **Resolução 80, de 09 de maio de 1987** (publicada no DOU nº 093 de 21/05/1987), que, em seu artigo 1°, dispõe:

> *"É competência do FISIOTERAPEUTA, **elaborar o diagnóstico fisioterapêutico** compreendido como avaliação físico-funcional, sendo esta, um processo pelo qual, através de metodologias e técnicas fisioterapêuticas, são analisados e estudados os desvios físico-funcionais intercorrentes, na sua estrutura e no seu funcionamento, com a finalidade de detectar e parametrar as alterações apresentadas, considerados os desvios dos graus de normalidade para os de anormalidade; **prescrever**, baseado no constatado na avaliação físico-funcional as técnicas próprias da Fisioterapia, qualificando-as e quantificando-as; dar ordenação ao processo terapêutico baseando-se nas técnicas fisioterapêuticas indicadas; **induzir o processo terapêutico** no paciente; **dar altas** nos serviços de Fisioterapia, utilizando o critério de reavaliações sucessivas que demonstrem não haver alterações que indiquem necessidade de continuidade destas práticas terapêuticas."* (Grifado)

17. No mesmo sentido, a Resolução 4/2022 do Conselho Nacional de Educação, que institui Diretrizes Curriculares Nacionais do Curso de Graduação em Fisioterapia, e assim dispõe:

> Art. 5º A formação do Fisioterapeuta tem por objetivo dotar o profissional dos conhecimentos requeridos para o exercício das seguintes competências e habilidades específicas:
> [...]
> **VI - realizar consultas, avaliações e reavaliações do paciente colhendo dados, solicitando, executando e interpretando exames propedêuticos e complementares que permitam elaborar um diagnóstico cinético-funcional, para eleger e quantificar as intervenções e condutas fisioterapêuticas apropriadas, objetivando tratar as disfunções no campo da Fisioterapia, em toda sua extensão e complexidade, estabelecendo prognóstico, reavaliando condutas e decidindo pela alta fisioterapêutica;**

18. Na mesma toada, por meio da Resolução 428, que fixa e estabelece o Referencial Nacional de Procedimentos Fisioterapêuticos, o COFFITO incluiu a "**Ultrassonografia cinesiológica – por seguimento**" entre os procedimentos listados no capítulo que elenca Exames e Testes Funcionais de competência do profissional fisioterapeuta.

19. O Referencial Nacional de Procedimentos Fisioterapêuticos, nos termos do art. 7° da Resolução COFFITO 428, "*constitui-se em um instrumento básico para a caracterização do trabalho do FISIOTERAPEUTA no Sistema de Saúde Brasileiro, classificando e hierarquizando os procedimentos fisioterapêuticos, baseados na saúde funcional e, a índices remuneratórios adequados ao exercício ético-deontológico da Fisioterapia brasileira*".

20. Dessa forma, conforme se verifica, o fisioterapeuta é profissional técnica e legalmente habilitado pelo ordenamento jurídico brasileiro para realizar consultas e elaborar diagnóstico fisioterapêutico, assim como para eleger e quantificar **qualquer conduta – e não apenas a ultrassonografia cinesiológica – que objetive tratar e/ou diagnosticar qualquer disfunção no campo da Fisioterapia**.

21. E foi exatamente nessa linha que o Tribunal Regional Federal da 5ª Região (TRF-5), no dia 16 de fevereiro de 2018, reconheceu, à unanimidade, a legitimidade do fisioterapeuta para solicitar exames complementares vinculados à sua atividade profissional, de modo a embasar o diagnóstico fisioterapêutico, conforme se extrai do voto do relator, desembargador Emiliano Zapata Leitão:

> ***TRF – 5 (AC 0810503-32.2016.4.05.8400)***
>
> ***Voto do Relator***
>
> *[...]*
>
> *O cerne da questão reside em saber se o profissional fisioterapeuta pode ou não solicitar exames complementares para embasar o seu diagnóstico fisioterapêutico ou se apenas os médicos têm a prerrogativa de solicitar tais exames.*

O Decreto-Lei nº 938/69, que dispõe sobre as profissões de fisioterapeuta e terapeuta ocupacional, estabelece que é atividade privativa do fisioterapeuta executar métodos e técnicas fisioterápicos com a finalidade de restaurar, desenvolver e conservar a capacidade física do paciente (art. 3º).

O Conselho Federal de Fisioterapia e Terapia Ocupacional - COFFITO, no uso das atribuições que lhe foram conferidas pela Lei nº 6.316/75, editou a Resolução nº 80, de 09/05/87, segundo a qual "o FISIOTERAPEUTA é profissional competente para buscar todas as informações que julgar necessárias no acompanhamento evolutivo do tratamento do paciente sob sua responsabilidade, recorrendo a outros profissionais da Equipe de Saúde, através de solicitação de laudos técnicos especializados; Bem como, os resultados dos exames complementares, a eles inerentes (art. 3º).

No caso em exame, o Instituto de Radiologia de Natal Ltda, em resposta à notificação extrajudicial feita pelo CREFITO1, justificou que a negativa em realizar o exame complementar requerido pelo fisioterapeuta se fundamentou em parecer proferido pelo Conselho Federal de Medicina (PC/CFM/Nº21/1985), pelo qual "a solicitação de exames complementares, só pode ser feita por médico, já que é complementação do exame clínico, portanto, parte integrante do diagnóstico médico, este que somente pode ser realizado por profissional legalmente habilitado conforme art. 17 da Lei nº 3.268 de 30/09/57".

Ocorre que a Lei nº 12.842/13, que dispõe sobre o exercício da medicina, não estabelece que a solicitação de exames complementares constitui ato privativo de médico.

Confira-se:

"Art. 4º São atividades privativas do médico:

[...]

Ressalte-se que a Presidência da República vetou a previsão contida no inciso I do referido art. 4º, segundo a qual seria atividade privativa do médico "formulação do diagnóstico nosológico e respectiva prescrição terapêutica", sob a justificativa de que tal previsão "impediria a continuidade de inúmeros programas do Sistema Único de Saúde que funcionam a partir da atuação integrada dos profissionais de saúde, contando, inclusive, com a realização do diagnóstico nosológico por profissionais de outras áreas que não a médica".

Considerando-se, portanto, que a solicitação de exames complementares não se encontra entre as atividades privativas do médico, não há óbice a que o fisioterapeuta possa solicitar exames complementares vinculados à sua atividade profissional, de modo a poder embasar o diagnóstico fisioterapêutico.

> *Com estas considerações, DOU PROVIMENTO à apelação e inverto a sucumbência. É como voto. Recife, 08 de fevereiro de 2017. (data do julgamento) Des. Federal EMILIANO ZAPATA LEITÃO - Relator Convocado.*

22. E, especificamente, **sobre a possibilidade de realização de exame de ultrassonografia por profissional fisioterapeuta**, em recente sentença, **no dia 24/10/2023**, o juízo da 20ª Vara Federal Cível da Subseção Judiciária do Distrito Federal assim **julgou improcedente** ação civil pública ajuizada pelo CONSELHO FEDERAL DE MEDICINA - CFM em face do CONSELHO FEDERAL DE FISIOTERAPIA E TERAPIA OCUPACIONAL – COFFITO.

23. Na ação, o CFM pretendia fosse "julgada procedente a pretensão a fim de que seja declarada a nulidade das Resoluções COFFITO n. 404/2011, 408/2011 e 482/2017, especificamente no que se fere à possibilidade de realização da ultrassonografia pelos fisioterapeutas".

24. A sentença encontra-se anexada á presente petição (doc. 2).

25. Além disso, também bem recentemente, no julgamento do REsp 1.592.450/RS, o STJ reconheceu a competência do fisioterapeuta e do terapeuta ocupacional para diagnosticar doenças, prescrever tratamentos e solicitar exames complementares.

STJ Institucional Processos Jurisprudência Precedentes Comuni

DECISÃO

25/11/2022 07:00

Para Primeira Turma, fisioterapeuta e terapeuta ocupacional podem diagnosticar e indicar tratamentos

Ao julgar os embargos de declaração no **REsp 1.592.450**, a Primeira Turma do Superior Tribunal de Justiça (STJ), por unanimidade, concluiu que é permitido ao fisioterapeuta e ao terapeuta ocupacional diagnosticar doenças, prescrever tratamentos e dar alta terapêutica.

Com essa decisão, o colegiado reformou seu entendimento anterior de que caberia exclusivamente ao médico a tarefa de diagnosticar, prescrever tratamentos e avaliar resultados, enquanto o fisioterapeuta e o terapeuta ocupacional, diferentemente, ficariam responsáveis apenas pela execução das técnicas e dos métodos prescritos.

EMENTA

PROCESSUAL CIVIL. EMBARGOS DE DECLARAÇÃO. REQUISITOS. PRESENÇA. CONSELHO DE FISIOTERAPIA E TERAPIA OCUPACIONAL. EXERCÍCIO DAS PROFISSÕES. RESOLUÇÕES NORMATIVAS. INTERPRETAÇÃO HISTÓRICO-SISTEMÁTICA. LEI N. 12.842/2013. RAZÕES DE VETO DESCONSIDERADAS. ATOS RESERVADOS A MÉDICOS. ATIVIDADES DEBATIDAS NOS AUTOS. INEXISTÊNCIA.

[...]

4. Não houve a devida atualização do Decreto-Lei n. 938/1969, que provê sobre as profissões de fisioterapeuta e terapeuta ocupacional, isto é, enquanto, na prática, as profissões seguramente evoluíram bastante nos últimos cinquenta anos, a legislação continua engessada no texto daquela época.

5. Na decisão recorrida, destacou-se que acórdãos do STF e do STJ, em datas mais distantes, teriam concluído que não cabe ao fisioterapeuta ou terapeuta ocupacional diagnosticar nem indicar tratamentos porque sua função seria a de executar os métodos e técnicas prescritos pelos médicos, **atentando-se, porém, à peculiaridade de que, após os referidos julgamentos, teriam decorridos longos anos, com evolução de todas as carreiras discutidas nos autos e ocorridos fatos supervenientes, buscando-se trazer a discussão para o contexto atual**.

VOTO DO RELATOR (Ministro Gurgel de Faria)

> Portanto, independentemente das convicções pessoais dos julgadores sobre o tema em questão, se a conclusão deve ser de que **não é vedado ao fisioterapeuta e terapeuta ocupacional diagnosticar, prescrever e dar alta terapêutica, não há como reconhecer a ilegalidade das resoluções tidas por irregulares no acórdão recorrido**.

VOTO-VISTA (Ministro Benedito Gonçalves)

> No mesmo sentido, comungo do raciocínio do Ministro Gurgel de Faria, ao reconhecer ter feito inicialmente uma interpretação sistêmica das leis no voto inicialmente apresentado, mas destacando a necessidade de, peculiarmente, no presente caso, fazer uma interpretação sistemática-histórica, pela relevância da análise do referido veto, **possibilitando que fisioterapeutas e terapeutas ocupacionais, sem ingressarem no campo médico, possam realizar diagnósticos e solicitação de exames para o tratamento de doenças no escopo de suas respectivas áreas de atuação**.
>
> (Recurso Especial 1.592.450-RS | Ministro Relator: Gurgel de Faria | Data do Julgamento: 22 de novembro de 2022).

26. Portanto, resta evidente que o fisioterapeuta é profissional tecnicamente habilitado, e legalmente autorizado, para realizar, na sua prática profissional, o exame de ultrassonografia musculoesquelética.

4.4. DA EQUIVOCADA (OU MAL INTENCIONADA) INTERPRETAÇÃO DADA À LEI 12.842/2013 PELO CREMAL

27. Na petição Inicial, nos autos de origem, o CREMAL afirma que a Lei 12.842/2013, que regulamenta a profissão da medicina, teria atendido as expectativas da classe médica, uma vez que teria dirimido toda e qualquer dúvida sobre quais seriam as atividades privativas dos médicos.

> Com a edição da Lei n. 12.842/2013, a chamada Lei do Ato Médico, toda e qualquer dúvida que existia em relação aos atos que podem ser realizados pelos profissionais médicos foi dirimida, já que expressamente estabelecidos em lei, inclusive quais os atos privativos dessa atuação.

28. A realidade é outra.

29. Diferente o espírito de satisfação que o CREMAL tenta transparecer, os vetos implementados pela Presidência da República, e mantidos pelo Congresso Nacional, causaram revolta na classe médica.

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Saúde

Dilma sanciona Ato Médico, mas veta diagnóstico exclusivo

Presidente Dilma Rousseff também derrubou trecho que restringia aos médicos a prescrição de um tratamento. Lei entra em vigor 60 dias após a publicação

Por Da Redação
11 jul 2013, 11h39

ÉPOCA
COLUNAS CANAIS ASSINE

TEMPO

CFM diz que vetos são agressão e traição aos médicos

Presidente do Conselho Federal de Medicina, Roberto D'Avila, diz que categoria vai lutar para derrubá-los no Congresso

AGÊNCIA BRASIL
12/07/2013 - 12h34 - Atualizado 12/07/2013 12h34

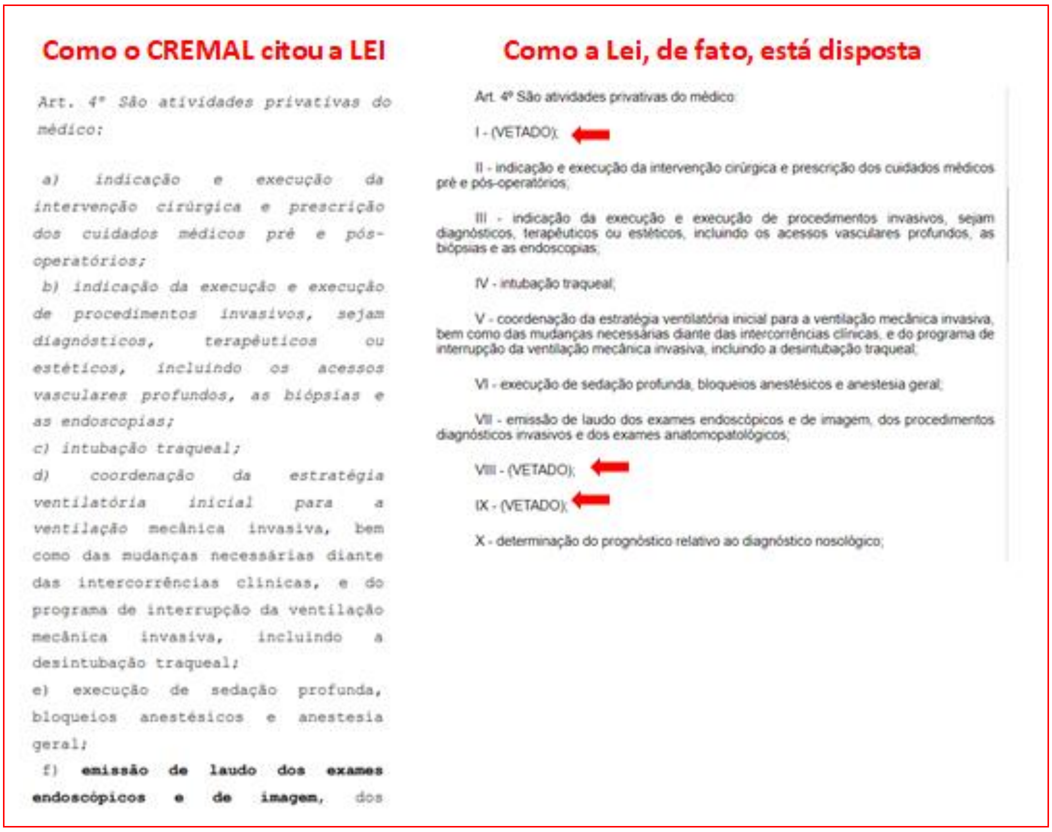
O presidente do CFM, Roberto d'Ávila, afirmou que os vetos de Dilma Rousseff ao Ato Médico são uma agressão à categoria (Foto: Valter Campanato/ABr)

30. Com se vê, a retirada da exclusividade aos médicos para diagnosticar, representou um verdadeiro "balde de água" fria no projeto de monopolização da assistência à saúde encampado pelo Conselho Federal de Medicina.

31. Portanto, infelizmente, o que se conclui é que o CREMAL faltou com a verdade nos autos de origem, induzindo o Juízo agravado ao erro, ao afirmar que "**a realização de diagnóstico é prerrogativa e especialidade dos médicos**" (sic).

32. E para amparar tal afirmativa falsa, o CREMAL promoveu um verdadeiro malabarismo hermenêutico na Lei 12.842/2013.

33. Inicialmente, para aumentar a confusão na cabeça do r. Juízo de origem, transcreveu o artigo 4º da Lei apontando o que seriam as atividades privativas do médico **em alíneas**, e não em incisos, como o texto verdadeiro:



Como o CREMAL citou a LEI

Art. 4º São atividades privativas do médico:

a) indicação e execução da intervenção cirúrgica e prescrição dos cuidados médicos pré e pós-operatórios;

b) indicação da execução e execução de procedimentos invasivos, sejam diagnósticos, terapêuticos ou estéticos, incluindo os acessos vasculares profundos, as biópsias e as endoscopias;

c) intubação traqueal;

d) coordenação da estratégia ventilatória inicial para a ventilação mecânica invasiva, bem como das mudanças necessárias diante das intercorrências clinicas, e do programa de interrupção da ventilação mecânica invasiva, incluindo a desintubação traqueal;

e) execução de sedação profunda, bloqueios anestésicos e anestesia geral;

f) **emissão de laudo dos exames endoscópicos e de imagem,** dos

Como a Lei, de fato, está disposta

Art. 4º São atividades privativas do médico:

I - (VETADO);

II - indicação e execução da intervenção cirúrgica e prescrição dos cuidados médicos pré e pós-operatórios;

III - indicação da execução e execução de procedimentos invasivos, sejam diagnósticos, terapêuticos ou estéticos, incluindo os acessos vasculares profundos, as biópsias e as endoscopias;

IV - intubação traqueal;

V - coordenação da estratégia ventilatória inicial para a ventilação mecânica invasiva, bem como das mudanças necessárias diante das intercorrências clínicas, e do programa de interrupção da ventilação mecânica invasiva, incluindo a desintubação traqueal;

VI - execução de sedação profunda, bloqueios anestésicos e anestesia geral;

VII - emissão de laudo dos exames endoscópicos e de imagem, dos procedimentos diagnósticos invasivos e dos exames anatomopatológicos;

VIII - (VETADO);

IX - (VETADO);

X - determinação do prognóstico relativo ao diagnóstico nosológico;

34. Para não chamar a atenção do juiz de origem para os vetos implementados no art. 4º, o CREMAL – infelizmente – faltou com a verdade, ao ponto de alterar a disposição verdadeira da Lei, o que é MUITO GRAVE.

35. Em seguida, fazendo menção ao que seria alínea "g" do artigo 4º, o CREMAL conclui que "**quem pode realizar o diagnóstico nosológico: o médico**" (sic):

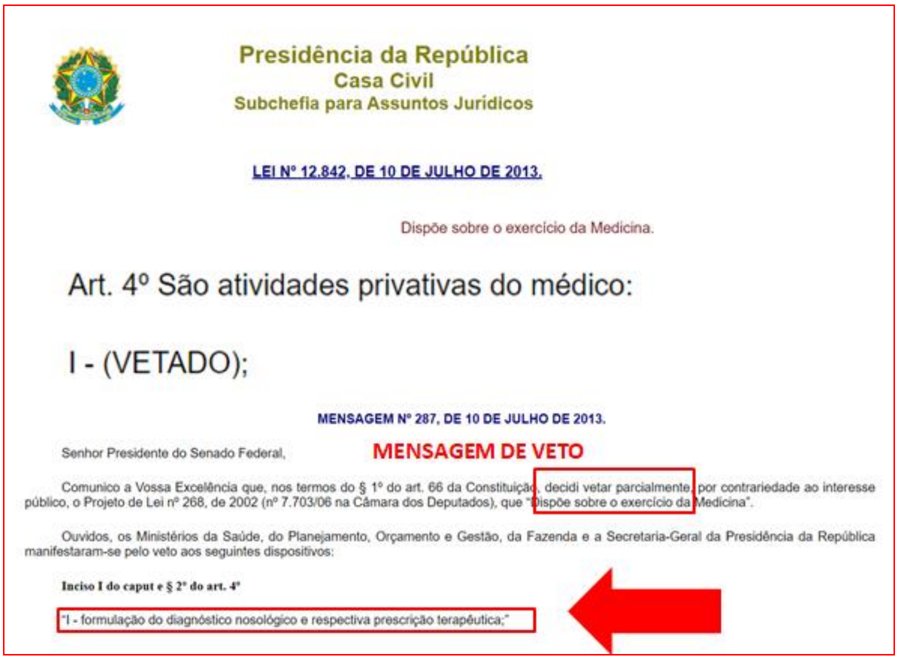
> **O PROGNÓSTICO PODE SER ENTENDIDO COMO O "PARECER (CONCLUSÃO)** do médico a respeito e evolução provável de uma doença". Esse raciocínio é lógico, pois, o profissional que é competente para realizar o diagnóstico nosológico (verificação), será aquele capacitado para **definir o prognóstico (conclusão), este último, repita-se, ato privativo do médico** (art. 4°, alínea "g").
>
> Dessa forma, essencial destacar que um grande salto de qualidade legislativa feito na edição dessa nova lei foi a conceituação e a previsão de **quem pode realizar o diagnóstico nosológico: o médico.**

36. Ora, nesse ponto, observam-se três inverdades:

i. Não existe alínea "g" no artigo 4º da Lei 12.842/2013;

ii. A Lei não define prognóstico como atividade privativa do médico;

iii. O dispositivo da lei por meio do qual se pretendia tornar diagnóstico nosológico atividade privativa do médico foi vetado pela Presidência da República (inciso I do art. 4º)



Presidência da República
Casa Civil
Subchefia para Assuntos Jurídicos

LEI Nº 12.842, DE 10 DE JULHO DE 2013.

Dispõe sobre o exercício da Medicina.

Art. 4º São atividades privativas do médico:

I - (VETADO);

MENSAGEM Nº 287, DE 10 DE JULHO DE 2013.

Senhor Presidente do Senado Federal,

MENSAGEM DE VETO

Comunico a Vossa Excelência que, nos termos do § 1º do art. 66 da Constituição, decidi vetar parcialmente, por contrariedade ao interesse público, o Projeto de Lei nº 268, de 2002 (nº 7.703/06 na Câmara dos Deputados), que "Dispõe sobre o exercício da Medicina".

Ouvidos, os Ministérios da Saúde, do Planejamento, Orçamento e Gestão, da Fazenda e a Secretaria-Geral da Presidência da República manifestaram-se pelo veto aos seguintes dispositivos:

Inciso I do caput e § 2º do art. 4º

"I - formulação do diagnóstico nosológico e respectiva prescrição terapêutica;"

Fonte: https://www.planalto.gov.br/ccivil_03/_ato2011-2014/2013/lei/l12842.htm

37. O que o inciso X, e não a inexistente alínea "g" do artigo 4º, diz é que a "determinação do prognóstico relativo ao diagnóstico nosológico" é atividade privativa do médico.

38. Ora, se diagnóstico nosológico NÃO É atividade privativa do médico, em razão do veto implementado no inciso I do artigo 4º, o respectivo prognóstico também não o é.

39. O prognóstico, que se traduz como o eventual curso e evolução de uma condição, guarda relação direta com determinado diagnóstico.

40. Se o diagnóstico nosológico for estabelecido por profissional **fisioterapeuta**, o que se tem é um **diagnóstico fisioterapêutico**, e o respectivo **prognóstico fisioterapêutico** também será formulado dentro das competências legais e técnicas guardadas para o **fisioterapeuta**.

41. Se o diagnóstico nosológico, por sua vez, for estabelecido por profissional **médico**, o que se tem é um **diagnóstico médico**, e o respectivo **prognóstico médico** será formulado dentro das competências legais e técnicas guardas para o **médico**.

42. E assim se dá, sucessivamente, para todas as profissões de saúde.

43. Essa é a principal consequência jurídica do veto implementado pela Presidência da República no inciso I do artigo 4º da Lei 12.842/2013, que pretendia tornar **formulação de diagnóstico** atividade privativa do médico.

5. DOS PEDIDOS

72. Por tudo exposto, requer:

a. Seja o CREFITO-1 admitido nos presentes autos na condição de AMICUS CURIAE, aplicando, nesse sentido, as disposições trazidas pelo artigo 138 do CPC;

b. Sejam consideradas as contribuições trazidas pelo CREFITO-1 para revogar a liminar concedida por meio da decisão agravada e negar provimento ao presente agravo de instrumento.

Nestes Termos,

Pede e Espera Deferimento,

Recife/PE, 18 de Dezembro de 2023.

Carlos Francisco da Silva

Advogado – OAB/PE: 46.301

INSTRUMENTO PARTICULAR DE MANDATO

O CONSELHO REGIONAL DE FISIOTERAPIA E TERAPIA OCUPACIONAL DA 1ª REGIÃO (CREFITO-1), autarquia federal instituída pela lei nº 6.316/1975 , neste ato representado por seu Presidente, **Dr. FLÁVIO MACIEL DIAS DE ANDRADE,** brasileiro, casado, fisioterapeuta, com inscrição no CREFITO nº 46.142-F, inscrito no CPF nº 021.126.294-33 , RG nº 4.460.224 SSP/PE, residente e domiciliado à Rua Francisco da Cunha, 1910/1701, Bloco B, Boa Viagem, Recife/PE, CEP: 51.020-041, filho de FRANCISCO DIAS DE ANDRADE E GERDA MARIA MACIEL DE ANDRADE, e-mail: ftflaviomaciel@yahoo.com.br; constitui e nomeia seus procuradores: **CARLOS FRANCISCO DA SILVA,** brasileiro, casado, advogado, inscrito na OAB/PE sob o nº 46.301 , CPF nº: 021 .569.804-54; **CARLOS ALBERTO LOPES DOS SANTOS,** brasileiro, casado, advogado, inscrito na OAB/PE sob o nº 12.399, CPF nº 097.642.164-04, **CLAUDIO PINHEIRO DE LIMA**, brasileiro, casado, advogado, inscrito na OAB/PE 58.813, CPF nº 834.673.434-49; **DAVID FÉLIX RIBEIRO DA SILVA**, brasileiro, solteiro, advogado, inscrito na OAB/PE, sob o nº 49.941, CPF nº: 107.355.064-85; **JOSÉ LEANDRO DA SILVA PINTO**, brasileiro, solteiro, advogado, inscrito na OAB/PE sob o nº 49.266, CPF nº 095.798.034-55; aos quais confere e outorga os poderes da cláusula *ad judicia e et extra,* para representarem esta Autarquia Federal perante todas as esferas administrativas e judiciais, a exemplo do ministério público, cartórios extrajudiciais e órgãos judiciais, em qualquer juízo, instância ou tribunal, com amplos poderes para o foro em geral e especiais, devendo promover todas as medidas jurídicas cabíveis e necessárias à defesa de seus interesses, podendo, inclusive, recorrer, transigir, firmar compromisso ou acordos, reconhecer a procedência do pedido, renunciar ao direito sobre o que se funda a ação, receber, dar quitação, requerer parcelamentos de dívidas, receber intimações, documentações e notificações, representá-lo perante tabeliães, escrivães e oficiais de cartório, extrair cópias, acessar dados sob sigilo fiscal e processos administrativos, agindo em conjunto ou separadamente, podendo ainda substabelecer esta a outrem com ou sem reservas de iguais poderes, e tudo o mais proceder para o fiel desempenho deste mandato.

Recife/PE, 20 de Junho de 2023.

Dr. FLÁVIO MACIEL DIAS DE ANDRADE
Presidente do CREFITO-1

SENTENÇA TIPO "A"
PROCESSO: 1043821-22.2021.4.01.3400
CLASSE: AÇÃO CIVIL PÚBLICA (65)
POLO ATIVO: CONSELHO FEDERAL DE MEDICINA
POLO PASSIVO:CONSELHO FEDERAL DE FISIOTERAPIA E TERAPIA OCUPACIONAL
REPRESENTANTES POLO PASSIVO: ALEXANDRE AMARAL DE LIMA LEAL - DF21362

SENTENÇA

Cuida-se de ação civil pública ajuizada por **CONSELHO FEDERAL DE MEDICINA - CFM** em face do **CONSELHO FEDERAL DE FISIOTERAPIA E TERAPIA OCUPACIONAL - COFFITO**, objetivando "seja julgada procedente a pretensão a fim de que seja declarada a nulidade das Resoluções COFFITO n. 404/2011, 408/2011 e 482/2017, especificamente no que se fere à possibilidade de realização da ultrassonografia pelos fisioterapeutas, já que não há lei federal que permita e dê respaldo às atividades dispostas em tal ato normativo, de caráter infralegal, sendo declarada a nulidade das resoluções com proibição de edição de qualquer outra semelhante com o mesmo objeto".

Conta que o COFFITO editou "as Resoluções n. 404/2011, 408/2011 e 482/2017, que visam autorizar tanto a realização quanto a elaboração de diagnóstico e laudos decorrentes de ultrassonografia cinesiológica por fisioterapeutas"; que "a realização de consultas, prescrição de medicamentos, requisição de exames e emissão de laudo são atribuições exclusivas do profissional médico, de acordo com a Lei n. 12.842, de 10 de julho de 2013, a Lei do Ato Médico".

Alega que "o COFFITO exorbitou por completo as atribuições e competências que lhe são impostas pela lei"; que a emissão de laudo dos exames endoscópicos e de imagem, a determinação do prognóstico relativo ao diagnóstico nosológico e a realização de perícia médica, segundo art. 4º da Lei nº 12.842/2013, são atividades privativas de médicos; que é "inócua a pretensa intenção esposada na Resolução em questão, pois: o fisioterapeuta não está capacitado a fornecer diagnóstico, muito menos para emitir laudo; e, na eventual hipótese de constatar situação grave, deverá remeter o caso ao médico responsável", o que acarretaria em perda de tempo, recursos financeiros, e risco de diagnóstico errado, prejudicando o paciente; que "inexiste LEI na carreira do fisioterapeuta que lhe confira a prerrogativa de realização de diagnóstico, muito menos a realização de exame de imagem, inexistindo qualquer respaldo à atuação de tal profissional na realização de ultrassom"; que, "atualmente, a "Ultrassonografia" está inserida dentro da listagem de especialidades médicas aprovadas pela Comissão Mista de Especialidades, integrando o ramo da "Radiologia e diagnóstico por imagem" (Resolução CFM n. 2221/2018 que homologou a Portaria CME n. 01/2018). Nesse ponto, cumpre informar que, para o médico obter registro e poder se anunciar como especialista em radiologia e diagnóstico por imagem, é necessária a realização de residência médica, em período não inferior a 03 (três anos) ou por meio de concurso realizado pela Associação Medica Brasileira/Colégio Brasileiro de Radiologia e Diagnóstico por Imagem".

O COFFITO se manifestou acerca do pedido liminar por meio do documento id. 613586355.

Foi indeferida a liminar (id. 655103481).

O COFFITO apresentou contestação, alegando, preliminarmente, inépcia da inicial, pois não possui causa de pedir próxima ou remota em relação aos trechos dos atos normativos impugnados.

No mérito, pugna pela improcedência total dos pedidos.

Réplica ao id. 819121588.

Decisão id. 1247459288 indeferiu o pedido de ingresso, na condição de *amicus curiae*, da Associação Médica Brasileira – AMB e outros.

Ao id. 1281441781, o Ministério Público Federal apresentou parecer, no qual opina pela extinção do processo, sem julgamento do mérito, em relação ao pedido formulado em face da Resolução COFFITO nº 408/2011, conforme dispõe o art. 485, VI, do CPC; e pela improcedência dos pedidos formulados em relação às Resoluções COFFITO nº 404/2011 e 482/2011.

É o relatório. **DECIDO**.

Trata-se, na hipótese, de ação civil pública em que se busca a anulação de ato administrativo praticado pelo Conselho Federal de Fisioterapia e Terapia Ocupacional – COFFITO, ao editar as Resoluções 404/2011, 408/2011 e 482/2017, que visam autorizar tanto a realização quanto a elaboração de diagnóstico e laudos decorrentes de ultrassonografia cinesiológica por fisioterapeutas.

Conforme consignado na decisão id. 655103481, a autora se insurge contra a "elaboração de diagnóstico e laudos decorrentes de ultrassonografia cinesiológica por fisioterapeutas", sob o argumento de que se trataria de atribuição exclusiva do profissional médico, de acordo com a Lei nº 12.842, de 10 de julho de 2013.

Entretanto, observo que, ao listar as atividades privativas do médico, o §7º do art. 4º da Lei nº 12.842/2013 ressalva que:

§ 7º O disposto neste artigo será aplicado de forma que sejam resguardadas as competências próprias das profissões de assistente social, biólogo, biomédico, enfermeiro, farmacêutico, fisioterapeuta, fonoaudiólogo, nutricionista, profissional de educação física, psicólogo, terapeuta ocupacional e técnico e tecnólogo de radiologia.

Destarte, entendo que o mencionado artigo não pode servir de fundamento para inibir os profissionais fisioterapeutas de exercer de forma ampla sua competência, utilizando para tanto as ferramentas que tenham disponíveis.

Além disso, convém destacar recente posicionamento adotado pelo STJ, segundo o qual cabe ao Judiciário respeitar o processo legislativo que **não** estabeleceu como privativo do médico a função de diagnosticar doenças e prescrever tratamentos.

Por ocasião do julgamento, fez-se uma análise da mensagem de veto dos dispositivos da Lei n. 12.842/2013 (Mensagem n. 287/2013), verificando-se que foi vetado o inciso I do caput e § 2º do art. 4º:

I - formulação do diagnóstico nosológico e respectiva prescrição terapêutica;

§ 2º Não são privativos do médico os diagnósticos funcional, cinésio-funcional, psicológico, nutricional e ambiental, e as avaliações comportamental e das capacidades mental, sensorial e perceptocognitiva.

As razões dos vetos foram as seguintes:

O texto inviabiliza a manutenção de ações preconizadas em protocolos e diretrizes clínicas estabelecidas no Sistema Único de Saúde e em rotinas e protocolos consagrados nos estabelecimentos privados de saúde. **Da forma como foi redigido, o inciso I impediria a continuidade de inúmeros programas do Sistema Único de Saúde que funcionam a partir da atuação integrada dos profissionais de saúde, contando, inclusive, com a realização do diagnóstico nosológico por profissionais de outras áreas que não a médica. É o caso dos programas de prevenção e controle à malária, tuberculose, hanseníase e doenças sexualmente transmissíveis, dentre outros.** Assim, a sanção do texto poderia comprometer as políticas públicas da área de saúde, além de introduzir elevado risco de judicialização da matéria. O veto do inciso I implica também o veto do § 2º , sob pena de inverter completamente o seu sentido. Por tais motivos, o Poder Executivo apresentará nova proposta que mantenha a conceituação técnica adotada, porém compatibilizando-a com as práticas do Sistema Único de Saúde e dos estabelecimentos privados.

Diante disso, promovendo interpretação sistemática e histórica de toda a legislação supracitada, inclusive das razões de veto, concluiu-se que o Judiciário deve prestar deferência às discussões que já foram desenvolvidas na via própria, durante o processo legislativo, e que melhor refletem valores democráticos. Assim, firmou-se a compreensão de que, independentemente das convicções pessoais dos julgadores sobre o tema em questão, se a conclusão deve ser de que não é vedado ao fisioterapeuta e terapeuta ocupacional diagnosticar, prescrever e dar alta terapêutica, não há como reconhecer a ilegalidade das resoluções discutidas.

Transcrevo a ementa do citado julgado do STJ:

PROCESSUAL CIVIL. EMBARGOS DE DECLARAÇÃO. REQUISITOS. PRESENÇA. CONSELHO DE FISIOTERAPIA E TERAPIA OCUPACIONAL. EXERCÍCIO DAS PROFISSÕES. RESOLUÇÕES NORMATIVAS. INTERPRETAÇÃO HISTÓRICO-SISTEMÁTICA. LEI N. 12.842/2013. RAZÕES DE VETO DESCONSIDERADAS. ATOS RESERVADOS A MÉDICOS. ATIVIDADES DEBATIDAS NOS AUTOS. INEXISTÊNCIA.

1. Os embargos de declaração têm por escopo sanar decisão judicial em que haja obscuridade, contradição, omissão ou erro material.

2. Antes de enfrentar a discussão devolvida nos aclaratórios, é necessário promover breve digressão a respeito do processo, a qual evidenciará a complexidade relativa a seu julgamento.

3. Trata-se de ação ajuizada em 2004 (portanto, há quase vinte anos), e para discutir possível incompatibilidade entre legislação da década de 1960 com resoluções, em sua maioria, das décadas de 1980 e 1990, sendo certo que o julgamento do apelo especial exigiu o olhar para tal passado sem se descuidar dos fatos relevantes e supervenientes que aconteceram desde aquelas longínquas datas.

4. Não houve a devida atualização do Decreto-Lei n. 938/1969, que provê sobre as profissões de fisioterapeuta e terapeuta ocupacional, isto é, enquanto, na prática, as profissões seguramente evoluíram bastante nos últimos cinquenta anos, a legislação continua engessada no texto daquela época.

5. Na decisão recorrida, destacou-se que acórdãos do STF e do STJ, em datas mais distantes, teriam concluído que não cabe ao fisioterapeuta ou terapeuta ocupacional diagnosticar nem indicar tratamentos porque sua função seria a de executar os métodos e técnicas prescritos pelos médicos, atentando-se, porém, à peculiaridade de que, após os referidos julgamentos, teriam decorridos longos anos, com evolução de todas as carreiras discutidas nos autos e ocorridos fatos supervenientes, buscando-se trazer a discussão para o contexto atual.

6. Nesse cenário, entendeu-se que a ratio dos precedentes anteriores permanecia incólume, em razão da interpretação sistemática aplicada aos arts. 1º, 3º e 4º do Decreto-Lei n. 938/1969 e aos supervenientes arts. 1º, 2º, parágrafo único, II, 4º, X, XI e XIII e §§1º e 7º, da Lei n. 12.842/2013, que dispõe sobre o exercício da medicina.

7. Caso em que, ao promover interpretação sistemática de dispositivos legais aprovados, o acórdão recorrido incorreu em omissão quanto às normas vetadas e às razões do veto, as quais, embora não tenham sido

apresentadas pelas partes anteriormente, eram fundamentais à construção da exegese sistemático-histórica que foi ali desenvolvida.

8. Ao consultar a mensagem de veto dos dispositivos da Lei n. 12.842/2013 (Mensagem n. 287/2013), verifica-se que o art. 4º, I, o qual dispunha que era ato privativo de médico a "formulação do diagnóstico e respectiva prescrição terapêutica" foi vetado, sob a justificativa de que, "... da forma como foi redigido, o inciso I impediria a continuidade de inúmeros programas do Sistema Único de Saúde que funcionam a partir da atuação integrada dos profissionais de saúde, contando, inclusive, com a realização do diagnóstico nosológico por profissionais de outras áreas que não a médica [...]".

9. Prevaleceu durante o processo legislativo a ideia de que não seria privativo do médico a função de diagnosticar doenças e prescrever tratamentos, conclusão que não foi espelhada na decisão embargada.

10. No particular, mantendo-se fidelidade ao raciocínio desenvolvido no acórdão recorrido, mas promovendo interpretação sistemática e histórica de toda a legislação, inclusive das razões do veto, conclui-se que o Judiciário deve prestar deferência às discussões que já foram entabuladas na via própria, durante o processo legislativo, e que melhor refletem valores democráticos.

11. Acolhimento dos embargos de declaração do CREFITO-5/RS e do COFFITO, para sanar omissão e integrar o acórdão recorrido, emprestando efeitos infringentes aos aclaratórios, de modo a negar provimento ao recurso especial. Embargos de declaração do CREMERS e do SIMERS rejeitados.

(EDcl no REsp n. 1.592.450/RS, relator Ministro Gurgel de Faria, Primeira Turma, julgado em 22/11/2022, DJe de 31/1/2023.)

Pelo exposto, **JULGO IMPROCEDENTES OS PEDIDOS**, nos termos do art. 487, I, do CPC.

Sem custas ou honorários advocatícios, nos termos do art. 18 da Lei nº 7.347/1985.

Havendo recurso de apelação, à parte recorrida para contrarrazões. Apresentadas preliminares nas contrarrazões, vista ao apelante. Tudo cumprido, remetam-se ao TRF1.

Publique-se. Intime-se.

BRASÍLIA, 24 de outubro de 2023.

(assinado eletronicamente)

LIVIANE KELLY SOARES VASCONCELOS

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NOTA TÉCNICA/2021/PROJUR/GT/SJDF/1043821-22

1. OBJETIVO

1.1. Análise técnica acerca da competência e atuação do profissional Fisioterapeuta na realização de ultrassonografia cinesiológica.

2. INTERESSADO

2.1. Nota Técnica solicitada pela Procuradoria Jurídica do Conselho Federal de Fisioterapia e Terapia Ocupacional – COFFITO para Instrução do processo nº 1043821-22.2021.4.01.3400, da 20ª Vara Federal Cível da Seção Judiciária do Distrito Federal, movido pelo Conselho Federal de Medicina – CFM, em que se discutem as Resoluções COFFITO nº 404/2011, 408/2011 e 482/2017.

3. FUNDAMENTAÇÃO PRÉVIA

3.1. Os Exames Funcionais constam na lista de Procedimentos Fisioterapêuticos contidos no Referencial Nacional de Procedimentos Fisioterapêuticos (RNPF), onde a Ultrassonografia Cinesiológica é referendada. A prescrição de procedimentos referendados nos capítulos dos Atendimentos Fisioterapêuticos descritos no RNPF depende do Diagnóstico Fisioterapêutico, hipotetizado a partir de análise semiológica desenvolvida durante a consulta fisioterapêutica – procedimento também parte do RNPF, reconhecido e contemplado pela Agência Nacional de Saúde Suplementar (ANS). Todos os exames funcionais descritos no RNPF são instrumentos de avaliação complementares para análise semiológica sob ótica do fisioterapeuta, ou seja, com o propósito de quantificar e qualificar as deficiências cinético-funcionais, caracterizadoras dos Diagnósticos Fisioterapêuticos. Tais Diagnósticos pressupõem a necessidade de hipotetizar os respectivos Prognósticos Fisioterapêuticos.

3.2. Nesse contexto vale fundamentar e enfatizar que as palavras “Diagnóstico” e “Prognóstico” não são termos privativos de uma única profissão.

3.3. Origem da palavra Diagnóstico:

3.3.1. Do grego *διαγνωστικός*, pelo latim *diagnosticu* (*dia*="através de, durante, por meio de" + *gnosticu*="alusivo ao conhecimento de").

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3.3.2. base Indoeuropéia gn-, que gerou, em Grego, gnosis, “conhecimento” e seus derivados. Gnóme significava “razão, entendimento”

3.3.3. Temos mais derivados importantes dessa raiz. Um deles é diagnóstico, de dia, “através” e gignósko, “conhecer, saber”. O nome de uma doença é descoberto “através do conhecimento”, após avaliar os sinais e sintomas.

3.3.4. A etimologia da palavra diagnóstico vem do grego “diagnóstikós”, que significa capaz de distinguir, de discernir.

3.3.5. Diagnosticar é o ato de analisar e fazer o recolhimento de dados necessários para avaliação dos diversos problemas.

3.4. Para estabelecer qual é o problema (diagnóstico) – se doença, se deficiência cinético-funcional ou outro inerente a outra profissão de saúde – é necessário a análise semiológica desenvolvida durante a consulta, cujos olhares clínicos e propósitos são distintos conforme as especificidades da profissão.

3.5. Significado básico da palavra semiologia:

3.5.1. É a ciência geral dos signos.

3.5.2. União das palavras gregas semeion, que significa sinal, e logos, estudo.

3.5.3. É uma área do conhecimento que se dedica a compreender os sistemas de significação desenvolvidos pela sociedade. Tem por objeto os conjuntos de signos, sejam eles linguísticos, visuais, ou ainda ritos e costumes.

3.5.4. Um signo é a combinação do significado e o significante, ou seja, do conceito com o objeto em si. Como por exemplo uma placa de trânsito. Ela isolada é só um conjunto visual, de cores e desenhos. É a partir do significado que lhe dão que ela se constitui um signo, e ganha novo sentido.

3.5.5. Semiologia sob o olhar do médico: ato de analisar sinais e sintomas – e exames complementares – inerentes à uma doença.

3.5.6. Semiologia sob o olhar do fisioterapeuta: ato de analisar sinais e sintomas – e exames complementares – inerentes à uma deficiência cinético-funcional.

3.5.6.1. Especificidades da semiologia sob o olhar do fisioterapeuta:

3.5.6.1.1. Feita durante a Consulta Fisioterapêutica, visa identificar alterações estruturais e/ou funcionais, sob a ótica da deficiência cinético-funcional, a fim

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de quantificar e interpretar prejuízos à cinética humana, implícita no Diagnóstico Fisioterapêutico.

3.5.6.1.2. O exame clínico-funcional visa quantificar a deficiência cinético-funcional – ou o risco da mesma – obtido na Consulta Fisioterapêutica, onde o foco é a saúde funcional.

3.5.6.1.3. Anamnese: Relato da disfunção cinética / História da Funcionalidade Atual (HFA) / História da Funcionalidade Pregressa (HFP).

3.5.6.1.4. Exame Físico: Interpretar a Deficiência Cinético-Funcional / Limitação de atividades e/ou limitação da participação social ou os riscos destas.

3.5.6.1.5. Exames Funcionais: Exames complementares executados e/ou analisados pelo fisioterapeuta, que visam quantificar a deficiência cinético-funcional e subsidiar a construção do Diagnóstico Fisioterapêutico.

3.5.6.1.6. Registros Assistenciais: feita durante o período de condução da assistência fisioterapêutica, onde o diagnóstico e o prognóstico podem sofrer variações e consequente mudança na prescrição fisioterapêutica.

3.5.7. Definição de Diagnóstico Fisioterapêutico:

3.5.8. processo de registro das impressões relacionadas às deficiências funcionais do movimento e de seus fatores causais, relacionados aos sistemas mental, cardiovascular, respiratório e neuromioarticular. Neste sentido, é necessário que o fisioterapeuta realize avaliação qualitativa e quantitativa das funções e estruturas corporais relacionadas ao movimento, das limitações de atividades e das restrições à participação social, bem como dos fatores pessoais e ambientais.

3.6. Origem da palavra Prognóstico:

3.6.1. Prognóstico é uma previsão baseada em fatos ou dados reais e atuais, que pode indicar o provável estágio futuro de um processo.

3.6.2. Em suma, o prognóstico é todo o resultado que é tido como uma hipótese ou probabilidade, ou seja, algo que pode acontecer devido as circunstâncias observadas no presente.

3.6.3. Diferença entre diagnóstico e prognóstico: o primeiro está relacionado unicamente com o conhecimento e condição do presente, ou seja, ao que é observado no momento. Por outro lado, o prognóstico é o conhecimento prévio sobre algo que provavelmente pode acontecer no futuro, resultado este obtido a partir de interpretações feitas com base no diagnóstico.

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3.6.4. Isso significa que, no âmbito da fisioterapia, o prognóstico fisioterapêutico está intrinsecamente ligado ao diagnóstico fisioterapêutico, sendo o primeiro dependente do segundo para existir.

3.7. Definição de Prognóstico Fisioterapêutico:

3.7.1. Parte do processo fisioterapêutico – consulta (semiologia) / diagnóstico / prognóstico – proveniente do diagnóstico fisioterapêutico, estabelecido a partir da análise de dados semiológicos observados no presente, com o intuito de hipotetizar um estágio futuro de uma deficiência cinético-funcional.

4. PARECER TÉCNICO-CIENTÍFICO

4.1. A partir de uma perspectiva histórica, a ultrassonografia tem sido utilizada tradicionalmente para fins médicos desde a década de 1950 com o objetivo de avaliar as características morfológicas e a integridade estrutural de vários órgãos e tecidos. Contudo, com os avanços no conhecimento a respeito dessa tecnologia surgiu uma diversidade de aplicações às quais se estenderam para além do uso tradicional. Dentre estas, vem se destacado a utilização da ultrassonografia para fins reabilitativos.

4.2. O uso da ultrassonografia para auxiliar na reabilitação musculoesquelética vem se desenvolvendo rapidamente nos últimos 30 anos. A primeira publicação sobre o tema é datada de 1968 quando pesquisadores correlacionaram volume muscular com a capacidade de geração de força. No entanto, foi o trabalho de pesquisadores da Universidade de Oxford na década de 1980 que chamaram a atenção para o uso da ultrassonografia por fisioterapeutas. Vários estudos demonstraram as vantagens dessa ferramenta para melhorar as rotinas de tratamento e de diagnóstico fisioterapêutico. Assim, na década de 1990 ocorreu um grande interesse na aplicação da ultrassonografia para fins fisioterapêuticos. Isso ocorreu a partir da publicação de uma série de estudos comprovando a segurança, a viabilidade e a precisão desta ferramenta. Em maio de 2006, aconteceu nos EUA o primeiro simpósio internacional sobre a utilização da ultrassonografia para fins fisioterapêuticos promovido pela faculdade de fisioterapia da Army-Baylor University. O objetivo desse simpósio foi desenvolver diretrizes de boas práticas para o uso desta ferramenta e desenvolver uma agenda de pesquisa internacional e colaborativa relacionada ao uso da ultrassonografia por fisioterapeutas. Foi neste evento que a ultrassonografia para auxiliar na reabilitação foi denominada de ultrassonografia reabilitativa, também conhecida no Brasil como ultrassonografia cinesiológica.

4.3. Neste simpósio foi estabelecido que a ultrassonografia cinesiológica é um procedimento utilizado por fisioterapeutas para avaliar a morfologia e a função dos músculos e tecidos moles durante a realização de exercícios físicos e de atividades da vida diária. Portanto, Está ferramenta vem sendo utilizada para auxiliar na aplicação de intervenções terapêuticas destinadas a melhorar a função neuromuscular. Isso inclui fornecer diagnóstico funcional e feedback ao paciente e ao fisioterapeuta para melhorar os resultados clínicos.

4.4. Em resumo, a partir da ultrassonografia cinesiológica é possível estabelecer com maior precisão a presença de alterações morfofuncionais, bem como o nível de recuperação a partir das condutas fisioterapêuticas estabelecidas. Desta forma, faz-se necessária a utilização desta ferramenta por parte dos fisioterapeutas.

4.5. A ultrassonografia cinesiológica é indicada tanto para diagnóstico funcional, quanto para auxiliar no tratamento, bem como para avaliar a resposta ao tratamento. Esta ferramenta pode ser utilizada em qualquer fase das alterações funcionais e nos mais diversos campos (do desporto à unidade de terapia intensiva). Para uso diagnóstico, a ultrassonografia cinesiológica pode ser utilizada para detectar alterações morfofuncionais como: comprimento, espessura, diâmetro, área de secção transversa, volume, comprimento do fascículo e ângulo de penação, alterações funcionais neurofisiológicas; presença de edema/inflamação neuromusculares e em tecidos moles; para avaliar a diminuição da capacidade contrátil e de estiramento. Estes são apenas alguns exemplos da utilização da ultrassonografia cinesiológica para uso no diagnóstico funcional. No que se refere ao tratamento, a ultrassonografia cinesiológica pode auxiliar como feedback para pacientes e fisioterapeutas no processo de reaprendizado motor. Com relação à utilização desta ferramenta para a análise da eficácia do tratamento, o fisioterapeuta pode em tempo real e com precisão verificar objetivamente a melhora das alterações morfofuncionais. Isso pode auxiliar o profissional na determinação do plano terapêutico e nos seus possíveis ajustes, bem como no estabelecimento de prognóstico funcional.

4.6. A ultrassonografia cinesiológica é um método não invasivo, sem emissão de radiação e capaz de gerar diagnósticos funcionais. Assim, considerando a lei federal 12.842, de 10 de julho de 2013, a Resolução do Conselho Federal de Fisioterapia e Terapia Ocupacional (COFFITO) 381/2010 e a Resolução COFFITO 400/2011 (artigo 3º), o fisioterapeuta especialista está

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habilitado para utilização da ultrassonografia não só no campo da pesquisa, mas também na prática clínica.

4.7. A ultrassonografia cinesiológica pode ser utilizada para diagnosticar as alterações morfofuncionais, auxiliar no tratamento como feedback e para o acompanhamento das respostas ao tratamento de qualquer alteração funcional de órgãos e sistemas. Assim, a depender do objetivo esta ferramenta pode ser utilizada diariamente ou quando o profissional julgar necessário, no contexto de avaliação e reavaliações.

4.8. A fim de compreender e utilizar devidamente a ultrassonografia cinesiológica, é necessário o conhecimento básico sobre os princípios físicos envolvidos nesse método diagnóstico. Essa técnica de imagem é baseada na emissão e recepção de ondas ultrassônicas, e as imagens são obtidas por processamento eletrônico de feixes de ultrassom refletidos de maneira singular pelas diversas estruturas do corpo humano. O conhecimento e o ajuste de alguns parâmetros durante a ultrassonografia cinesiológica são fundamentais para a melhor aquisição das imagens.

4.9. Para utilizar a ultrassonografia cinesiológica de forma precisa o fisioterapeuta precisa dominar as seguintes áreas e disciplinas: (i) anatomia geral do sistema musculo esquelético e do sistema nervoso; (ii) biomecânica; (iii) biofísica; (iv) radiologia aplicada a ultrassonografia; e (v) princípios da ultrassonografia cinesiológica. Assim, a formação de um especialista em ultrassonografia cinesiológica pode consumir até 200 horas entre aulas teóricas e estágios.

5. POPULAÇÃO ALVO

5.1. A população-alvo que se beneficiará da Ultrassonografia Cinesiológica são indivíduos com agravos funcionais sistêmicos à saúde tanto agudos quanto crônicos, crianças, adolescentes, adultos e idosos, de ambos os sexos. No Brasil, estima-se que 65% da população adulta, pelo menos uma vez ao ano, apresente dor lombar. São quase 50.000 leitos nas unidades de terapia intensiva com pacientes restritos ao leito com alto risco de desenvolver a polineumiopatias da doença crítica. A partir de apenas dois exemplos citados é possível estimar um público alvo em torno de dezenas de milhões de pacientes.

5.2. Descrição do problema de saúde ao qual se aplica a tecnologia proposta, incluindo a descrição da doença ou da condição de saúde, diagnóstico e prognóstico funcional, tratamentos conhecidos, bem como dados epidemiológicos do problema de saúde

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5.3. Indivíduos com alterações funcionais em todas as especialidades da fisioterapia, que sejam indicados para realizar avaliação e tratamento fisioterapêutico, considerando que esse exame avalia e ajuda no tratamento das alterações morfofuncionais.

5.4. Descrição das evidências científicas relativas à eficácia, efetividade, acurácia e segurança da tecnologia em saúde proposta, comparadas às tecnologias alternativas em saúde, por meio de apresentação de revisão sistemática ou parecer técnico-científico – PTC, desenvolvido de acordo com a edição atualizada das diretrizes metodológicas de elaboração de PTC e de revisão sistemática e meta-análise de estudos, publicadas por fisioterapeutas no Brasil;

5.5. A ultrassonografia cinesiológica vem sendo cada vez mais utilizada na prática clínica. Por se tratar de um procedimento de avaliação, para auxílio no tratamento e para o acompanhamento dos indivíduos, há guidelines que o referenciam e recomendam em diversas condições de saúde.

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7. GRUPO DE TRABALHO

7.1. Dr. Paulo Eugênio

7.2. Dr. Marcelo Terra

7.3. Dr. Marcelo Farani

7.4. Dr. Wagner Haun

7.5. Dr. Wilen Silva

7.6. Dr. Francimar Ferrari

7.7. Dr. João Magalhães

7.8. Dr. Luiz Fernando Moderno

7.9. Dr. Fernando Muniz

8. DESPACHO

8.1. De acordo. Encaminhe-se à representação judicial do COFFITO.

ROBERTO MATTAR CEPEDA

Presidente do COFFITO

Int. Z. angew. Physiol. einschl. Arbeitsphysiol. 26, 26—32 (1968)

Calculation of Muscle Strength per Unit Cross-Sectional Area of Human Muscle by Means of Ultrasonic Measurement

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Received February 2, 1968

Summary. By means of the ultrasonic photography of the cross-section of the acting muscle bundle, together with the measurement of the muscle strength developed by the subject with maximum effort, the strength per unit area of the muscle was calculated in 245 healthy human subjects, including 119 male and 126 female.

The result was summarized as the following:

1. The ultrasonic method used in this work was possibly admitted as the best way to calculate the cross-sectional area of the muscle.

2. The arm strength was fairly proportional to the cross-sectional area of the flexor of the upper arm regardless of age and sex.

3. The strength per unit cross-sectional area of flexor of the upper arm was 6.3 kg/cm² in the average, standard deviation of 0.81 kg/cm². When cross-sectional area of muscle was measured at extensive position of the forearm the strength per unit area was calculated to be 4.7 kg/cm² at flexed position of the forearm.

4. As to the individual variation, the strength per unit area was distributed in a range from 4 kg/cm² to 8 kg/cm².

5. The strength per unit cross-sectional area was almost the same in male and female regardless of age. In addition to that, there was not found any significant difference in ordinary and trained adult.

The muscle strength per unit cross-sectional area has been calculated by many authors. It has been understood that the strength must be proportional to the physiological cross-sectional area of the muscle (HETTINGER, 1961). There are found, however, some differences among the results of researches as the followings: 6—10 kg/cm² (FICK, 1910), 6.24 kg/cm² (HERMANN, 1898), 9.2 kg/cm² (MORRIS, 1948), 4 kg/cm² (HETTINGER, 1964).

The present authors have conducted a study to determine the strength per unit cross-sectional area by means of ultrasonic method in living human subject. They also intend to make clear whether some differences exist among ages and sexes as well as trained and untrained.

Methods and Procedures

1. Subjects

As the subject 245 healthy persons of 119 male and 126 female participated to the experiment.

2. Measurement of Maximum Strength

The muscle strength was measured at the arm flexor at the right angle of the elbow joint in sitting position isometrically. The subject contracted the muscle against the cloth belt attached over the wrist with maximum effort. The belt, 45 mm wide, was connected with a straingauge tensiometer. The legs were extended on a chair. To get the maximum strength, any special procedure, was not used. After three trials for measurement, the highest value was adopted as the maximum strength of each individual.

3. Measurement of the Cross-Sectional Area of the Muscle

The subject was asked to keep the lying position, while his arm was fixed to extend to the bottom of the water tank (Fig. 1). The ultrasonic scanner circulates around the upper arm to be tested for 30 sec. The pulsed echo reflects on the cathode ray screen in brightness modulation.

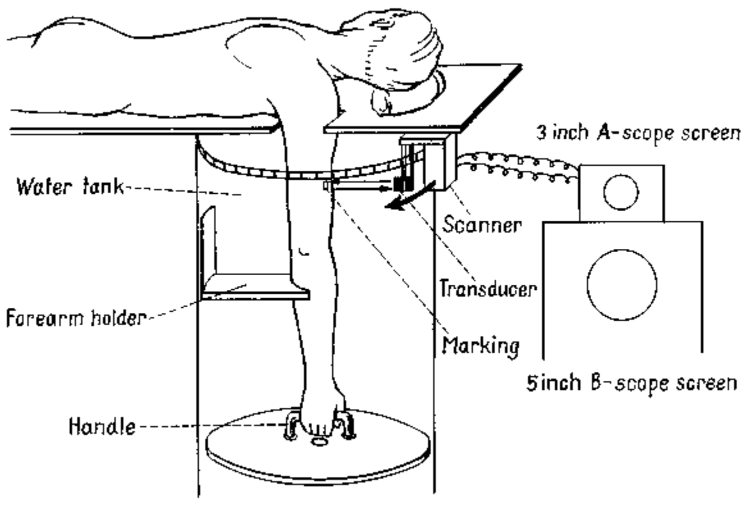

Fig. 1. Scheme of ultrasonic equipment

The frequency of ultrasonic wave was chosen to be 2.25—5 megacycle (MC) per second to get clear view of bone, muscle as well as subcutaneous fat. Fig. 2 shows the cross-sectional picture of the upper arm.

In this picture, the boundaries among subcutaneous fat, muscle, fascia and bone were observed clearly. Under consideration of the structure of subcutaneous fat and fascia, muscle of the upper arm was devided into flexor and extensor.

To measure the size of the tissues, a calibration curve was made by means of bakelite models of several diameters.

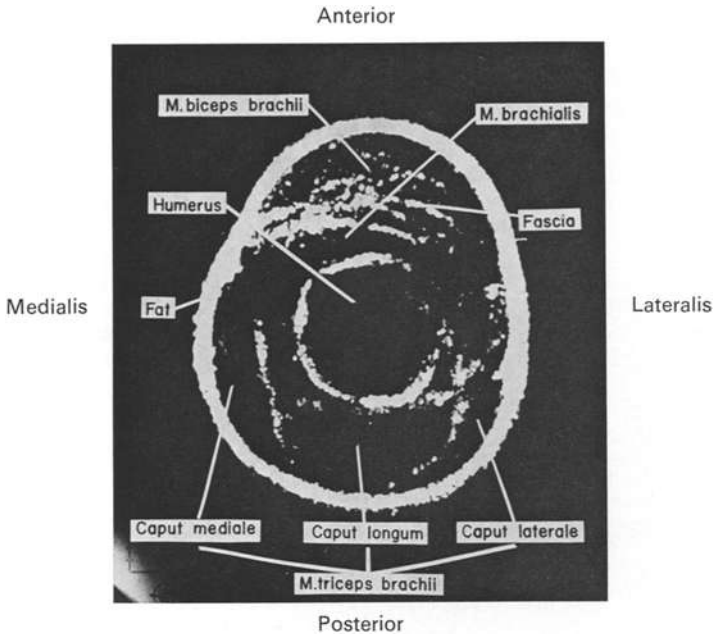

Fig. 2. Cross-sectional view of human upper arm by ultrasonic method

4. Calculation of Absolute Strength

To calculate the absolute strength of flexor muscle, biceps brachii, the following procedure was applied. The arm of the subject flexed at the elbow joint at right angle as the same position as in the measurement of strength, X-ray photograph

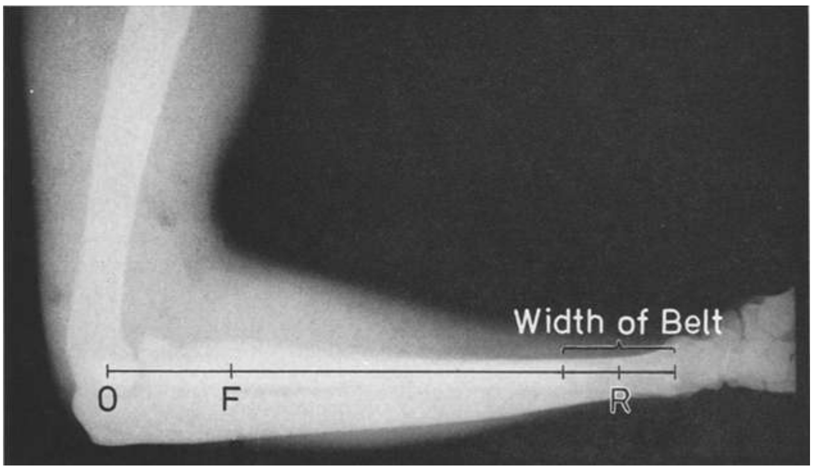

Fig. 3. Determination of fulcrum (*O*), force point (*F*) and resistance point (*R*) by means of X-ray photograph

was taken as was shown in Fig. 3. The distance between the arm and X-ray tube was held to be 2 m.

From the picture, the lever arms were measured for further calculation: The *O* means the center of axis of rotation of the elbow joint at the condylus humeri which acts as fulcrum. The *F* means the point at which biceps brachii muscle attaches tuberositas radii. It acts as the force point. The *R* means the point on which the belt is applied connected with tensiometer which acts as the resistance point.

In order to know whether the ratio of "resistance arm" and "force arm" may change in advance of age, measurement was done in two groups of young boys and adult men (Table 1). From these results, any significant difference between the averages of the ratio was not found in both groups ($P > 0.1$). Therefore the ratio could be estimated to be 4.90 in the average with the standard deviation of 0.29.

Table 1. *Ratio of lever arm for calculation of the absolute muscle strength*

Age	Number of subjects	Ratio of lever arm $= \frac{\text{resistance arm (OR)}}{\text{force arm (OF)}}$
Boys 13	5	5.08 ± 0.10 (mean $\pm$ S. D.)
Adult men 20—30	10	4.81 ± 0.32 (mean $\pm$ S. D.)

From the measured strength *(M)*, the absolute strength *(A)* was calculated as follows:

$$A = M \cdot 4.90.$$

Result and Discussion

The measured strength of the arm flexor was plotted against the cross-sectional area of the flexor muscle as shown in Fig. 4.

This presents a close relationship between the strength of the arm flexor and cross-sectional area of the flexor observed in all the subjects including male and female, young and adult of trained and untrained.

The strength per unit cross-sectional area of the muscle (kg/cm^2) was calculated from the arm strength and the cross-sectional area of the flexor of the upper arm. Table 2 presents the average of the strength per unit area respected to age and sex.

It was found in Table 2 that the strength per unit area was almost the same in male and female, regardless of age. In addition to that, there was not found significant difference in ordinary and trained adult as shown in Table 3.

As to the individual variation, the strength per unit area is distributed in a range from 4 kg to 8 kg as shown in Fig. 5.

Morris (1948) reported that the strength per unit area of the flexor of the upper arm was 9.2 kg/cm^2 in male, and 7.1 kg/cm^2 in female

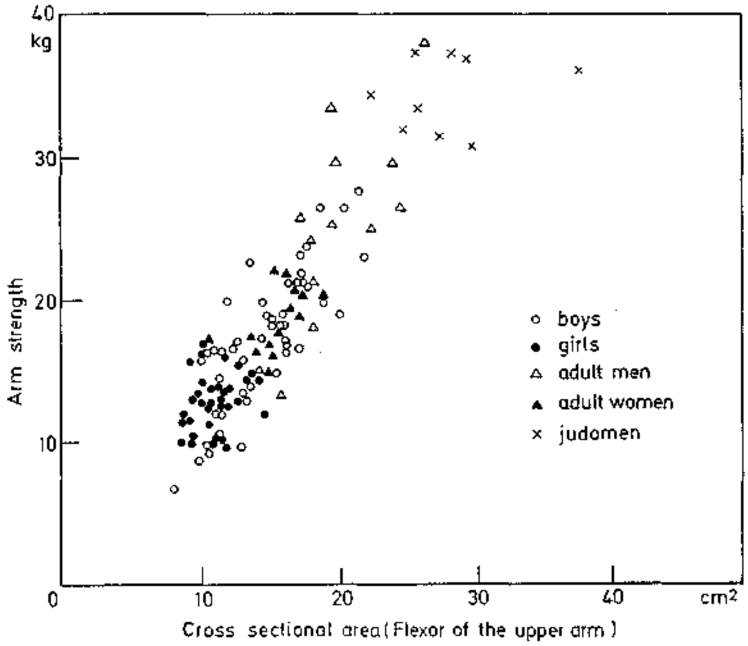

Fig. 4. Relationship between arm strength and cross-sectional area of flexor

Table 2. *The strength per unit cross-sectional area*

Age (yrs)		Arm strength (kg)	Flexor of upper arm (cm^2)	Strength per unit cross-sectional area (kg/cm^2) of muscle
12	M[a] (12)	14.7 ± 2.9[b]	12.1 ± 2.3	6.0 ± 1.1
	F (10)	13.1 ± 2.0	10.1 ± 1.7	6.4 ± 0.9
13	M (21)	17.6 ± 2.2	13.0 ± 0.6	6.7 ± 0.9
	F (19)	13.1 ± 2.0	10.6 ± 1.0	6.1 ± 1.1
14	M (15)	19.5 ± 2.7	14.4 ± 1.5	6.7 ± 0.8
	F (11)	11.9 ± 1.1	11.0 ± 1.3	5.3 ± 0.8
15	M (23)	19.1 ± 3.4	14.3 ± 2.1	6.6 ± 0.9
	F (13)	14.1 ± 1.0	11.2 ± 1.6	6.3 ± 0.9
16	M (12)	21.7 ± 3.2	16.6 ± 2.7	6.5 ± 1.0
	F (18)	14.4 ± 1.7	11.5 ± 1.3	6.1 ± 0.6
17	M (18)	21.8 ± 2.9	16.9 ± 2.7	6.4 ± 0.9
	F (8)	15.0 ± 2.2	11.4 ± 1.7	6.3 ± 0.5
18	F (14)	16.0 ± 2.0	13.5 ± 1.6	5.8 ± 0.8
19	F (19)	16.6 ± 1.9	13.6 ± 2.3	6.1 ± 1.0
20s	M (12)	27.4 ± 5.2	20.1 ± 2.9	6.7 ± 1.1
	F (14)	18.2 ± 2.6	14.5 ± 1.8	6.2 ± 1.8
Obese boys (7)		25.8 ± 5.0	23.3 ± 4.0	5.5 ± 1.0
Univ. Judomen (9)		34.5 ± 3.0	27.3 ± 1.3	6.4 ± 0.9

[a] Bracket () shows the number of subject, M = male, F = female. — [b] Mean ± S. D.

Table 3. *Strength of ordinary male and trained Judo athletes*

Subject	N	Arm strength	Strength per unit area
Ordinary 20 yrs	12	27.4 ± 5.2 kg	6.7 ± 1.1 kg/cm²
Judomen	9	34.5 ± 3.0 kg	6.4 ± 0.9 kg/cm²
(Mean ± S. D.)			

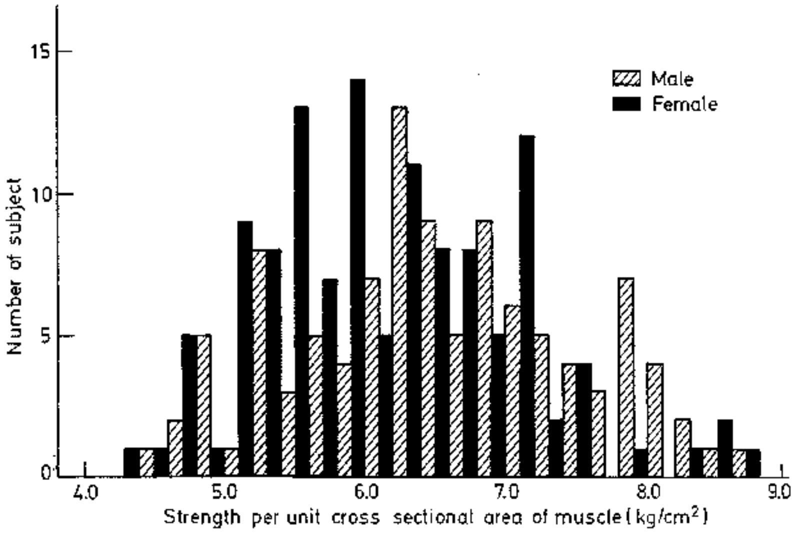

Fig. 5. The individual variation of the strength per unit cross-sectional area of the flexor muscle

subject, based on the measurement of the passive strength. Morris mentioned a possibility that the subject could exert the highest strength of 10 kg/cm² as suggested by Fick, if the subject would be trained for highest concentration.

Franke (1920) reported the highest value of 11.1 kg/cm² in the flexor of the upper arm.

As to the measurement of the cross-sectional area of the flexor, other authors, including Morris, Franke, Hermann, used the anatomical data measured in cadaver and data observed in X-ray film in living subject. Compared with these classical methods, the ultrasonic method could be available to differentiate more accurately the tissue components of the living subject.

The flexor of upper arm, including biceps brachii and brachialis, was chosen for this experiment, because the muscle fibers run parallel to the longitudinal axis of the muscle bundle.

On the other hand, the cross-sectional area of the flexor was calculated, in an flexed position to an angle of 90 degrees, in a maximum contraction. The cross-sectional area was larger by 34% in flexed position than in extended one. According to these procedures, the strength per unit area of the flexor was calculated to be approximately 4.7 kg/cm² in the average.

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MEASUREMENT OF QUADRICEPS MUSCLE WASTING BY ULTRASONOGRAPHY*

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SUMMARY

Grey-scale ultrasonography can produce an image of the quadriceps muscle from which it is possible to measure its cross-sectional area (CSA). The between-days coefficient of variation for quadriceps CSA (at mid-thigh) in 14 legs of seven subjects each scanned on four days was reduced to 4.0% by averaging four scans on each day.

Bilateral scans (at the mid-thigh level) were used to measure the severity of quadriceps wasting in 21 otherwise healthy adult patients with a difference in thigh circumference following unilateral knee immobilization or injury.

Quadriceps wasting as demonstrated by the scans was consistently more severe than the disparity in whole thigh cross-sectional area at the same level or the disparity in anthropometric estimates of fat-free thigh volume. Investigations concerned with changes in quadriceps muscle bulk must therefore use a technique (such as ultrasonography) which allows measurement of the quadriceps itself.

IMMOBILIZATION or injury of the knee joint quickly results in weakness and wasting of the ipsilateral quadriceps muscle, and the restoration of quadriceps strength is important for the recovery of normal knee function and control (Duthie and Ferguson, 1973). Since the measurement of quadriceps strength in patients with a recent history of lower-limb trauma is often difficult, the need for, and the effectiveness of, physiotherapeutic exercise are usually assessed on the basis of estimates of muscle bulk and not of strength. Although their reproducibility is poor (Nicholas *et al.*, 1976; Kirwan *et al.*, 1979), thigh circumference measurements are used to estimate changes in quadriceps bulk. Moreover, quite large changes in the size of the quadriceps may be obscured by the variable thickness of the surrounding layer of subcutaneous fat (Ingemann-Hansen and

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† Dr. Nichols died on 8 September 1979.

Requests for reprints to Dr. A. Young.

Halkjaer-Kristensen, 1977) and the presence in the thigh of a large bulk of other muscles. The latter remains a potential problem even if skinfold thickness measurements are used to estimate the volume of subcutaneous fat.

Evidence from a muscle-biopsy study suggests that after tibial fracture the wasting process may often be highly selective, affecting the quadriceps much more than the other thigh muscles (Sargeant *et al.*, 1977). However, any attempt to extrapolate from observations of muscle fibre size to conclusions about whole muscle size depends on major assumptions regarding the number of fibres in the muscle and the extent to which the biopsy findings are representative of events in the muscle as a whole.

This paper describes how ultrasonography may be used to provide an image of a cross-section of the quadriceps and how the cross-sectional area of this image is affected by knee injury and/or immobilization.

METHODS

Quadriceps scanning

An image of a transverse section through the quadriceps muscle group was obtained by means of a conventional diagnostic ultrasound scanner with grey scale attachment (Nuclear Enterprises, 'Diasonograph NE4200'). Scans were made at a point (hereafter referred to as 'mid-thigh') half-way between the greater trochanter and the lateral joint line of the knee. The height of this point above the floor was recorded so that it could be identified on future occasions.

Scanning was performed with the subject supine and his leg supported with the knee extended. The leg was supported with the hip flexed to 5° (or sometimes 10°) to allow scanning from more posterior points on the thigh circumference, thus ensuring that an adequate image could be compounded. The scanning gantry was tilted through an equal angle so that a transverse scan was still obtained. The best images were usually obtained with a much attenuated sound input of frequency 2.5 MHz, and a compensation rate of 5 dB/cm, with care being taken not to distort by compression. The last condition was easier to meet when using a probe of small face area. The probe used was Nuclear Enterprises NE4328 (13 mm LIF, 2.25 MHz). Arachis oil was used as the coupling medium.

The scan image was photographed to give an ultrasonogram on Nuclear medicine NMB film (Kodak) which was about half life-size.

Quadriceps cross-sectional area

The outline of the quadriceps group was traced from the photograph of each scan and the cross-sectional area (CSA) of the quadriceps was measured by cutting-out and weighing the tracing.

Thigh circumference

Thigh circumference was measured by tape measure, at 'mid-thigh', with the subject standing.

Fat-free thigh volume

Thigh volume was estimated by measuring its circumference at three levels and treating the thigh as two truncated cones (after Jones and Pearson, 1969). The levels were defined on the dominant or uninjured leg (normal subjects or patients respectively) as (i) gluteal fold, (ii) knee plus one third sub-ischial height and (iii) narrowest point above the knee. The circumferences of the non-dominant (or injured) limb were measured at the same heights above the ground.

The thickness of subcutaneous fat was estimated by applying the regression equations of Davies and Sargeant (1975) to skinfold thickness measurements made anteriorly and posteriorly at level (ii). These measurements were made with Harpenden skinfold calipers (British Indicators Ltd). The anterior skinfolds were measured with the subjects standing, but for the posterior measurements it was necessary for them to lie prone with the knee flexed, so that a measureable skinfold could be lifted. The fat-free thigh volume was then calculated by subtraction of the estimated fat volume from the estimated total thigh volume.

SUBJECTS

Repeatability study

Four female and three male adults participated in a study of the repeatability of ultrasonographic measurements of quadriceps cross-sectional area. Two of the male subjects had mild unilateral wasting secondary to knee injury.

Cross-sectional study of quadriceps wasting

Patients (five female and 16 male) were recruited from the physiotherapy 'knee class'

TABLE

PATIENTS WITH UNILATERAL THIGH MUSCLE WASTING

Diagnosis	Age (years)	Sex	Difference in mid-thigh circumference (cm)	(%)
Meniscectomy	19	F	4.3	−7.9
Meniscectomy	19	M	1.8	−3.5
Meniscectomy	20	M	1.7	−3.1
Meniscectomy	26	M	0.5	−1.0
Meniscectomy	27	M	1.9	−3.9
Meniscectomy	28	M	1.4	−3.0
Meniscectomy	33	M	0.4	−0.8
Knee injury	19	M	3.3	−6.8
Knee injury	23	M	1.3	−2.6
Knee injury	44	M	0.5	−1.0
Knee injury + POP	22	F	1.7	−3.3
Knee injury + POP	27	M	1.8	−4.2
Knee injury + POP	27	M	2.0	−3.7
Knee injury + POP	34	F	1.6	−3.3
Fractured tibia	23	M	6.1	−12.4
Fractured tibia	29	F	2.7	−5.9
Fractured tibia	31	M	2.5	−4.5
Fractured tibia + pes anserinus transfer	35	M	2.9	−5.4
Pes anserinus transfer	39	M	1.6	−3.4
Arthrotomy	19	F	1.8	−3.6
Arthrotomy	36	M	0.5	−0.9

and from an orthopaedic out-patient clinic. These were essentially healthy young adults (median age 27 years; range 19–44) who were referred to us if their therapist had measured at least 2 cm discrepancy in mid-thigh circumference following knee injury or immobilization (Table). (This difference was not always confirmed when the patients were remeasured by the investigators.)

Patients with a history of injury to the other lower limb within the preceding two years were excluded, as were any with clinical evidence to suggest denervation, muscle disease, or inflammatory joint disease. The patients had a wide range of underlying orthopaedic diagnoses (Table), with post-meniscectomy patients forming the largest single group.

RESULTS

Quadriceps scanning

It was always easy to distinguish the femur and the four parts of the quadriceps in the transverse ultrasonograms (Fig. 1, Plate IX and Fig. 2, Plate X). Difficulties in scan interpretation arose in two areas. The boundary between biceps femoris and the quadriceps was sometimes hard to define where the short head of the biceps is closely applied to the posterior aspect of the lateral mass of the quadriceps. A more difficult boundary to define was that of vastus medialis with adductor longus and sartorius.

Satisfactory scans were obtained more readily for female subjects than for male subjects. Of the males, those with the smallest skinfolds tended to be the hardest to scan—distortion by compression was harder to avoid and, in the very lean, the transducer ringing period obscured the outer border of the muscle.

Repeatability study

Each thigh of each of the seven subjects was scanned four times on each of four visits. The 'between-scans' variance gave a coefficient of variation of 5.2%. (Errors in cutting out and weighing of the tracings made only a minimal contribution to this.)

The net 'between visits' coefficient of variation was 6.1%. If the component of variance attributable to the 'between-scans' variation was reduced by averaging each subject's four scans on each occasion, the net 'between-visits' coefficient of variation was reduced to 4.0%.

Although the female subjects were easier to scan, there was no significant difference between the coefficients of variation calculated for males and females. However this could, of course, simply reflect the small number of subjects.

Cross-sectional study of quadriceps wasting

The same pattern of results was obtained for the post-meniscectomy group as for the other patients and the results will therefore be reported together.

The injured/uninjured limb ratio for the mid-thigh circumference-squared was consistently greater than the corresponding ratio for quadriceps cross-sectional area (mean of four scans on each thigh) (Fig. 3). The two ratios show a weak, linear correlation ($r = 0.50; 0.05 > P > 0.01$).

It appears that in these patients, the reduction in the cross-sectional area of the whole thigh was consistently less than the reduction in quadriceps cross-sectional area. To test whether this discrepancy might be explained simply by a greater thickness of subcutaneous fat in the injured limb, the injured/uninjured limb ratios for quadriceps

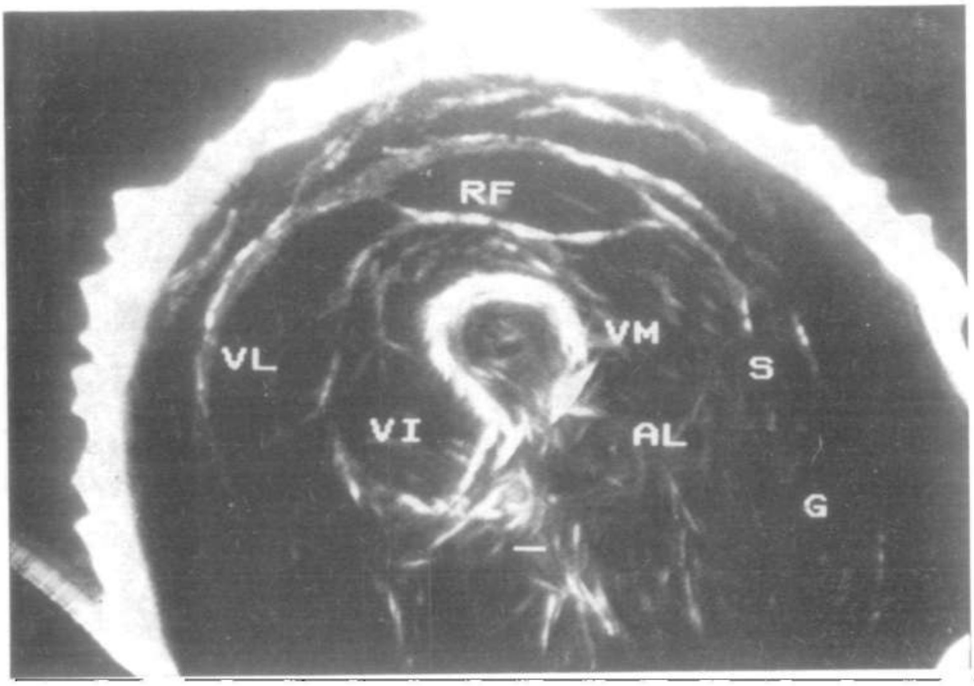

FIG. 1.—Normal transverse ultrasonogram made at the mid-thigh level in a 19-year-old girl (VI = vastus intermedius; VL = vastus lateralis; RF = rectus femoris; VM = vastus medialis; AL = adductor longus; S = sartorius; G = gracilis).

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PLATE X

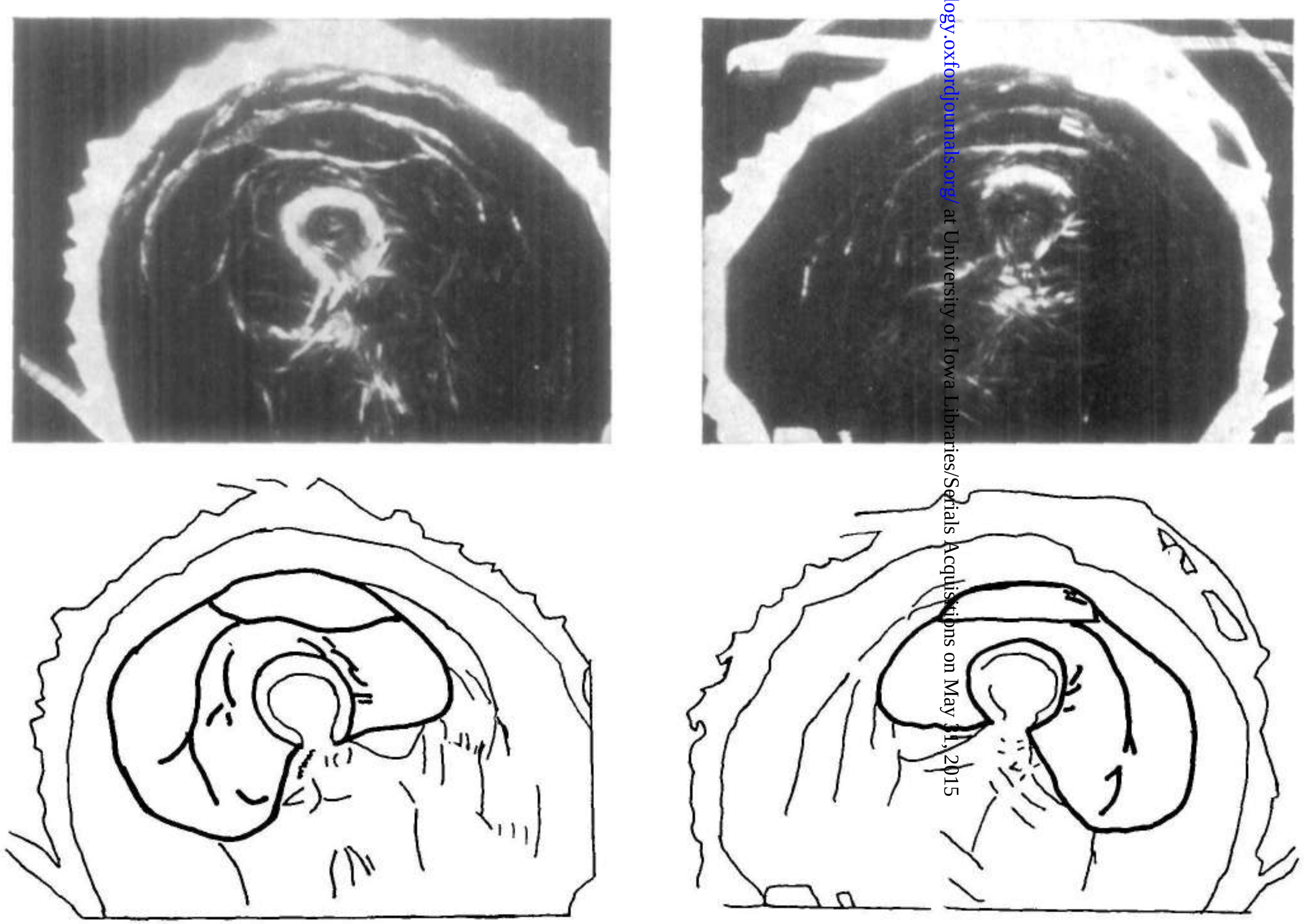

FIG. 2.—Bilateral transverse ultrasonograms made at the mid-thigh level in a patient with unilateral thigh muscle wasting following a meniscectomy. The quadriceps' outlines are indicated by the heavier lines in the diagrams. Measurement shows a difference in quadriceps cross-sectional area of −22%.

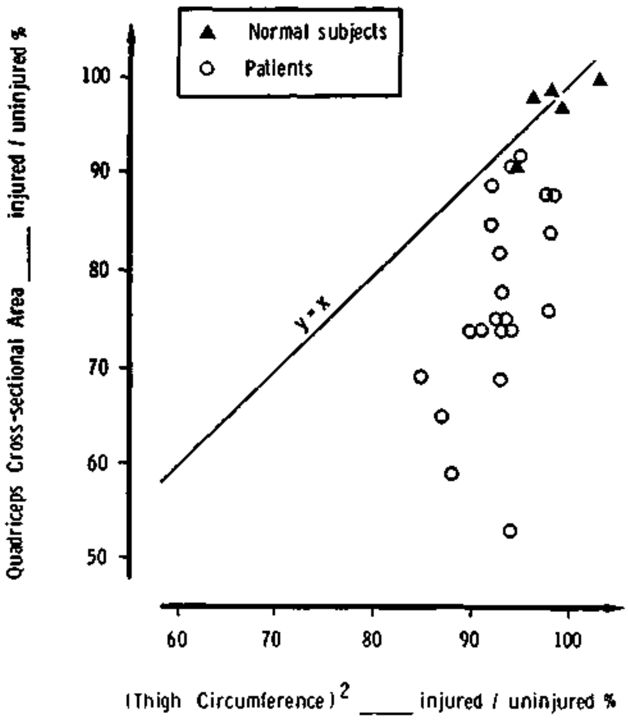

FIG. 3.—The injured/uninjured limb ratio for quadriceps cross-sectional area plotted against the equivalent ratio for thigh circumference-squared. (The graph also includes the corresponding weaker limb/stronger limb ratio for five normal young men.)

cross-sectional area were replotted against the ratios for fat-free thigh volume (Fig. 4). The discrepancy between the ratios persists ($P < 0.001$), although it is less pronounced.

DISCUSSION

Quadriceps scanning

The use of ultrasonography to delineate individual skeletal muscles in man, and so measure their cross-sectional area, was first described by Ikai and Fukunaga in 1968. They subsequently used the technique in a study of the effects of physical training on the strength of elbow flexion and the cross-sectional area of the anterior compartment of the upper arm (Ikai and Fukunaga, 1970). However, their technique did not allow adequate differentiation between muscles. Moreover, the procedure was not widely applicable as it involved scanning the limb submerged in a water-bath. As a result, there were no other published reports of this application of ultrasonography until Dons *et al.* (1979) used it to obtain an indication of quadriceps cross-sectional area. Difficulty in distinguishing muscle boundaries meant that they were limited to measuring skin to bone thickness at 33° intervals around a 100° sector of the antero-lateral thigh and did not actually measure quadriceps cross-sectional area.

Human muscle cross-sectional area has been measured *in vivo* by computerized axial tomography (Häggmark *et al.*, 1978; Häggmark and Eriksson, 1979; Bulcke *et al.*, 1979). However this technique requires sophisticated and expensive equipment of very

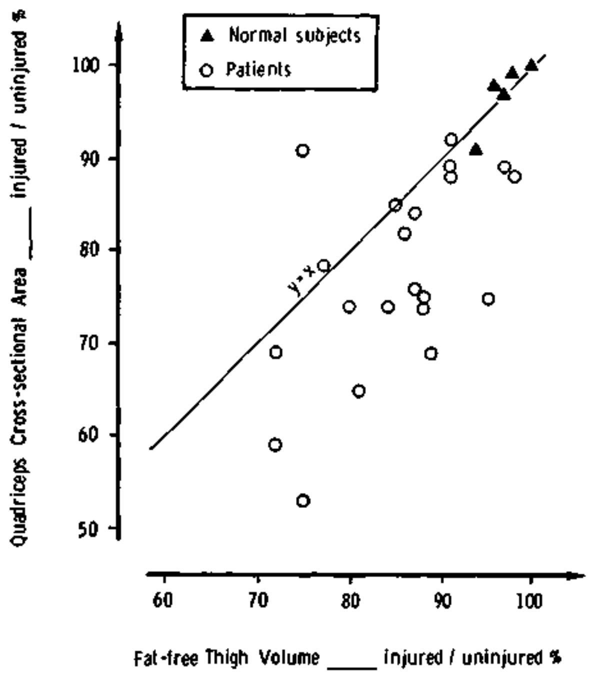

FIG. 4.—The injured/uninjured limb ratio for quadriceps cross-sectional area plotted against the equivalent ratio for fat-free thigh volume. (The graph also includes the corresponding weaker limb/stronger limb ratio for five normal young men.)

limited availability. Moreover, the radiation exposure entailed in axial tomography of an extremity, although small (Perry and Bridges, 1973), still places significant ethical limitations on the use of the technique for sequential measurements.

The principal advantage of computed tomography would be its superior image resolution (Ferrucci, 1979*a*). However this study demonstrates that a practised operator using a modern ultrasonic scanner can obtain a satisfactory image of a transverse section through the quadriceps muscle group. Our experience of scanning the quadriceps suggests that other muscles could probably also be studied in this way, after a period of preliminary experimentation to establish the appropriate details of scanning technique.

The high reflectivity of fat for ultrasound means that an obese abdomen is difficult to scan successfully (Ferrucci, 1979*b*). However, a substantial layer of subcutaneous fat facilitates thigh ultrasonography by minimizing deformation of the underlying muscle during scan compounding. This is particularly relevant when scanning a limb of small radius since adequate compounding is then impossible without significant compression of the skin surface. Whatever its radius, a very lean thigh cannot be scanned successfully by the technique described, since the ringing period of the transducer obscures the outer boundary of the muscle. Such a limb would have to be scanned through a water-bath.

It also seems likely that a thigh with a substantial layer of subcutaneous fat also has a greater amount of intermuscular fat which may make it easier to delineate the intermuscular boundaries.

Cross-sectional study of quadriceps wasting

In a biopsy study of seven patients with quadriceps wasting following lower-leg fracture and subsequent knee immobilization (Sargeant *et al.*, 1977), measurements of muscle fibre size suggested that quadriceps atrophy might sometimes be much greater than would be expected from anthropometric estimates of fat-free thigh volume. This conclusion depended on the assumption that the fibre size measurements were representative of events in the quadriceps as a whole. The work of Häggmark *et al.* (1978) lent some weight to this assumption: they showed that for nine male subjects there was a linear relationship between MFA and the CSA of vastus intermedius plus vastus lateralis as measured by computerized axial tomography.

This study has now confirmed that, after knee injury or immobilization, estimates of muscle wasting based on thigh circumference measurements seriously underestimate the severity of the quadriceps wasting actually present. Moreover, this discrepancy cannot be explained simply by a greater thickness of subcutaneous fat in the injured limb. It seems that in these patients the wasting process is largely localized to the quadriceps itself, sparing the other thigh muscles. Strictly speaking, confirmation of this requires a longitudinal study since changes may also be occurring in the uninjured limb.

Small differences in thigh circumference are not only difficult to demonstrate reliably (Nicholas *et al.*, 1976; Kirwan *et al.*, 1979) but they may conceal large differences in quadriceps cross-sectional area. A 2.5 cm difference in mid-thigh circumference probably means a 22–33% difference in quadriceps CSA (95% confidence limits of prediction, if larger thigh circumference = 50 cm).

For routine clinical practice, thigh muscle ultrasonography is too time-consuming to have an important place as a measure of muscle wasting. Nevertheless, studies such as this give a better appreciation of the true implication of a clinically demonstrable difference in thigh circumference. On the other hand, ultrasonography is a potentially useful tool for physiotherapy research since a study of the treatment of muscle wasting demands measurement of the individual muscle group involved. Indeed, we should suggest that it would be a waste of time to base any research study of quadriceps physiotherapy on measurements of thigh circumference.

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We wish to thank Dr. P. Stamper and Dr. W. Fletcher (consultant radiologists) for their help in developing the muscle scanning technique and for allowing us to use their ultrasonography facilities. We are also grateful to the consultant staff of the Nuffield Orthopaedic Centre who allowed us access to their patients, to the physiotherapy staff of the Nuffield Orthopaedic Centre for their help in recruiting patients and, of course, to the patients themselves.

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Measurement of Quadriceps Cross-sectional Area by Ultrasonography: A Description of the Technique and its Applications in Physiotherapy

Maria Stokes and Archie Young

The effect of physiotherapy on muscle growth can be evaluated by direct measurements of the individual muscle concerned, eg. using ultrasound B-scanning. The technique is suitable for adoption by physiotherapists to use independently or in collaboration with specialists in diagnostic imaging. Details of the technique are described, and the difficulties met while making and interpreting the scans are discussed. The purpose of this paper is to stress the importance of muscle-size measurements and to encourage physiotherapists to use ultrasound scanning to obtain them.

INTRODUCTION

Physiotherapists spend a lot of time helping patients build up their muscles, yet there are very few objective tests to evaluate the effects of treatment. Strength measurements, while very useful, are not always appropriate e.g. when reflex inhibition, pain, or fear of pain are present. Measurements of muscle bulk cannot be made accurately with a tape measure due to the presence of varying amounts of subcutaneous fat and other muscles in the limb. Muscle wasting (Young *et al.*, 1982) and muscle growth (Young *et al.*, 1983) are seriously underestimated by the tape measure.

Grey-scale ultrasound B-scanning produces an image of the muscle which allows accurate measurement of its cross-sectional area (CSA) (Ikai & Fukunaga, 1968; Young *et al*, 1980). Computerised axial tomography (CAT) (Haggmark *et al*, 1978), and nuclear magnetic resonance (NMR) are other imaging techniques which can also be used to measure muscle CSA. The advantages of ultrasound over these methods are: that ultrasound equipment is readily available in most hospitals, there is no exposure to radition, and it can be used independently by a physiotherapist. Various muscles can be measured using ultrasound but this paper describes scanning of the quadriceps. Details of the technique (including a small repeatability study) and the problems encountered are described.

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SUBJECTS STUDIED

Including the five normal subjects in the repeatability study, 52 normal subjects (who took part in research projects) and 12 patients have been scanned by one of the authors who is a physiotherapist. The subjects included two orthopaedic patients who had persistent problems of quadriceps weakness due to knee joint injury and ultrasound scanning was used to aid evaluation of their treatment. The other patients had endocrine 'myopathies' and were being studied during their medical treatment.

METHOD OF SCANNING THE QUADRICEPS

The machine used is a compound B diagnostic ultrasound scanner with grey scale attachment (A Nuclear Enterprises, 'Diasonograph NE 4200' is used but other compound B scanners would be satisfactory). The frequency which produces the clearest definition for scanning the quadriceps (2.5 MHz) is similar to those used in therapeutic ultrasound (0.75–3 MHz) but the power is about 1/100 of that used for treatment (Lunt, 1977). A water-based coupling medium is used in preference to oil as it produces better definition of the image. When the probe is placed on the skin the ultrasound beam is reflected back to the probe from tissue interfaces which are at 90° to the beam and these appear as dots on an oscilloscope screen (Fig 1). The probe is moved around the surface of the thigh in a sweeping fashion and the dots become lines (Fig 2). Gradually an image of a slice through the thigh is built up on the screen. If the image is satisfactory it can be photographed (Fig. 3).

Routinely, scans are made at mid-thigh which is defined as halfway between the most prominent point of the greater trochanter and the lateral joint line of the knee (Young *et al.*, 1980). At this

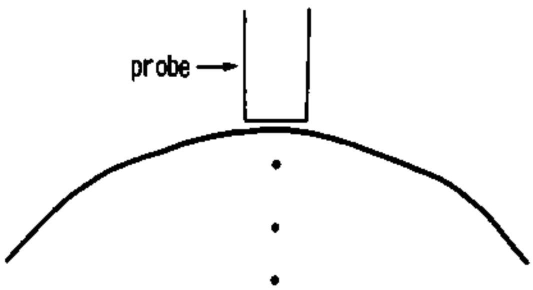

Fig. 1 The ultrasound beam is reflected back to the probe from tissue interfaces which it strikes at 90°. The interfaces appear as dots on the oscilloscope.

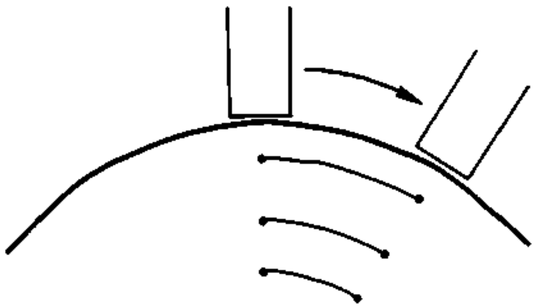

Fig. 2 As the probe is moved around the surface of the thigh, the dots become lines building up a picture of a cross-section through the thigh.

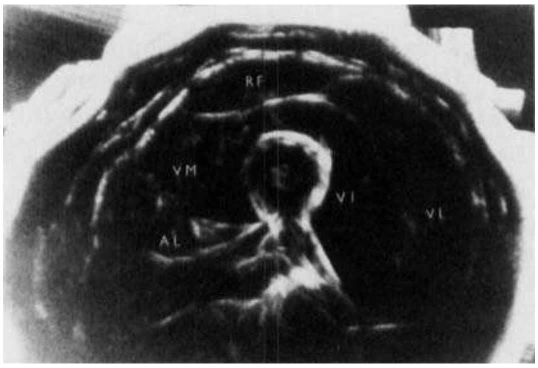

Fig. 3 Scan of a transverse section through mid-thigh. VL=Vastus Lateralis, VM=Vastus Medialis, RF=Rectus Femoris, VI=Vastus Intermedius, AL=Adductor Longus.

level in the thigh all the four heads of quadriceps are well represented (although not in equal proportions). When scanning is to be repeated at a future date, a mark at the level of the scans is traced on to a transparent sheet together with permanent skin blemishes e.g. freckles and scars, to allow accurate relocation of the site (Dons *et al.*, 1979). The subject lies supine with the knee extended and the hip is slightly flexed (5°) by supporting the leg with sandbags behind the knee and ankle. The scanning probe is mounted in a gantry which is positioned over the subject. The angle of the hip in which the leg is supported allows the probe to scan from the postero-lateral aspect of the thigh, therefore completing the muscle outline. The scanning gantry is tilted through an equal angle so that scans are made at 90° to the thigh.

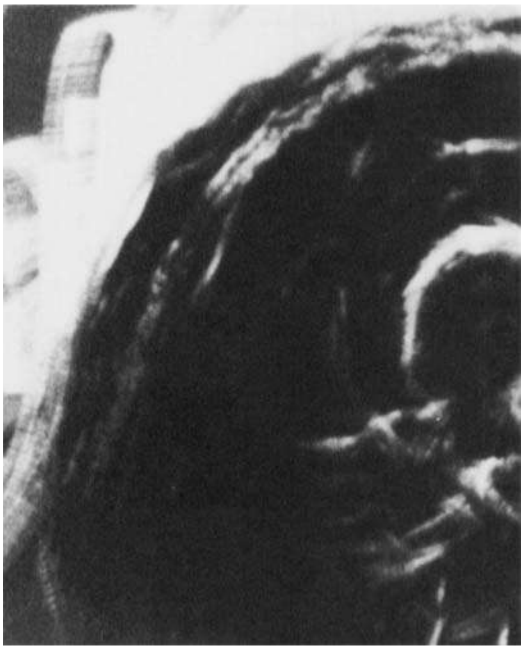

Fig. 4 Medial part of the thigh before completion of scan.

Fig. 5 Indentation of the probe into the thigh has allowed better definition of the boundary (arrowed) between vastus medialis and adductor longus.

The medial part of the thigh is scanned first, and detail occasionally becomes obscured after scanning the lateral side. In such instances scanning is restarted, the medial part is photographed (Fig. 4), and then the rest of the scan is completed. Certain parts of the muscle outline are sometimes difficult to define (*vide infra*) so the scan is first photographed to preserve the basic outline and then extra coupling medium is placed at sites where, by indenting the skin with the probe, the ultrasound beams can be directed at 90° to the ill-defined tissue interface (Fig. 5). The extra coupling medium also serves to 'build up' the surface. Each subject has 4 scans taken of each thigh, and these are photographed. The quadriceps' outline is later traced from each scan and its CSA measured with a MOP electronic planimeter (Reichert-Jung). The mid-thigh CSA of a single quadriceps on a single visit is calculated as the mean of the results of four scans. The total time taken to obtain the four scans on two thighs, photograph and develop them, is between 1/2 and 3/4 h. Obviously this would be too time-consuming for routine clinical practice, but would be acceptable in some clinical situations and in research.

Repeatability study

Five female volunteers from the hospital staff at the Nuffield Orthopaedic Centre, Oxford took part (Table 1). None of them had muscle, neurological or joint disease. Each subject had both quadriceps scanned on two occasions (ranging from 3–11 days apart). There was good

Table 1
Bilateral measurements of quadriceps cross-sectional area at mid-thigh, made on two occasions, in five normal women—repeatability study

		Quadriceps CSA (cm^2)					
		Right			Left		
Weight (kg)	Age (Age)	Day 1	Day 2	CV (%)	Day 1	Day 2	CV (%)
53	40	39.3	40.2	1.6	41.2	42.1	1.5
60	24	45.2	47.4	3.4	47.8	47.3	0.7
72	31	54.7	56.6	2.4	48.4	49.2	1.2
80	28	70.4	68.3	2.0	67.4	68.6	1.2
82	24	53.8	53.5	0.4	50.6	53.5	3.9
		Mean CV=2.0%			Mean CV=1.7%		

CSA=Cross-sectional area

$$CV = \text{Coefficient of variation} = \frac{\text{Standard Deviation}}{\text{Mean}} \times 100$$

agreement between the values for quadriceps CSA obtained on the two occasions for all five subjects (Table 1). The coefficient of variation between the visits was 2% which was lower than that previously reported (4%) by Young *et al.* (1980). This difference may have arisen because the earlier study's method for re-locating mid-thigh (by measuring the height from the floor) was not as reproducible as using a transparent sheet. This small study showed that measurements made independantly by a physiotherapist were at least as repeatable as those previously reported.

Difficulties in making and interpreting the scans

Learning how to operate the equipment was not difficult, but much practice was required to produce an image which was not distorted by compression with the probe, but which still showed good definition of the complete perimeter of the quadriceps (Fig. 3). When scanning lean thighs, the muscle was easily distorted by compression, and the smaller amounts of inter-muscular fat led to poorer definition of muscle boundaries; males were more difficult to scan than females as they tended to have less fat.

Two parts of the muscle outline which were often awkward to define were the boundaries between biceps femoris (short head) and vastus lateralis, and between vastus medialis and adductor longus (Fig. 3). The slight elevation of the thigh and occasional deliberate indentations of the skin improved these boundaries.

Including the repeatability study, 64 subjects have been independently scanned on 90 occasions (Table 2). Of 704 scans, only 20 were not measurable (the accuracy of interpretation of the outline was judged at the time of tracing the

Table 2
Total number of scans taken

	Normal subjects	Patients	Total
Number of subjects	52	12	64
Number of occasions	58	32	90
Scans taken	464	240	704
Scans not measured	4	16	20 (2.8%)

scans). The outlines were not satisfactory in one scan from each of 11 subjects, and two scans from each of three subjects. On one occasion, three scans from one patient were destroyed due to problems with the camera. Normally three more would have been taken to replace these but the patient had severe chronic bronchitis and was unable to remain lying for more scans. Although 3% of the scans were rejected, measurements of quadriceps CSA were successfully obtained for all of the subjects.

Research and clinical applications of ultrasound scanning

Ultrasound scanning used in studies of muscle wasting e.g. (Young *et al.*, 1982) showed that a 5% reduction in mid-thigh circumference (measured using a tape measure) may conceal a 22–33% reduction in quadriceps CSA. Muscle growth studies have also included the use of ultrasound scanning (Ikai & Fukunaga, 1970; Young *et al.*, 1983).

A normal range for the close relationship between quadriceps' size (using ultrasound scanning) and its isometric strength has been established for normal subjects of different ages (Young *et al.*, 1984 & 1985). Isometric strength was measured with the subject seated, the hip and knees at 90° and the lower leg dependant (Edwards *et al.*, 1977). An inextensible strap, which was placed around the ankle (just above the malleoli), was attached to a strain gauge at the back of the chair. As the subject tried to straighten his knee, the force exerted at the ankle was recorded on an oscillograph. The ratio of quadriceps strength to its CSA is the same in young and old women (Young *et al.*, 1984) and in old men, but in young men the relationship is not so straightforward (Young *et al.*, 1985). The close relationship in females was used to evaluate the relative contributions to weakness of atrophy and inhibition in two female patients with knee pain and severe unilateral quadriceps wasting (Fig. 6). The quadriceps strength of their injured limbs was inappropriately low for the size of their atrophic quadriceps. This suggested inhibition of quadriceps contraction, either due to pain or some other stimuli from the injured knee (Stokes & Young, 1984). One of the patients received an

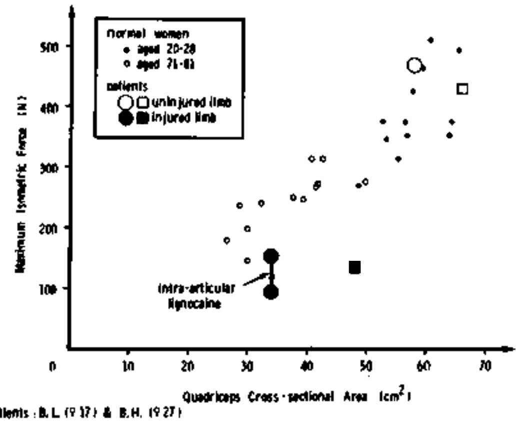

Fig. 6 The evaluation of atrophy and inhibition in sports medicine. The quadriceps size and strength of two female patients with unilateral knee pain are shown in relation to the normal female range. (See text for explanation of effect of intra-articular lignocaine.)

injection of lignocaine into the knee joint which enabled her to exert more force, confirming that the discrepancy between the original strength and that expected for the size of the muscle was due, at least in part, to afferent stimuli from the knee. These investigations made important contributions to the correct selection and evaluation of rehabilitation received by these two patients. Also, they suggest that serial measurements of quadriceps size might be more valuable than strength measurements in patients with inhibition (whether voluntary or involuntary), particularly those with joint disease.

Future work, involving scanning the thigh at different levels, might provide evidence for or against theories of selective atrophy and hypertrophy of the different heads of the quadriceps.

Ultrasound scanning has been used to look at muscle in other ways apart from measuring its size. For example, it has been used for investigating dystrophic muscle (Heckmatt *et al.*, 1980). Fornage *et al.*, (1982) used ultrasound to detect muscle lesions in athletes and were able to accurately assess their severity before embarking on surgical repair. In a case report of a patient with pyomyositis, real-time (RT) ultrasound and CAT scanning were used for diagnosis, and RT scanning was also used to guide percutaneous drainage of the abcess, thus avoiding surgery (Yousefzadeh *et al.*, 1982).

CONCLUSIONS

Ultrasonography could be used to make measurements of muscle size which are essential in research and valuable in the clinical evaluation of treatment. It is hoped that this paper will encourage other physiotherapists to adopt the technique and that as its use becomes more widespread, so too will its applications in other areas of physiotherapy.

Acknowledgments

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Evidence of Lumbar Multifidus Muscle Wasting Ipsilateral to Symptoms in Patients with Acute/Subacute Low Back Pain

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The effect of low back pain on the size of the lumbar multifidus muscle was examined using real-time ultrasound imaging. Bilateral scans were performed in 26 patients with acute unilateral low back pain (LBP) symptoms (aged 17–46 years) and 51 normal subjects (aged 19–32 years). In all patients, multifidus cross-sectional area (CSA) was measured from the 2nd to the 5th lumbar vertebrae (L2-5) and in six patients, that of S1 was also measured. In all normal subjects, CSA was measured at L4 and in 10 subjects measurements were made from L2-5. Marked asymmetry of multifidus CSA was seen in patients with the smaller muscle being on the side ipsilateral to symptoms (between-side difference 31 ± 8%), but this was confined to one vertebral level. Above and below this level of wasting, mean CSA differences were < 6%. In normal subjects, the mean differences were < 5% at all vertebral levels. The site of wasting in patients corresponded to the clinically determined level of symptoms in 24 of the 26 patients, but there was no correlation between the degree of asymmetry and severity of symptoms. Patients had rounder muscles than normal subjects (measured by a shape ratio index), perhaps indicating muscle spasm. Linear measurements of multifidus cross-section were highly correlated with CSA in normal muscles but less so in wasted muscles, so CSA measurements are more accurate than linear dimensions. The fact that reduced CSA, i.e., wasting, was unilateral and isolated to one level suggests that the mechanism of wasting was not generalized disuse atrophy or spinal reflex inhibition. Inhibition due to perceived pain, via a long loop reflex, which targeted the vertebral level of pathology to protect the damaged tissues was the likely mechanism of wasting. The lack of correlation between severity of wasting and symptoms highlights the need for objective measurement in the assessment of the paraspinal muscles in LBP. [Key words: low back pain, muscle size, lumbar multifidus, real-time ultrasound]

The paraspinal muscles play a vital role in the stability and functional movement of the vertebral column but their role in spinal dysfunction is unclear. The lumbar multifidus, which is thought to be particularly important for stability,[14] is the largest and most medial of the lumbar back muscles. It consists of five separate bands which receive their own innervation.[15] These bands spread caudolaterally from the midline, each originating from one lumbar vertebra and attaching to mamillary processes, the iliac crest, and the sacrum, so they are polysegmental.

Objective direct measurement of muscle might help in the assessment of low back pain (LBP) and aid the choice of appropriate treatment. Imaging techniques can be used to measure muscle size and the relative advantages of techniques such as ultrasound scanning, computerized tomography, and magnetic resonance imaging in rehabilitation have been discussed elsewhere.[26] Real-time (RT) ultrasound scanning was used in the present study to measure the cross-sectional area (CSA) of the lumbar multifidus muscle. The degree of between-side symmetry of multifidus CSA has been documented in healthy young adults.[9] Linear dimensions can be measured on the images, e.g., depth or width of the muscle cross-section, and these are more rapid to obtain than CSA. Some linear dimensions were defined and shown to be highly correlated with CSA in normal muscles.[9] Preliminary data from two patients with acute onset of LBP at the level of the 4th–5th lumbar vertebrae (L4-5), in whom bilateral scans were taken at the level of symptoms, indicated that multifidus CSA was markedly reduced on the symptomatic side of the spine. This indicated that ultrasound measurements may be useful for assessing patients but a controlled study was needed to establish the sensitivity of ultrasound measurements in determining the vertebral level of dysfunction.

If muscle wasting with low back pathology were due to disuse atrophy, perhaps from pain, a reduction in muscle size might be expected to be seen throughout the length of the muscle over different levels of the lumbar spine. Reflex inhibition can also occur, even in the absence of pain,[7] and has a more specific pattern of wasting. For example, with knee joint damage, afferent stimuli from the joint inhibit activation of alpha motor

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Table 1. Demographic Data for the Patients with Acute Low Back Pain

	Men	Women
n	16	10
Age (yr)		
Mean	29.2	33.6
SD	8.2	8.3
Range	17–46	19–43
Weight (kg)		
Mean	77.3	61.9
SD	9.2	13.2
Range	64–91	48–90
Height (m)		
Mean	1.78	1.62
SD	0.05	0.11
Range	1.7–1.92	1.5–1.8
Duration of symptoms (days)		
Mean	12.1	14.6
SD	13.9	16.6
Range	1–56	1–56

neurons to quadriceps via a spinal reflex mechanism.[7,11,24] If wasting in LBP patients were due to reflex inhibition, the segmental anatomical arrangement and innervation of the multifidus fascicles described earlier might dictate that the site of greatest wasting would be below the vertebral level of pathology and symptoms, i.e., where the bulk of these segmental fascicles is situated. Unilateral symptoms might also produce unilateral wasting, at least in the acute stage, which could be assessed by the degree of asymmetry of muscle size. Precise local examination of the muscle might therefore help to elucidate the mechanisms of muscle wasting in back pain patients, e.g., disuse atrophy or reflex inhibition.

The present study documented asymmetry of multifidus CSA and shape in patients with acute and subacute, unilateral, low back symptoms. Multifidus was examined at different levels of the lumbar spine to investigate the possible mechanism of the wasting seen in acute LBP. The correlation between CSA and linear measurements was also examined to see whether linear measurements could accurately predict CSA in patients and thus assess the clinical usefulness of RT ultrasound scanning. Part of this work has been published as an abstract.[23]

■ Method

All subjects gave their informed consent and the study was approved by the Medical Ethical Review Committees of the University of Queensland and Mater Hospital, Brisbane.

Patients. Twenty six patients (16 males), aged 17–46 years, suffering their first episode of LBP were studied. All had unilateral symptoms, some with pain referral to the leg. Subjects were recruited from the Accident and Emergency Department of the Mater Public Hospital and University of Queensland Physiotherapy Department Clinic. Most had no specific diagnosis other than acute or subacute LBP and were referred for physiotherapy. Patient demographic details and duration of symptoms are shown in Table 1.

Ten of the 26 patients had routine plain x-rays before referral. The x-rays were reported as being normal in nine cases and osteophytic lipping at L3-4 and L4-5 was present in one subject (AC; aged 46). A subsequent CT scan in one patient (AK) indicated a postero-lateral disc bulge, which encroached onto the thecal sac, at L5-S1. Exclusion criteria were previous history of LBP or injury, previous lumbar surgery, observable spinal deformity (e.g. scoliosis), neuromuscular or joint disease, and any sports or fitness training program involving the back muscles within the previous 3 months.

Clinical Examination. On referral to physiotherapy, subjects were examined by a manipulative physiotherapist. This assessment was performed independently of the ultrasound scanning, neither examiner being aware of the other's findings. The data extracted from this physical examination included the area of the patient's pain (as an inclusion criterion), their movement status, and the lumbar level from which the manipulative physiotherapist considered symptoms were arising.

The area of pain was mapped on a body chart but quality of pain was not evaluated. Active lumbar spine movements were examined. Because absolute measures of lumbar spine ranges of movement do not provide discriminating information in back pain patients due to large variability between individuals,[1,5] active movements were scaled to rank the effect of the back condition on the movements of lumbar flexion, extension, and lateral flexion. Based on the scale used by Stakovic and Olof,[20] a qualitative rating scale for each movement was comprised: zero for no pain; one for pain only at end of range; two when pain limited movement to a moderate degree; and three when pain severely limited movement. For later analysis, a movement index was calculated by dividing the total movement score by a factor of four (as there were four movements).

Straight leg raising (SLR) was measured using an oil-filled precision Rippstein goniometer[18] and any differences between sides associated with the production of back or leg pain was recorded. The degree of SLR was taken at the limit of tolerable pain or, in cases in which no pain was produced, it was measured in the usual manner. The technique of manual examination was used to identify the patient's symptomatic lumbar segment. This examination technique is commonly used by manipulative physiotherapists in clinical examination. It is still a controversial method and the number of studies investigating its sensitivity and specificity in detecting the symptomatic level are limited. However, two studies to date have addressed the issue, one in the cervical spine[13] and one in the lumbar spine.[12] In these studies, the accuracy of manual examination to detect the symptomatic level was tested against medical diagnostic methods of either nerve or facet blocks,[13] or provocative discograms.[12] The results of both studies indicate high levels of sensitivity and specificity of manual examination to nominate the painful level. More research is required to test the validity of manual examination but, as in other clinical studies of back pain,[2] it was used in the present study as the population investigated (first episode of back pain of recent onset) did not justify the use of more invasive diagnostic techniques such as zygapophysial joint or nerve blocks or, at the extreme, discograms or myelograms.

The techniques of manual examination for the lumbar segments are described in physiotherapy and medical texts on this subject.[4,16] In the present study, the segments from T12-L1 to

L5-S1 were tested in each patient. In principle, the examiner passively moves the lumbar segments while the patient is in a recumbent position. In side lying, motion is induced in each physiological direction using the pelvis as a lever and the tissue resistance to motion is palpated between the spinous processes of each adjacent lumbar level. When the patient is in the prone position, each segment is gently stressed with direct pressure applied through the spinous process. Clinical decisions on the symptomatic level are made on the basis of reproduction of the patient's pain on the test movements in conjunction with an abnormal quality or quantity of tissue resistance to segmental motion.

In the present study, a radiographer scanned the multifidus at each level of the lumbar spine and first sacral level while the physiotherapist independently examined each level for symptoms using manual examination. Two completely independent assessments were therefore made of the clinical evidence of back pain. To add to the research base of manual examination, some measure of its efficiency would be obtained if any relationships were determined between the nominated painful level and the pattern or site of any muscle wasting.

Normal Subjects. Fifty one volunteers (21 males, 30 females, aged 19–32 years) from among hospital and university staff and students were studied (Table 2). Exclusion criteria were as for the patients (except those relating to the patients' current back problems).

Ultrasound Scanning. The technique has been described in detail elsewhere.[9] Briefly, a real-time ultrasound machine (Acuson 128XP) equipped with a 5MHz curved (convex) array was used (Figure 1). With the subject lying prone, the lumbar spinous processes were palpated and marked on the skin with a pen. Warmed gel was applied to the skin, and the convex array placed transversely over the spinous process. An image that included both the right and left multifidus muscles simultaneously was then obtained. The image was stored on the screen and an electronic on-screen calliper was used to trace around each muscle border giving an immediate read-out of the muscle CSA. Two linear measurements were also made on each muscle cross-section and have been described previously.[9] These were defined as the greatest distance from border to border, and then the greatest distance perpendicular to this. These dimensions were in lateral and anteroposterior directions and were measured to examine whether their relationship with CSA was as close in wasted muscles as it is in normal muscles.[9]

Table 2. Demographic Data for the Normal Subjects Studied

	Men	Women
n	21	30
Age (yr)		
Mean	25.0	25.3
SD	4.9	3.4
Range	18–36	19–32
Weight (kg)		
Mean	72.8	59.7
SD	13.0	7.8
Range	52–96	49–78
Height (m)		
Mean	1.79	1.67
SD	0.75	0.61
Range	1.68–1.94	1.55–1.77

Figure 1. The real-time ultrasound scanner (Acuson 128XP) used to obtain images of the lumbar multifidus muscles. The transducer is being held over the muscle at the level of the 5th lumbar vertebra of a back pain patient lying in the prone position.

One investigator obtained the images on the screen and another investigator, who was blind as to the side and level of LBP symptoms in patients, made the measurements on the scans. Photographs of scans were taken for permanent records but measurements were not made on these. Bilateral imaging was performed in all subjects. In 20 patients and 10 normal subjects, multilevel images were made from the 2nd to the 5th lumbar vertebrae (L2-5) and in 6 patients from L2-S1. In 41 normal subjects, images were made at the L4 level.

The validity of ultrasound to measure CSA of multifidus at different lumbar levels has been established against measurements obtained by magnetic resonance imaging (MRI).[10] In that study, the lumbar multifidus was measured at five levels (L_2–S_1) on different days by two independent radiographers. The results revealed that there was no significant difference between measurements made by MRI and ultrasound at any level. The MRI scanning, through use of an axial pivot scan, provided definitive proof of lumbar level location, thus indicating that the specific lumbar level can also be made accurately by ultrasound.

The repeatability of the scanning technique of multifidus in the hands of one of the present investigators has been reported

Table 3. Profile of Patient Data

Patient	Level* US	Level* Clinical	% Difference CSA	Length of History (Days)	Pain Area	Movement Score (0–3)	SLR Difference (Degrees)
AK	L_5	L_5–S_1	46.4	8	(L) LB-L	2.5†	40
SA	L_5	L_5–S_1	46.4	12	(R) LB	0.8	10
RM	L_5	L_5–S_1	44.9	1	(R) LB	2.0	15
LM	L_5	L_5–S_1	39.6	1	(R) LB	0.5	0
SPH	L_5	L_5–S_1	37.5	9	(R) LB-B	0.8	0
AC	L_3	L_{3-4}	35.4	26	(R) LB	1.2	0
WS	L_4	L_{4-5}	35.3	7	(L) LB	0.5	0
MG	L_5	L_5–S_1	34.0	13	(R) LB	1.0	20
MS	L_5	L_5–S_1	33.3	14	(L) LB	1.0	0
MP	L_5	L_5–S_1	32.1	5	(R) LB	1.5	20
JP	L_5	L_5–S_1	31.8	4	(R) LB-B	1.2	2
DH	L_5	L_5–S_1	31.7	14	(L) LB-L	1.0	0
MW	L_5	L_5–S_1	31.6	14	(R) LB-B	0.5	6
SPe	L_5	L_5–S_1	30.8	9	(L) LB-T	0.25	0
WK	L_5	L_5–S_1	30.8	1	(R) LB	1.5	10
FS	L_5	L_5–S_1	30.3	21	(L) LB	1.0	2
VT	L_3	L_{3-4}	29.0	14	(R) LB	0	3
LC	L_5	L_5–S_1	28.6	56	(R) LB-T	1.0	20
EC	L_3	L_{3-4}	27.7	3	(L) LB	1.5	10
BN	L_4	L_{4-5}	27.3	3	(L) LB	0.25	0
GP	L_5	L_5–S_1	27.1	1	(R) LB	1.2	8
BRK	L_3	L_{3-4}	24.0	28	(R) LB-B	1.0	0
JH	L_4	L_5–S_1	22.9	3	(R) LB	2.0	20
HLS	L_4	—	19.6	15	(R) LB-B	0	8
	L_5	—	20.3				
AF	L_4	L_{4-5}	18.9	1	(L) LB	0.75	0
KC	L_5	L_5–S_1	14.5	56	(L) LB	0.5	18

* US—level of greatest percentage difference in CSA between sides measured by ultrasound; Clinical—symptomatic level as determined by clinical manual examination.
† Calculated on flexion and extension only as pain level too great for further examination.
SLR Straight leg raise = difference (degrees) between ranges on the right and left sides.
Area of pain: LB = low back; LB-B = low back with referral to buttock; LB-T = low back with referral to thigh; LB-L = low back with referral to lower leg.
Results are presented in order of degree of between-side difference in cross sectional area (CSA), i.e. wasting, which was always greatest on the symptomatic side.

previously and was shown to be very good.[9] Measurements repeated between days were made with a coefficient of variation (CV) of 6% and those repeated within-day with a CV of 4.9%. There are no known risks with the use of ultrasound imaging[21] which is used extensively in obstetrics.

Statistical Analysis. Symmetry of measurements between the two sides was assessed for muscle size and shape. The means, standard deviations, and ranges were calculated on each side, and for the percentage differences between sides. Muscle shape was determined by expressing the two linear measurements as a ratio (anteroposterior dimension divided by lateral dimension). Between-side differences in size and shape were examined between the larger and smaller muscles in normal subjects and symptomatic versus nonsymptomatic sides in LBP patients using the Mann-Whitney U test, which was also used to examine differences between groups.

Analysis of the multilevel data involved comparison of the degree of asymmetry between the different vertebral levels by analysis of variance (ANOVA). Duncan's multiple range test, which is a post hoc multiple comparison test, was used to examine for significant differences between the ANOVA results at the different levels.

Pearson's correlation was used to examine the relationships: between CSA and linear measurements (the latter being multiplied); and between the degree of asymmetry of CSA and the duration of symptoms, movement score and SLR difference. The chi-square test was used to compare the ultrasound and manual findings with respect to the level of symptoms.

■ Results

The US scans revealed that marked asymmetry, and thus wasting, of multifidus CSA occurred in each patient and was isolated to one vertebral level. This level corresponded to that identified by the manipulative physiotherapist as symptomatic in 24 of 26 patients (Table 3).

In one of the two patients (JH) in whom wasting and symptoms were not at the same level, wasting was greatest at L4, whereas the manual examination indicated symptoms at L5-S1. In the other patient (HLS), despite reports of back pain, no painful lumbar segments were found on manual examination yet considerable unilateral wasting was found at L4 (19.6% between-side difference) and L5 (20.3%). Omitting this one patient from analysis, the results indicate consistency between the segmental finding of muscle wasting and symptoms (chi-square, $P = 0.932$) and lend support to the efficiency of manual examination.

Muscle Wasting

Wasting in patients was demonstrated by asymmetry of CSA at the level of symptoms which was significantly greater ($P < 0.001$) than between-side differences in the normal subjects at all lumbar levels. This difference in asymmetry is illustrated for patients (n = 26) at the level of symptoms and normal subjects (n = 51) at L4 since this level was measured in all subjects (Figure 2). Such a comparison between the two groups is considered to be valid since the degree of asymmetry in normal subjects was similar at all vertebral levels (see below). In patients, the mean percentage between-side difference was 31 ± 8% (range 14–46%, $P < 0.001$) and in normal subjects 3 ± 4% (0–17%, $P < 0.001$) for the data in Figure 2. Only two patients had a difference of less than 20% and four normal subjects greater than 10% so the results were distinct for the two groups.

Multilevel Comparisons

Since the majority of patients showed greatest wasting at L5 (n = 17), the multilevel scan results for this group are illustrated to show the localized effect of pain (Figure 3a). Duncan's multiple-range test confirmed that results at L5 were significantly different from those at levels L2–4 ($P < 0.05$). Patients with symptoms at other levels showed the same phenomenon (see below). The normal subjects (n = 10) showed no differences ($P < 0.05$) between results at the different levels (Figure 3b).

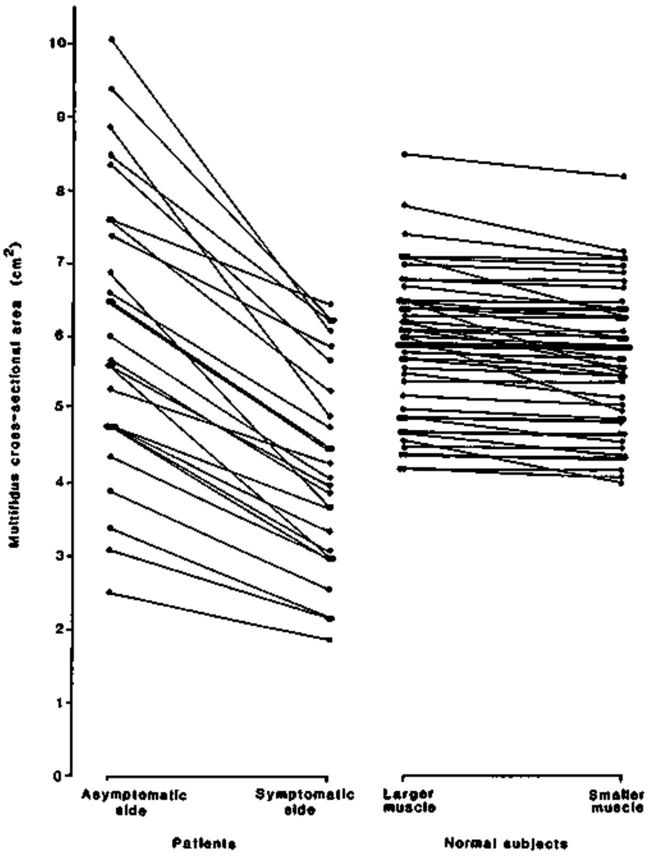

Figure 2. Between-side differences in multifidus cross-sectional area in low back pain patients (n = 26) who showed greater asymmetry than the normal subjects (n = 51). The degree of asymmetry was significantly different between the two groups ($P < 0.001$).

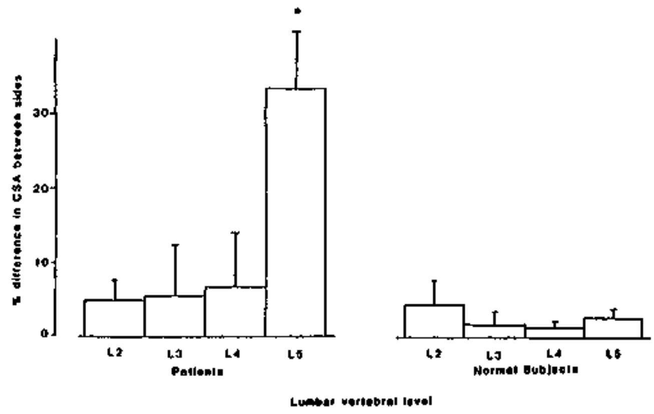

Figure 3. Multilevel scanning in (A) low-back pain patients revealed a marked between-side difference in multifidus cross-sectional area which was isolated to one vertebral level. Results for patients with symptoms at the level of the 5th lumbar (L5) vertebra (n = 17) are shown and smaller differences are seen at the 2nd to 4th lumbar levels (L2–4). Duncan's multiple range test showed that asymmetry at L5 was significantly different (*$P < 0.05$) to that at other levels. Results in (B) normal subjects (n = 10) were similar at all levels.

To examine wasting below the level of symptoms, which might indicate reflex inhibition, Duncan's test was also performed for measurements in relation to the vertebral level of greatest asymmetry. This was possible in 11 patients and the only significantly different results occurred at the level of symptoms (Figure 4).

Muscle Shape Ratios

Shape ratios were previously found to differ between normal males and females[9] and so the present data have

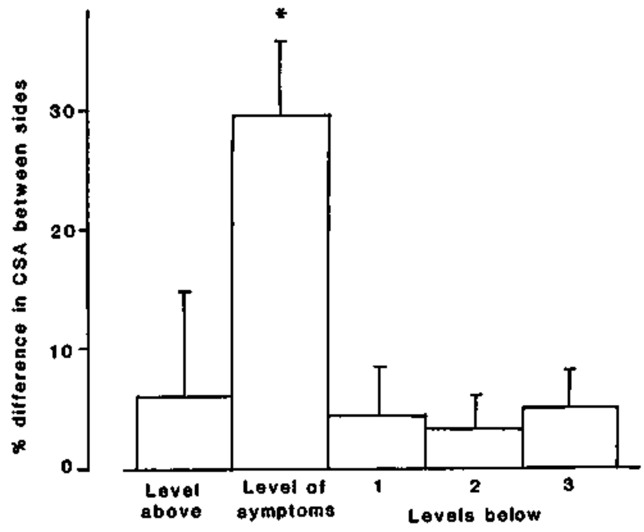

Figure 4. Levels below the site of greatest asymmetry and corresponding symptoms did not show large differences in multifidus cross-sectional area. This analysis included 11 patients (4 with symptoms at L3, 4 at L4 and 3 at L5). The numbers of observations at each level were: level above n = 11; level of symptoms n = 11; 1 level below n = 11; 2 levels below n = 5; 3 levels below n = 3. Duncan's Multiple Range Test showed that asymmetry at the level of symptoms was significantly greater (* $P < 0.05$) than that at the level above and levels below.

Table 4. Muscle Shape Ratios in Patients and Normal Subjects

	Shape Ratio		
	Symptomatic Side	Asymptomatic Side	Between-side Difference (%)
Patients			
Males			
Mean	1.11*	0.95	13
SD	0.17	0.13	
Females			
Mean	1.29***	1.01	21
SD	0.21	0.16	
Normal subjects	Larger value	Smaller value	
Males			
Mean	0.96	0.86	11
SD	0.10	0.12	
Females			
Mean	0.84	0.74	11
SD	0.15	0.15	

Significant difference between patients and normal subjects: * $P < 0.05$; *** $P < 0.001$.
Results show gender differences and also higher values (indicating rounder muscles) in patients, particularly on the side of symptoms.

been analyzed separately for gender. In patients at the level of symptoms, females had values for shape ratios that represented a rounder muscle shape than in normal females at L4 ($P < 0.001$). Ratios in male patients were also rounder than in normal males ($P < 0.01$) as shown in Table 4. The between-side differences in shape ratio were similar in both normal groups and male patients, whereas female patients showed greater asymmetry (Table 4).

Multifidus CSA and Linear Dimensions

The correlations between multifidus CSA and the linear dimensions (multiplied) at the level of symptoms in patients and L4 in the normal subjects are shown in Table 5. Correlations were highest in the normal subjects and on the non-symptom side in male patients and poorest on the symptomatic side in male patients and on both sides in female patients.

Clinical Findings in Patients

The clinical profiles obtained from the patient examination are presented in Table 3. Seventeen patients had LBP only while in five, pain was also referred to the buttock, two into the posterior thigh and two down to the leg. The manual examination techniques produced pain at only one lumbar level and there was no referral of pain to other specific segments on testing. The value presented for the SLR test in Table 3 is the difference between the range on the two sides. In 15 patients, SLR produced back pain, and in five patients, it produced leg pain. In the remaining six patients, SLR did not produce symptoms.

Table 5. Correlations (r) Between Linear Dimensions (Multiplied) and Multifidus Cross-sectional Area in Patients with Low Back Pain and Normal Subjects

	Men	Women
Patients		
Symptom side	0.75	0.85
Non-symptom side	0.96	0.85
Normal subjects		
Larger side	0.97	0.92

Relationship Between Objective and Clinical Findings

As can be readily deduced from Table 3, there was no relationship between CSA % difference and the duration of symptoms ($r = -0.34$), movement index score ($r = 0.37$) or difference in SLR ($r = 0.18$). In patients with symptoms for less than 14 days ($n = 20$, range 1–13 days, median 7.5) the between-side difference in CSA was 33 ± 7% (range 19–46%) and in those with a history longer than 15 days ($n = 6$, range 15–56 days, median 26) the difference was 25 ± 8% (14–35%). The CSA difference therefore tended to be greater in the more acute patients ($P < 0.05$).

Discussion

Unilateral wasting of multifidus on the symptomatic side could be detected by RT ultrasound imaging in acute LBP patients and this was isolated to one vertebral level. The greatest effect of pain on muscle size occurred at the same vertebral level as symptoms, found on clinical manual examination, in the majority of patients (24 of 26). The severity of wasting (reflected by the degree of asymmetry) was not related to the severity of any of the clinical indicators of abnormality.

The rapidity of onset and localized distribution of wasting suggests that disuse atrophy was not the cause and that a selective mechanism was in operation. It was hypothesized that if reflex inhibition occurred, the greatest wasting would be seen below the level of symptoms but this was not found (Figure 4). Another possibility was selective atrophy of the shorter laminar fibers of multifidus but these are infrequently present and only contribute a very small percentage to multifidus CSA.[3] Furthermore, the close proximity of multifidus to the zygapophyseal joints might be expected to cause wasting from local effects but some of the present patients had symptoms suggestive of disc involvement (confirmed in one patient) which is not directly associated with the multifidus muscle. The asymmetry at the level of symptoms did not indicate hypertrophy on the asymptomatic side since values for CSA on this side were consistent with those at adjacent levels and the only CSA value which did not conform was that at the site of symptoms.

Despite the nonspecific, and probably varied, diagnoses of the patients, all but one showed marked asymmetry at one vertebral level indicating that this may not have been due to a local effect. Wasting at the level of symptoms may be explained by inhibition from perceived pain, via a long loop reflex, preventing movement to protect structures at the level of pathology. The rapid onset of wasting may indicate a metabolic effect of inhibition. One possibility is that the circulation could be decreased by muscle spasm, thus influencing muscle metabolism. The rounder shape of the muscle in the LBP patients, indicated by the shape ratio, suggested that spasm was present.

In the chronic situation, a CT scan study found generalized atrophy but also relative increases in multifidus CSA on the symptomatic side.[22] This finding is consistent with histologic evidence of type I fiber hypertrophy and type II fiber atrophy[8] and also increased paraspinal muscle activation in chronic LBP.[6] These long-term changes may indicate an adaptative response to muscle wasting.

The high correlation between CSA and linear measurements found in the normal subjects in this and a previous study[9] validates their use when the muscle is not wasted. The sensitivity of linear measurements for assessing CSA is reduced in wasted muscles (Table 5) and measurement of CSA is therefore more accurate. Real-time ultrasound studies have also found high correlations between linear and CSA measurements in the normal anterior tibial muscles[17] and quadriceps[25] but the latter study found that linear measurements were poor predictors of muscle wasting.

The lack of correlation between the severity of wasting and clinical findings is similar to that seen between the severity of quadriceps inhibition with knee joint pathology and the absence of pain and obvious effusion.[19,24] The clinical importance of this discrepancy is that patients thought to have relatively trivial symptoms can have marked wasting which can be missed by clinical examination alone.

Although the muscles on the 'uninjured' side of the spine may not always be 'normal', between-side differences in CSA are at least detectable in the acute phase. Asymmetry, however, may be normal in some subjects, e.g., sports involving predominantly unilateral use of muscles. The significant between-side differences in CSA in the present normal subjects were not clinically significant since a degree of asymmetry is to be expected. Documentation of the degree of normal asymmetry is more important than the level of significance to provide reference data for comparison with patients. In the present group of patients, there was a tendency for the asymmetry of CSA to decrease with time indicating that either wasting on the contralateral side was occurring or that there was improvement on the injured side. The usefulness of assessment of asymmetry may therefore be limited to the acute phase after onset of LBP. Despite these considerations, serial monitoring of a muscle, without between-side comparisons, may still be useful.

The shape of the multifidus was slightly ovoid in the transverse direction in the present normal males and flatter in the females. Possible reasons for these differences have been discussed previously.[9] The female patients had rounder muscles than normal, perhaps indicating muscle spasm (Table 4). Normal males have fairly round muscles but the male patients had even rounder muscles on the symptomatic side so spasm was probably present although may be less evident than in females.

In conclusion, the localization of multifidus wasting to the side and level of symptoms indicates that wasting may be due to inhibition from perceived pain via a long-loop reflex pathway. The lack of correlation between ultrasound measurements and severity of symptoms highlights the need for objective measurement in the assessment of LBP patients.

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Measurement of Quadriceps Cross-sectional Area by Ultrasonography: A Description of the Technique and its Applications in Physiotherapy

Maria Stokes and Archie Young

The effect of physiotherapy on muscle growth can be evaluated by direct measurements of the individual muscle concerned, eg. using ultrasound B-scanning. The technique is suitable for adoption by physiotherapists to use independently or in collaboration with specialists in diagnostic imaging. Details of the technique are described, and the difficulties met while making and interpreting the scans are discussed. The purpose of this paper is to stress the importance of muscle-size measurements and to encourage physiotherapists to use ultrasound scanning to obtain them.

INTRODUCTION

Physiotherapists spend a lot of time helping patients build up their muscles, yet there are very few objective tests to evaluate the effects of treatment. Strength measurements, while very useful, are not always appropriate e.g. when reflex inhibition, pain, or fear of pain are present. Measurements of muscle bulk cannot be made accurately with a tape measure due to the presence of varying amounts of subcutaneous fat and other muscles in the limb. Muscle wasting (Young *et al.*, 1982) and muscle growth (Young *et al.*, 1983) are seriously underestimated by the tape measure.

Grey-scale ultrasound B-scanning produces an image of the muscle which allows accurate measurement of its cross-sectional area (CSA) (Ikai & Fukunaga, 1968; Young *et al*, 1980). Computerised axial tomography (CAT) (Haggmark *et al*, 1978), and nuclear magnetic resonance (NMR) are other imaging techniques which can also be used to measure muscle CSA. The advantages of ultrasound over these methods are: that ultrasound equipment is readily available in most hospitals, there is no exposure to radition, and it can be used independently by a physiotherapist. Various muscles can be measured using ultrasound but this paper describes scanning of the quadriceps. Details of the technique (including a small repeatability study) and the problems encountered are described.

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SUBJECTS STUDIED

Including the five normal subjects in the repeatability study, 52 normal subjects (who took part in research projects) and 12 patients have been scanned by one of the authors who is a physiotherapist. The subjects included two orthopaedic patients who had persistent problems of quadriceps weakness due to knee joint injury and ultrasound scanning was used to aid evaluation of their treatment. The other patients had endocrine 'myopathies' and were being studied during their medical treatment.

METHOD OF SCANNING THE QUADRICEPS

The machine used is a compound B diagnostic ultrasound scanner with grey scale attachment (A Nuclear Enterprises, 'Diasonograph NE 4200' is used but other compound B scanners would be satisfactory). The frequency which produces the clearest definition for scanning the quadriceps (2.5 MHz) is similar to those used in therapeutic ultrasound (0.75–3 MHz) but the power is about 1/100 of that used for treatment (Lunt, 1977). A water-based coupling medium is used in preference to oil as it produces better definition of the image. When the probe is placed on the skin the ultrasound beam is reflected back to the probe from tissue interfaces which are at 90° to the beam and these appear as dots on an oscilloscope screen (Fig 1). The probe is moved around the surface of the thigh in a sweeping fashion and the dots become lines (Fig 2). Gradually an image of a slice through the thigh is built up on the screen. If the image is satisfactory it can be photographed (Fig. 3).

Routinely, scans are made at mid-thigh which is defined as halfway between the most prominent point of the greater trochanter and the lateral joint line of the knee (Young *et al.*, 1980). At this

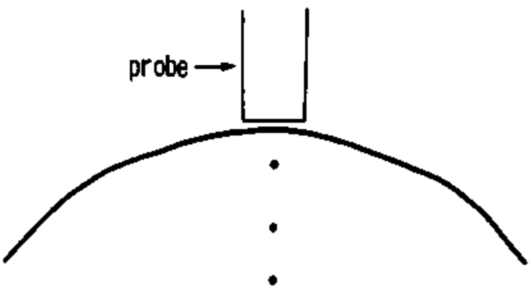

Fig. 1 The ultrasound beam is reflected back to the probe from tissue interfaces which it strikes at 90°. The interfaces appear as dots on the oscilloscope.

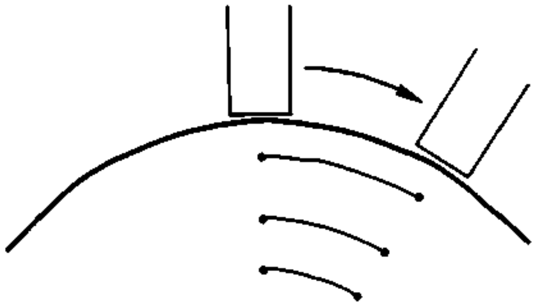

Fig. 2 As the probe is moved around the surface of the thigh, the dots become lines building up a picture of a cross-section through the thigh.

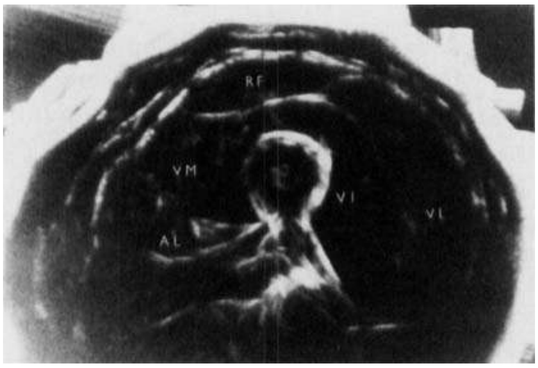

Fig. 3 Scan of a transverse section through mid-thigh. VL=Vastus Lateralis, VM=Vastus Medialis, RF=Rectus Femoris, VI=Vastus Intermedius, AL=Adductor Longus.

level in the thigh all the four heads of quadriceps are well represented (although not in equal proportions). When scanning is to be repeated at a future date, a mark at the level of the scans is traced on to a transparent sheet together with permanent skin blemishes e.g. freckles and scars, to allow accurate relocation of the site (Dons *et al.*, 1979). The subject lies supine with the knee extended and the hip is slightly flexed (5°) by supporting the leg with sandbags behind the knee and ankle. The scanning probe is mounted in a gantry which is positioned over the subject. The angle of the hip in which the leg is supported allows the probe to scan from the postero-lateral aspect of the thigh, therefore completing the muscle outline. The scanning gantry is tilted through an equal angle so that scans are made at 90° to the thigh.

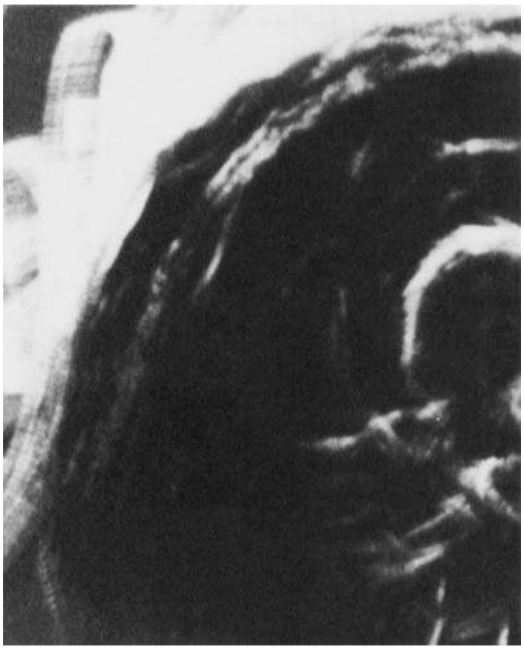

Fig. 4 Medial part of the thigh before completion of scan.

Fig. 5 Indentation of the probe into the thigh has allowed better definition of the boundary (arrowed) between vastus medialis and adductor longus.

The medial part of the thigh is scanned first, and detail occasionally becomes obscured after scanning the lateral side. In such instances scanning is restarted, the medial part is photographed (Fig. 4), and then the rest of the scan is completed. Certain parts of the muscle outline are sometimes difficult to define (*vide infra*) so the scan is first photographed to preserve the basic outline and then extra coupling medium is placed at sites where, by indenting the skin with the probe, the ultrasound beams can be directed at 90° to the ill-defined tissue interface (Fig. 5). The extra coupling medium also serves to 'build up' the surface. Each subject has 4 scans taken of each thigh, and these are photographed. The quadriceps' outline is later traced from each scan and its CSA measured with a MOP electronic planimeter (Reichert-Jung). The mid-thigh CSA of a single quadriceps on a single visit is calculated as the mean of the results of four scans. The total time taken to obtain the four scans on two thighs, photograph and develop them, is between 1/2 and 3/4 h. Obviously this would be too time-consuming for routine clinical practice, but would be acceptable in some clinical situations and in research.

Repeatability study

Five female volunteers from the hospital staff at the Nuffield Orthopaedic Centre, Oxford took part (Table 1). None of them had muscle, neurological or joint disease. Each subject had both quadriceps scanned on two occasions (ranging from 3–11 days apart). There was good

Table 1
Bilateral measurements of quadriceps cross-sectional area at mid-thigh, made on two occasions, in five normal women—repeatability study

		Quadriceps CSA (cm^2)					
		Right			Left		
Weight (kg)	Age (Age)	Day 1	Day 2	CV (%)	Day 1	Day 2	CV (%)
53	40	39.3	40.2	1.6	41.2	42.1	1.5
60	24	45.2	47.4	3.4	47.8	47.3	0.7
72	31	54.7	56.6	2.4	48.4	49.2	1.2
80	28	70.4	68.3	2.0	67.4	68.6	1.2
82	24	53.8	53.5	0.4	50.6	53.5	3.9
		Mean CV=2.0%			Mean CV=1.7%		

CSA=Cross-sectional area

$$CV=\text{Coefficient of variation}=\frac{\text{Standard Deviation}}{\text{Mean}}\times 100$$

agreement between the values for quadriceps CSA obtained on the two occasions for all five subjects (Table 1). The coefficient of variation between the visits was 2% which was lower than that previously reported (4%) by Young *et al.* (1980). This difference may have arisen because the earlier study's method for re-locating mid-thigh (by measuring the height from the floor) was not as reproducible as using a transparent sheet. This small study showed that measurements made independantly by a physiotherapist were at least as repeatable as those previously reported.

Difficulties in making and interpreting the scans

Learning how to operate the equipment was not difficult, but much practice was required to produce an image which was not distorted by compression with the probe, but which still showed good definition of the complete perimeter of the quadriceps (Fig. 3). When scanning lean thighs, the muscle was easily distorted by compression, and the smaller amounts of inter-muscular fat led to poorer definition of muscle boundaries; males were more difficult to scan than females as they tended to have less fat.

Two parts of the muscle outline which were often awkward to define were the boundaries between biceps femoris (short head) and vastus lateralis, and between vastus medialis and adductor longus (Fig. 3). The slight elevation of the thigh and occasional deliberate indentations of the skin improved these boundaries.

Including the repeatability study, 64 subjects have been independently scanned on 90 occasions (Table 2). Of 704 scans, only 20 were not measurable (the accuracy of interpretation of the outline was judged at the time of tracing the scans). The outlines were not satisfactory in one scan from each of 11 subjects, and two scans from each of three subjects. On one occasion, three scans from one patient were destroyed due to problems with the camera. Normally three more would have been taken to replace these but the patient had severe chronic bronchitis and was unable to remain lying for more scans. Although 3% of the scans were rejected, measurements of quadriceps CSA were successfully obtained for all of the subjects.

Table 2
Total number of scans taken

	Normal subjects	Patients	Total
Number of subjects	52	12	64
Number of occasions	58	32	90
Scans taken	464	240	704
Scans not measured	4	16	20 (2.8%)

Research and clinical applications of ultrasound scanning

Ultrasound scanning used in studies of muscle wasting e.g. (Young *et al.*, 1982) showed that a 5% reduction in mid-thigh circumference (measured using a tape measure) may conceal a 22–33% reduction in quadriceps CSA. Muscle growth studies have also included the use of ultrasound scanning (Ikai & Fukunaga, 1970; Young *et al.*, 1983).

A normal range for the close relationship between quadriceps' size (using ultrasound scanning) and its isometric strength has been established for normal subjects of different ages (Young *et al.*, 1984 & 1985). Isometric strength was measured with the subject seated, the hip and knees at 90° and the lower leg dependant (Edwards *et al.*, 1977). An inextensible strap, which was placed around the ankle (just above the malleoli), was attached to a strain gauge at the back of the chair. As the subject tried to straighten his knee, the force exerted at the ankle was recorded on an oscillograph. The ratio of quadriceps strength to its CSA is the same in young and old women (Young *et al.*, 1984) and in old men, but in young men the relationship is not so straightforward (Young *et al.*, 1985). The close relationship in females was used to evaluate the relative contributions to weakness of atrophy and inhibition in two female patients with knee pain and severe unilateral quadriceps wasting (Fig. 6). The quadriceps strength of their injured limbs was inappropriately low for the size of their atrophic quadriceps. This suggested inhibition of quadriceps contraction, either due to pain or some other stimuli from the injured knee (Stokes & Young, 1984). One of the patients received an

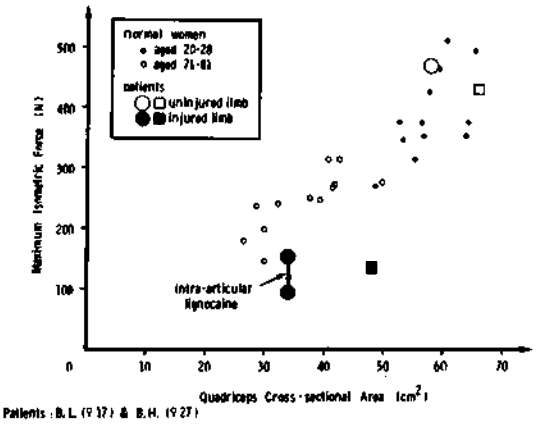

Fig. 6 The evaluation of atrophy and inhibition in sports medicine. The quadriceps size and strength of two female patients with unilateral knee pain are shown in relation to the normal female range. (See text for explanation of effect of intra-articular lignocaine.)

injection of lignocaine into the knee joint which enabled her to exert more force, confirming that the discrepancy between the original strength and that expected for the size of the muscle was due, at least in part, to afferent stimuli from the knee. These investigations made important contributions to the correct selection and evaluation of rehabilitation received by these two patients. Also, they suggest that serial measurements of quadriceps size might be more valuable than strength measurements in patients with inhibition (whether voluntary or involuntary), particularly those with joint disease.

Future work, involving scanning the thigh at different levels, might provide evidence for or against theories of selective atrophy and hypertrophy of the different heads of the quadriceps.

Ultrasound scanning has been used to look at muscle in other ways apart from measuring its size. For example, it has been used for investigating dystrophic muscle (Heckmatt *et al.*, 1980). Fornage *et al.*, (1982) used ultrasound to detect muscle lesions in athletes and were able to accurately assess their severity before embarking on surgical repair. In a case report of a patient with pyomyositis, real-time (RT) ultrasound and CAT scanning were used for diagnosis, and RT scanning was also used to guide percutaneous drainage of the abcess, thus avoiding surgery (Yousefzadeh *et al.*, 1982).

CONCLUSIONS

Ultrasonography could be used to make measurements of muscle size which are essential in research and valuable in the clinical evaluation of treatment. It is hoped that this paper will encourage other physiotherapists to adopt the technique and that as its use becomes more widespread, so too will its applications in other areas of physiotherapy.

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Long-Term Effects of Specific Stabilizing Exercises for First-Episode Low Back Pain

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Study Design. A randomized clinical trial with 1-year and 3-year telephone questionnaire follow-ups.

Objective. To report a specific exercise intervention's long-term effects on recurrence rates in acute, first-episode low back pain patients.

Summary of Background Data. The pain and disability associated with an initial episode of acute low back pain (LBP) is known to resolve spontaneously in the short-term in the majority of cases. However, the recurrence rate is high, and recurrent disabling episodes remain one of the most costly problems in LBP. A deficit in the multifidus muscle has been identified in acute LBP patients, and does not resolve spontaneously on resolution of painful symptoms and resumption of normal activity. Any relation between this deficit and recurrence rate was investigated in the long-term.

Methods. Thirty-nine patients with acute, first-episode LBP were medically managed and randomly allocated to either a control group or specific exercise group. Medical management included advice and use of medications. Intervention consisted of exercises aimed at rehabilitating the multifidus in cocontraction with the transversus abdominis muscle. One year and three years after treatment, telephone questionnaires were conducted with patients.

Results. Questionnaire results revealed that patients from the specific exercise group experienced fewer recurrences of LBP than patients from the control group. One year after treatment, specific exercise group recurrence was 30%, and control group recurrence was 84% ($P < 0.001$). Two to three years after treatment, specific exercise group recurrence was 35%, and control group recurrence was 75% ($P < 0.01$).

Conclusion. Long-term results suggest that specific exercise therapy in addition to medical management and resumption of normal activity may be more effective in reducing low back pain recurrences than medical management and normal activity alone. [Key Words: multifidus, low back pain, rehabilitation] **Spine 2001;26:E243–E248**

The major costs of low back pain (LBP) have been identified with two groups: those who develop chronic LBP and those who have recurrent disabling episodes of LBP.[12] These two groups incur 85% of the total costs.[13,23,33] Efforts have been made to identify the 2–3% of patients who go on to develop chronic symptoms,[22] but little is known about the factors that lead to recurrence.

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It is documented and generally accepted that a single episode of acute LBP has a favorable natural history with respect to symptom reduction and restoration of function and work capacity in the short term.[1] In the majority of cases, the pain associated with an initial acute episode resolves within 2–4 weeks.[5,7–11,21] It is estimated that 2–3% of patients go on to develop disabling chronic LBP after an acute episode.[5,18,22] However, the course of LBP for most primary care patients is recurrent rather than acute or chronic in the usual sense of these terms.[39]

When the frequency of low back pain recurrences following an acute episode is examined, the recurrence rate is found to be staggeringly high. Recurrence rates range from 60% to 86% for patients suffering recurrences, particularly in the first year after the acute episode.[3,35–37] Bergquist-Ullman and Larsson[3] conducted a detailed study of 217 workers in an industrial setting in Sweden. The median duration of pain for the initial episode was 35 days and short-term resolution of painful symptoms occurred in the majority of cases (70% within 2 months, 86% within 3 months). However, during the 1-year follow-up, 62% of the patients experienced at least one recurrence of LBP and a further 36% experienced two or more recurrences. The median time from resolution of the initial episode to the first recurrence of LBP was only 2 months. These high figures would suggest that it is important to identify the factors that may relate to this vulnerability to recurrence.

Although several processes are likely to be involved, the model provided by Panjabi[26,27] could provide an explanation for recurrences after painful symptoms have subsided. This model of spinal stability encompasses the passive, active, and neural control subsystems. It has been proposed that instability at the spinal segmental level is a loss of control or excessive motion in the spinal segment's neutral zone, which is associated with injury, degenerative disc disease, and muscle weakness.[26,27] It has been shown in *in vitro* biomechanical studies that muscles can provide segmental stabilization by controlling motion in the neutral zone, and the neutral zone can be returned to within physiologic limits by effective muscle control.[14,28,41] While various muscles may be able to control and protect the spinal segments, one muscle that has been investigated in relation to this role is the lumbar multifidus. The multifidus provides segmental stiffness and controls motion in the neutral zone.[14,28,34,41] Further evidence of this stabilizing role has been provided by *in vivo* animal research.[20] Investigations have also demonstrated a relation between multifidus muscle dysfunction and poor functional outcome and recurrence of LBP following disc surgery.[29,32]

Optimal functioning of the muscle system is desirable to control and protect the spinal segments following injury. Despite initial resolution of painful symptoms, failure to protect spinal segments could increase the likelihood of a recurrence of symptoms. Specific exercises targeting the multifidus and transversus abdominis muscles have been shown to decrease pain and disability in chronic low back pain patients.[25] Our research has shown the occurrence of localized segmental dysfunction of the multifidus muscle after an initial episode of acute unilateral LBP.[15,16] To establish the low back pain recurrence rates in the two groups, the present study presents the follow-ups of the patients from the study at 1 year and 3 years after treatment.

■ Methods

During a 6-month period, patients were recruited from a hospital accident and emergency department.[16] Men and women were eligible for the initial study if they were aged 18 to 45 years, were experiencing their first episode of unilateral mechanical LBP for less than 3 weeks, and presented to the accident and emergency department because of this condition. Inclusion and exclusion criteria are provided in detail elsewhere.[16] Thirty-nine patients were accepted into the study. All patients gave their consent and the Medical Ethical Review Committees of the University of Queensland and the Mater Adult Hospital, Brisbane, Australia approved the study.

Assessment Procedures. Assessments for the short-term phase of the trial were performed by two independent examiners, who were blinded to group allocation and patient presentation. The following assessments were conducted to establish baseline levels and to monitor improvement over time: pain (McGill Pain Questionnaire and Visual Analogue Scales), disability (Roland Morris Disability Index), range of motion (using inclinometers), habitual activity levels,[2] and muscle cross-sectional area (using ultrasound imaging).[16] The aim of the long-term follow-ups was to determine the incidence of recurrence of LBP. To meet this aim, a telephone questionnaire was selected as the most appropriate assessment tool. Methodologic research has indicated that well-designed telephone interviews provide results comparable to face-to-face interviews[6] and investigations of pain data obtained in this way also support the validity of telephone interviews.[38,39] The questionnaires were administered by a research assistant who was not involved in the first stage of the study and who was blind to group allocation. The questionnaires used to determine the recurrence rate of LBP episodes during the 1-year and 3-year year follow-up periods were devised especially for the patients in this study, as the information sought was specific to the design and methods implemented. The questionnaire consisted of three groups of questions, and took approximately 5 minutes to complete. Questions related to episodes of LBP experienced in the year after the study (1-year follow-up) and then in years two to three (3-year follow-up). A general opening question was used to determine whether patients had experienced any episodes of LBP in the time period in question. Subsequent questions determined the number of episodes experienced in that time frame, their length, severity, precipitating factors, and treatment sought. Ideally, it would have been useful to reimage the patients' multifidus muscles. This was not possible because many of the patients had relocated interstate or overseas.

Intervention and Patient Management. Patients in Group 1 (control group) received medical management, including advice on bedrest, absence from work, prescription of medication, and advice to resume normal activity as tolerated, whereas those in Group 2 (specific exercise group) additionally performed specific localized exercises aimed at restoring the stabilizing protective function of the multifidus. The exercises were designed specifically to activate and train the isometric holding function of the multifidus muscle at the affected vertebral segment (in cocontraction with the transversus abdominis muscle). Contraction of the multifidus was confirmed by real-time ultrasound imaging. This rehabilitation approach is described in detail elsewhere.[17,19,30,31] The intervention period was 4 weeks, and patients from the specific exercise group were seen twice per week in this period.

Statistical Analysis. Data analysis was performed using the SPSS statistics program. Comparability of baseline measurements between the two groups was assessed using a one-way analysis of variance (ANOVA) to examine differences in all baseline measurements. ANOVA also was used to examine differences between groups over time for all outcome measures used. For ultrasound imaging data, the percentage difference between the painful and nonpainful side was calculated for each vertebral level measured. Analysis of muscle recovery was conducted using the data from the most affected vertebral level (*i.e.*, the vertebral level with the largest percentage difference between sides). For the 1-year and 2–3-year follow-up analysis, the data were expressed as the likelihood of recurring LBP in the control group relative to that in the intervention group. A relative risk ratio of 1.00 indicates that patients in both groups were equally likely to report recurring LBP. A large risk ratio indicates that the treatment was effective, while a ratio less than one would indicate that the treatment increased the likelihood of recurrence. The significance of the treatment was determined with a χ^2 test. Because the three patients who were lost for 2–3-year follow-up were all from the control group, the analysis was repeated using the "best case" analysis, assuming that the three patients had all completely recovered, and did not suffer recurrences in this period.

■ Results

Study Sample

Patients were randomly allocated to Group 1 (control, n = 19) or Group 2 (specific exercise, n = 20). The demographics for the groups are shown in Table 1.

Baseline Characteristics

Comparability between groups was found to be satisfactory at baseline for age, height, weight, duration of symptoms, premorbid activity, and outcome measures used.[16]

Primary Outcomes for Weeks 1–4

Results of the short-term study have been presented in detail in an earlier report,[16] but in summary, ultrasound imaging revealed that asymmetry of the multifidus muscle was present with diminished muscle size evident on

Table 1. Demographic Data for Groups 1 (Control) and 2 (Specific Exercise)

	Group 1 (Control) n = 19			Group 2 (Specific Exercise) n = 20		
	Mean	SD	Range	Mean	SD	Range
Age (years)	31	8	17–45	31	7	22–44
Gender	9 male, 10 female			7 male, 13 female		
Height (cm)	173	7	159–187	171	10	157–185
Weight (kg)	73	13	51–105	72	17	52–113
Duration of Symptoms (Days)	9	7	1–21	8	8	1–21
Smokers	7	—	—	4	—	—
Worker's Compensation	5	—	—	8	—	—
Pre-morbid Activity Levels						
Work	3	.8	1.8–4.1	3	.7	1.6–4.3
Sport	2.3	1	1.5–4.3	2.8	1	1.5–4.8
Leisure	2.5	.6	1–3.8	2.6	.5	1.5–3.8

the patient's nominated painful side in all cases. The difference between the sides at the most affected vertebral level was expressed as a percentage of the CSA for the unaffected side at that level. The mean of these percentages was 22% ± 8.7% for the control group and 26% ± 8.7% for the specific exercise group (range, 12–46%). Results at follow-up immediately after the intervention period and at a 10-week follow-up examination revealed that multifidus muscle recovery was not spontaneous on remission of painful symptoms in control group patients. In the control group, multifidus CSA at the most affected vertebral level remained 16.8% ± 9.3% less at 4 weeks and 14% ± 6.3% less at ten weeks. Muscle recovery was more rapid and more complete in patients in Group 2 who received specific and localized exercises (P = 0.0001). Multifidus CSA at the most affected vertebral level was only 0.7% ± 2.5% less at 4 weeks and 0.2% ± 3.3% less at ten weeks. The other outcome measurements of disability and physical function were similar for the two groups at the 4-week examination (pain and disability had completely resolved in 90% of the patients). Although they resumed normal levels of activity, patients in Group 1 still exhibited significantly decreased multifidus muscle size at the 10-week follow-up examination, and the difference between groups was still significant ($P = 0.0001$).

Long-Term Follow-Up

Study Sample The response rate to the questionnaire at 1 year was 100%, with all 39 patients interviewed. Three patients could not be contacted for the 3-year interview, despite records of work, residence, mobile phone, and stable relative contact. All three were from the control group. For the 3-year follow-up interview, questions related to recurrence of symptoms in the previous 2 years.

Overall Recurrence Rate and Risk of Recurrences

Results of the contingency χ^2 analysis revealed that, in the year after the initial episode, patients in the control group were 12.4 times more likely to experience recurrences of LBP than patients in the specific exercise group (x^2 (1) = 12.41, $P < 0.001$). Additionally, these patients were 9 times more likely to experience LBP recurrences in years 2–3 (x^2 (1) = 9.31, $P < 0.01$). The risk of pain for each group is presented in Table 2, along with confidence intervals. In year 1, approximately 1 patient in the specific exercise group reported pain for every 3 patients who did not, whereas approximately 4 patients in the control group reported recurrences for every 1 that did not. In years 2–3, the likelihood of reporting recurrences of LBP in the exercise group increased slightly to around 2:5, while the likelihood of recurrences in the control group reduced to 10:3. A repeat analysis of the data using the best case analysis revealed that patients in the control group were still 5.9 times more likely to suffer recurrences of LBP than patients in the specific exercise group in years 2–3 (x^2 (1) = 5.92, $P = 0.015$). Figure 1 shows the pattern of recurrence over time for each patient of the two groups. Figure 1(a) shows the control group patients' recurrence patterns and 1(b) shows the specific exercise group patients' recurrence patterns.

Number and Severity of Recurrent Episodes

For the first year, the mean number of episodes reported by those in the control group was 4.2 ± 3.4 compared with 2.8 ± 2 episodes on average for the specific exercise group. Recurrent episodes of LBP were rated as "as se-

Table 2. Risk of Recurrent Episodes of LBP and Confidence Limits for Each Group in Year 1 and Years 2–3

	Year 1			Year 2–3		
	Risk	95% Confidence	Limits	Risk	95% Confidence	Limits
Exercise	.33	.16	.68	.37	.17	.81
Control*	4.12	1.43	11.88	3.35	1.33	8.44

* Less than 5 subjects in the control group reported no recurrences of LBP in both years.

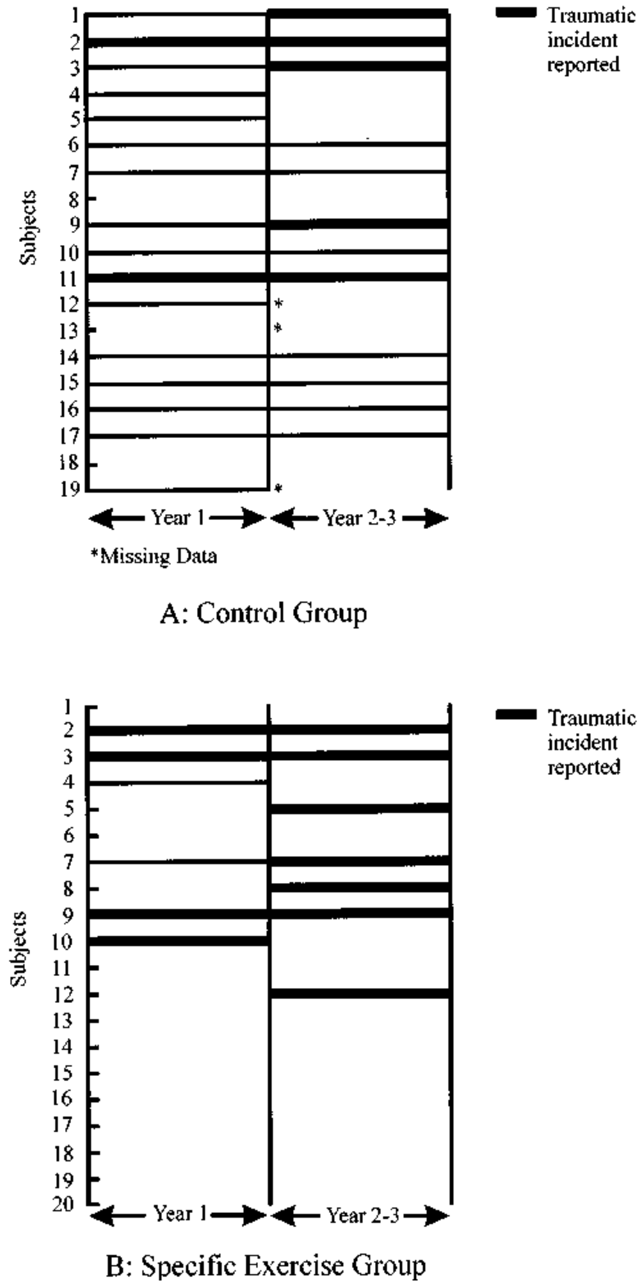

Figure 1. Pattern of LBP recurrence over time for each patient of the two groups. **A,** Control group. **B,** specific exercise group. 16 of 19 (84%) of the control group reported recurrences in the first year after the acute episode compared with 6 of 20 (30%) of the specific exercise group. In years 2–3, of the 16 patients from the control group who had experienced recurrences in the first year, 2 were lost to follow-up. 12 of 14 (86%) of the control group patients who experienced recurrences in the first year reported continuing recurrences. For years 2–3 there were recurrences reported in 12 of 16 (75%). For the specific exercise group, of the 6 who experienced recurrences in the first year, 4 continued to have recurrences during years 2 and 3. Three subjects who had not experienced recurrences in the first year reported acute injuries during years 2 through 3, with 7 of 20 reporting recurrences in years 2 through 3.

vere” as the original episode by 9 of 16 (56%) of the control group and 2 of 6 (33%) of the specific exercise group. For years 2–3, of those who experienced recurrences, 5 of 12 of the control and 4 of 7 of the specific exercise group reported persistent low level LBP that was subsequently aggravated by activities such as lifting. The number of specific episodes reported by the remaining patients in the two groups were similar (control group, mean = 5 ± 3.8 episodes, specific exercise group, mean = 4.6 ± 6.7). Recurrent episodes of LBP were rated as “as severe” as the original episode by 2 of 12 (17%) of the control group and 1 of 7 (14.2%) of the specific exercise group.

Precipitating Factors

At 1 year, a traumatic incident initialed the recurrences in 3 of 16 (19%) of the control group. These included bending and lifting (2 patients) and a trampoline accident. In contrast, 4 of 6 (67%) of the specific exercise group could relate traumatic incidences to recurrences. These included carrying a patient and slipping, heavy lifting (2 patients), and an incident that involved pulling a heavy sail on a boat. For years 2–3, a traumatic incident was related to recurrences in the preceding 2 years by 5 of 12 (42%) of the control group, and all (7 of 7) of the patients from the specific exercise group who experienced recurrences. The three patients in the specific exercise group who only reported episodes in years 2–3 related them to high-trauma incidents including a motor vehicle accident, a work-related heavy lifting incident, and an injury in representative level football. Apart from these cases, patients of both groups most commonly reported precipitating incidents related to lifting.

Treatment Sought

In the first year, treatment was sought by 8 of 19 (42%) of the patients from the control group and 3 of 20 (15%) of the specific exercise group. In all cases, this treatment consisted of medical management (time off from work, advice, medications) and physiotherapy treatment. A variety of physiotherapy treatments were reported. However, the patients did not report that the treating physiotherapists had prescribed specific multifidus exercises. Contamination of the exercise outcome from the 1-year follow-up can therefore be considered minimal. For years 2–3, 4 of 16 (25%) of the control group sought treatment in the 2-year period in comparison with 4 of 20 (20%) of the specific exercise group. Control group patients accessed physiotherapy, medical management, and one had received an orthopedic consult, whereas patients from the specific exercise group received physiotherapy only.

Patients Lost to Follow-Up

The three patients who were lost to follow-up for years 2–3 reported quite different patterns of recurrence over the 1-year follow-up period. Patient 12, at 1 year, reported that recurrent episodes started within 2–4 weeks of the 10-week initial trial period. She had experienced several episodes. The aggravating factor was prolonged sitting (studying), after which she reported experiencing pain at night. She did not suffer any traumatic predisposing injuries to precipitate these recurrences, but reported that they were milder than the original incident, for which she sought treatment. In contrast, patient 13 was one of the 16% from the control group who had not experienced any recurrences at the 1-year follow-up. After bending over to make a bed during the 1 year follow-up period, patient 19 experienced one 2-week episode of LBP as severe as the original incident, for which treatment was sought. This had resulted in time off work (2 days) but medications were not used.

■ Discussion

The results from the control group, who were managed medically and advised to resume normal activity, reflect the reported high recurrence rate of LBP that occurs after the initial episode.[3,35–37] Their recurrence rate at 1 year (84%) is similar to the rates previously reported and furthermore, for 56% of these subjects, the recurrences were reported as being as severe and disabling as the original episode. In contrast, the group to whom specific exercise was given to the multifidus reported only 30% recurrence at 1 year and these were reported as being "as severe" in only 33% of cases. Results from the control group lead us to agree with the report of Von Korff and Saunders[40] in that the course of LBP for most primary care patients is recurrent rather than acute or chronic in the usual sense of these terms. Furthermore, as expressed by Von Korff and Saunders,[40] it is necessary to assess not only the short-term outcome of the index episode but also the long-term outcomes over a sufficient period of time. The positive natural history of acute LBP in the short-term, without provision of long-term follow-up, may have led to an underestimation of the importance of early intervention, which aims to prevent recurrences. Results from the control group highlight that the greatest number of recurrences (especially severe disabling ones) occur predominantly in the first year after the original episode.

Few detailed reports of long-term follow-up of acute LBP are available. The most detail for the year following the initial episode is provided by Bergquist-Ullman and Larsson.[3] However, little information is available for longer-term outcomes. Von Korff and Saunders[39] report that LBP recurrence rates were similarly high at follow-up at 2 years. In this study, recurrence rates remained high for the control group for years two to three (75%), but episodes reported as equally severe as the original episode decreased from 56% to 17%. This investigation therefore demonstrated some moderation in LBP over time, and it has been previously reported that the risk of recurrence lessens 2 years after an acute episode.[24] As the highest rate of severe disabling recurrences occurred in the first year after the initial episode and one of the major costs of LBP is in association with those who have recurrent disabling episodes of LBP,[12] it would appear that intervention may have its maximal benefits in this period. However, long-term positive effects of the intervention used were demonstrated in this study (30% recurrence at 1 year to 35% recurrence rate for years two to three). This long-term benefit was achieved with a short intervention period (4 weeks).

There is now biomechanical evidence to explain the role of the multifidus in stabilization of the lumbar segments.[14,28,34,41] The rehabilitation approach aimed at retraining the multifidus for its functional role of protection and control of movements of the vertebral segments.[14,28,34,41] It is now possible to hypothesize how this approach may be effective to account for the long-term differences between the control and specific exercise groups. Following an acute injury to the low back, a deficit in the multifidus may leave the injured segment susceptible to further injury. Specific exercise therapy may be required to restore normal muscle function, with the long-term sequelae of a deficient multifidus in control subjects being a susceptibility to further injury and recurrence of LBP.

Furthermore, the biomechanical model provided by Cholewicki and McGill[4] may help to explain why recurrences occurred with seemingly little provocation, especially in the control group subjects. The model highlighted the importance of muscles that provide spinal segmental support, not only during high demand activities such as heavy lifting, but during low load activity requiring only low muscle forces. Deficient stabilization of lumbar segments caused by a deficient multifidus may explain LBP recurrence with minimal or no predisposing incidents.

This study provides one step forward in the knowledge concerning the long-term effects of conservative management for LBP patients. The results are promising in that they suggest that specific exercises help to reduce the high recurrence rate of LBP after the initial acute episode, and this pilot study may be used to determine a design model for further research. The limitations of this study include the small sample size and limited outcome measures (telephone questionnaire) for long-term follow-up. More evidence in a larger study population is required to further substantiate the findings of this study.

■ Conclusion

The results from this study showed that subjects with acute, first-episode LBP who received specific exercise therapy in addition to medical management and resumption of normal activity experienced fewer recurrences of LBP in the long-term than subjects who received only medical management and resumed normal activity. Biomechanical research may explain why it is important to focus on particular muscles for their stabilizing functions in rehabilitation.

Additional research on larger subject populations is required, and other factors will obviously be involved in low back pain recurrence. However, in terms of prevention of recurrences, this study might represent one step forward in the optimal management of the acute low back pain patient.

■ Key Points

- Following an initial episode of acute low back pain (LBP), the recurrence rate is high.
- This randomized clinical trial followed acute low back pain patients who undertook specific stabilization exercises and control subjects for 3 years.
- Results showed decreased recurrence of low back pain episodes in the specific exercise group compared with the control group.

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INVITED REVIEW

ABSTRACT: Muscle ultrasound is a useful tool in the diagnosis of neuromuscular disorders, as these disorders result in muscle atrophy and intramuscular fibrosis and fatty infiltration, which can be visualized with ultrasound. Several prospective studies have reported high sensitivities and specificities in the detection of neuromuscular disorders. Although not investigated in large series of patients, different neuromuscular disorders tend to show specific changes on muscle ultrasound, which can be helpful in differential diagnosis. For example, Duchenne muscular dystrophy results in a severe, homogeneous increase of muscle echo intensity with normal muscle thickness, whereas spinal muscular atrophy shows an inhomogeneous increase of echo intensity with severe atrophy. A major advantage of muscle ultrasound, compared to other imaging techniques, is its ability to visualize muscle movements, such as muscle contractions and fasciculations. This study reviews the possibilities and limitations of ultrasound in muscle imaging and its value as a diagnostic tool in neuromuscular disorders.

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MUSCLE ULTRASOUND IN NEUROMUSCULAR DISORDERS

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Ultrasound has been used in medical practice since the early 1950s, when Wild and colleagues discovered the ability of high-frequency ultrasonic waves to visualize living tissues.[95] Since then, the technique of ultrasound has rapidly expanded, leading to its widespread use in almost all fields of medicine because of its non-invasiveness and real-time display. In 1980 it was first discovered that diseased muscles showed a different appearance on ultrasound compared to healthy muscles.[38] Subsequently, several studies have established high sensitivities and specificities of ultrasound in the detection of neuromuscular disorders.[24,39,42,55,67,74,98] Currently, ultrasound is widely available and ultrasound techniques have further improved, resulting in display of muscle tissue with resolutions up to 0.1 mm.[18] This is higher than resolution than can be achieved with, for example, 3-Tesla magnetic resonance imaging (MRI).[58] In addition to muscles, ultrasound effectively images nerves and peripheral nerve disorders, such as carpal tunnel syndrome and neurinomas.[6,7,29,53,91,92]

Previous reviews on muscle ultrasound have focused primarily on trauma, malignancies, and infections of the musculoskeletal system.[14,30,34,61] In this review, we describe the application of ultrasound in patients with neuromuscular disorders. To present diagnostic accuracy (i.e., sensitivity and specificity) we reviewed only prospective studies. These studies included patients with symptoms suggestive of a neuromuscular disorder. The control group consisted of those with such symptoms but who eventually were found to have no neuromuscular disorders. Instead, they had other disorders, such as static perinatal encephalopathy or motor delay with spontaneous improvement without identifiable cause. Traumas and infections were not included in these studies.

Abbreviations: ALS, amyotrophic lateral sclerosis; CMD, congenital muscular dystrophy; CT, computed tomography; DMD, Duchenne muscular dystrophy; EMG, electromyography; MRI, magnetic resonance imaging; SMA, spinal muscular atrophy

Key words: dynamic; imaging; neuromuscular disorders; skeletal muscle; ultrasound

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BASIS OF ULTRASOUND IMAGING

Sound waves and their echoes form the basis of ultrasound images. A transducer sends out pulses of high-frequency sound waves and receives their ech-

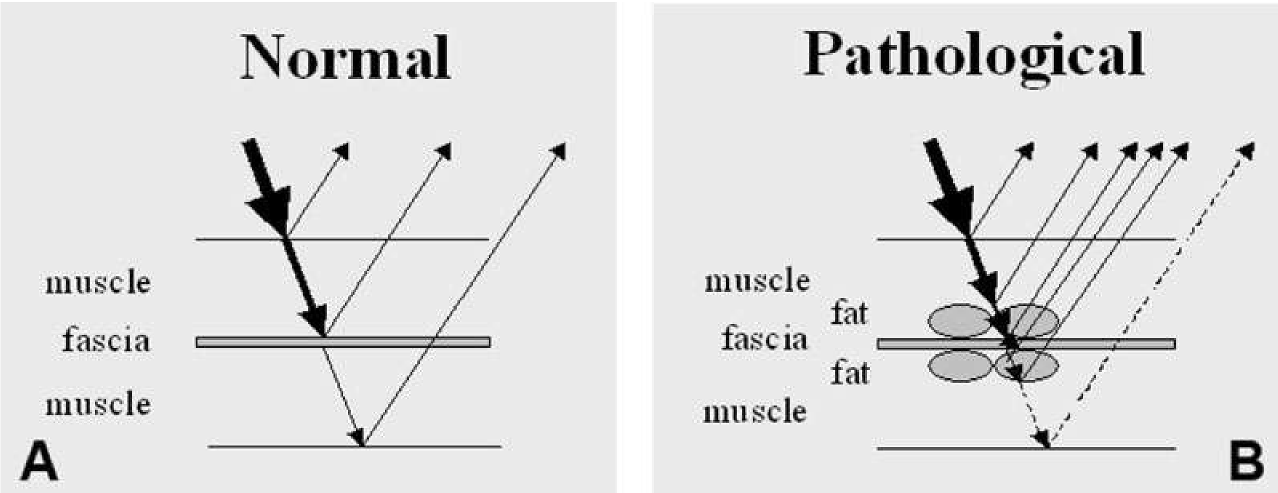

FIGURE 1. Schematic representation of the composition of an ultrasound image. Partial reflections of the ultrasound beam occur when the sound beam encounters a different tissue **(A)**. The ultrasound image is created based on these returning echoes and their temporal and acoustic properties. The amount of returning echoes per area determines the gray value of the image, that is, the echo intensity. In diseased or aged muscles, replacement by fat and fibrous tissue occurs. Both fat and fibrous tissue have a different acoustical impedance, thereby increasing the number of reflecting interfaces in the muscle, which gives the muscle a whiter appearance **(B)**.

oes. The creation of an image from all returning echoes is based on a computer analysis of the temporal and acoustic properties of the echoes. Simplified, the time between sending and receiving the ultrasound pulse determines the location of the corresponding pixel, whereas the amplitude of the sound wave corresponds to the brightness of the image.[25,88] Reflection of sound waves occurs when the ultrasound beam encounters tissue with different acoustical properties, that is, acoustical impedance, which comprises the combination of sound velocity through and the density of the tissue.[18,25,88]

Biological tissues contain mainly water and fat; both are well capable of transmitting sound and have only a small difference in acoustical impedance. When encountering a different tissue (e.g., muscle to fascia) the sound wave is partially reflected, whereas most of the sound is transmitted to deeper layers (Fig. 1A). The amount of returning echoes per square area determines the gray value of the image, that is, echo intensity. The largest differences in acoustical impedance are found between bone and air, which have sound velocities of approximately 300 and 4000 m/s, respectively, whereas in muscle the sound velocity is approximately 1580 m/s.[88] Therefore, transition to bone or air will cause a strong reflection, resulting in a bright spot on the ultrasound image. Consequently, because hardly any sound gets through, no structures beneath such a transition can be displayed.

When sound is transmitted through tissue, attenuation of the ultrasound beam occurs because of reflection, dispersion, and absorption of the sound. Deeper structures are therefore more difficult to display.[25] This can be partially compensated for with time-gain compensation, an integral part of image generation that enhances the amplitude of the sound coming from deeper structures. This has limitations, however, and when overlying tissues absorb too much sound, deeper structures cannot be visualized.

The resolution of an ultrasound image must be considered separately for the axial (depth along the beam) and lateral direction (transversely across the beam). The axial resolution is directly related to the frequency of the transducer; at best, it approaches the wavelength of the sound emitted by the transducer.[25,88] Diagnostic frequencies lie in the range of 2–20 MHz, with corresponding wavelengths of 0.8–0.08 mm. The lateral resolution of ultrasound is limited by the beam width and is several times larger than the axial resolution.[18] To achieve the best resolution, transducers with a high frequency are preferable. However, the depth of penetration is correlated inversely with frequency.[18] Generally, 5- or 7.5-MHz probes are used in muscle ultrasound studies, to ensure sufficient depth penetration. Nowadays, it is also possible to use broadband transducers (e.g., 5–17 MHz), combining the advantage of high frequencies to image superficial structures with high resolution and lower frequencies to reach deeper structures.

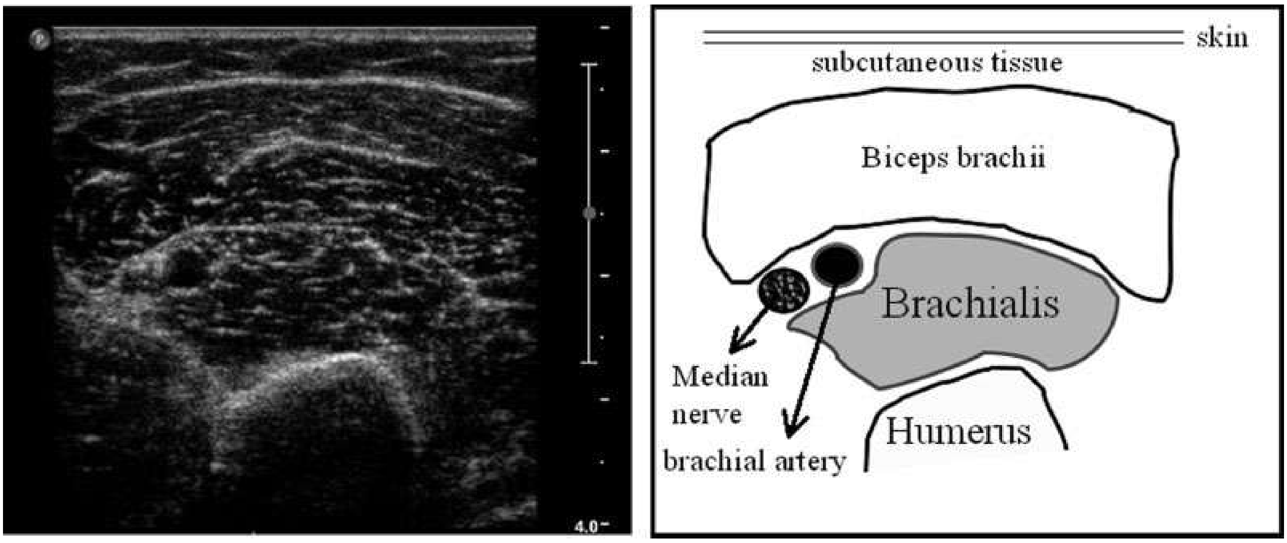

FIGURE 2. Normal ultrasound measurement of the biceps brachii muscle and surrounding tissues, measured at two thirds of the distance from the acromion to the antecubital crease of the left arm. The right panel depicts the different structures schematically.

NORMAL MUSCLE

Normal muscle tissue appears as a structure with low echo intensity (i.e., it is black in appearance). Muscle tissue is divided by echogenic sheets of perimysial connective tissue. This gives the muscle a speckled appearance in the transverse plane (Fig. 2), whereas, in the longitudinal plane, hyperechoic lines are visible, forming a linear or pennate structure (Fig. 3). The sonographic appearance of muscle is fairly distinct and can easily be discerned from surrounding structures such as subcutaneous fat, bone, nerves, and blood vessels. The boundaries of the muscle are clearly visible, as the epimysium surrounding the muscle is a highly reflective (echogenic) structure. In normal subjects the bone echo is strong and distinct, with an anechoic bone shadow underneath. Subcutaneous fat has a low echo intensity, but several echogenic septa of connective tissue may be visible within this tissue layer. Nerves and tendons are relatively hyperechoic compared to healthy muscles, whereas blood vessels are hypo- or anechoic circles or lines, depending on the direction of the ultrasound beam.[49,61]

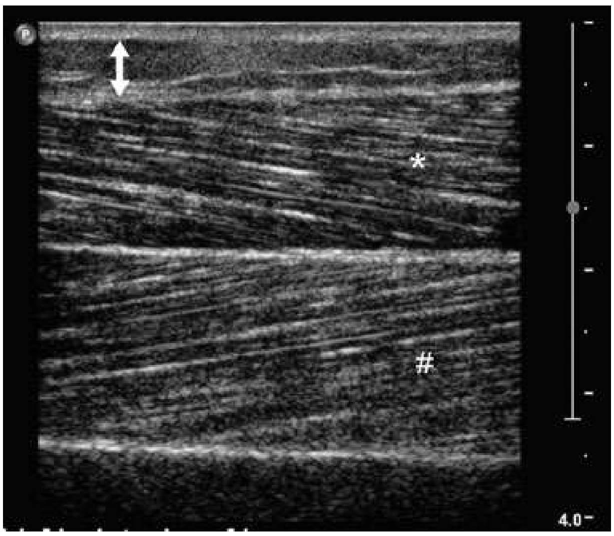

FIGURE 3. Muscle ultrasound of the proximal part of a normal anterior tibial muscle in longitudinal plane. Note the pennation angle clearly visible in both the superficial part (*) and deeper part (#) of the anterior tibial muscle, separated by the central fascia. Double arrow indicates subcutaneous tissue.

All superficial muscles can easily be depicted with ultrasound, although it can be difficult to image individual small muscles when multiple muscle groups overlap them. However, recent ultrasound technology using even higher frequencies has made this less problematic. Deeper muscles can be more difficult to visualize because of the reflection or absorption of sound by superficial tissue layers.

Muscle Thickness. Muscle ultrasound is a reliable method to measure muscle thickness and cross-sectional area,[71,75,82] with a test–retest correlation of 0.98–0.99,[71,77] and a 0.99 correlation with MRI.[71] Some studies have used ultrasound to establish muscle thickness in healthy subjects.[2,41,75,85,86] The established normal values are dependent on the place of measurement and the position of the subject. The same measurement protocol should be applied to use these normal values.

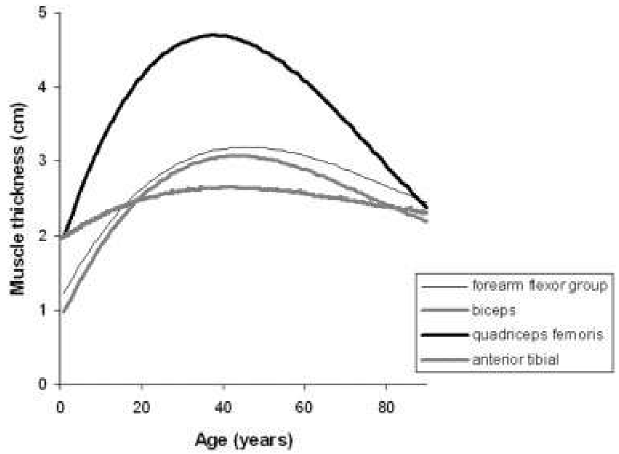

FIGURE 4. Muscle thickness is dependent on age.[46,47] This figure shows examples of the muscle thickness in men for the biceps brachii, forearm flexor, quadriceps, and anterior tibial muscles.

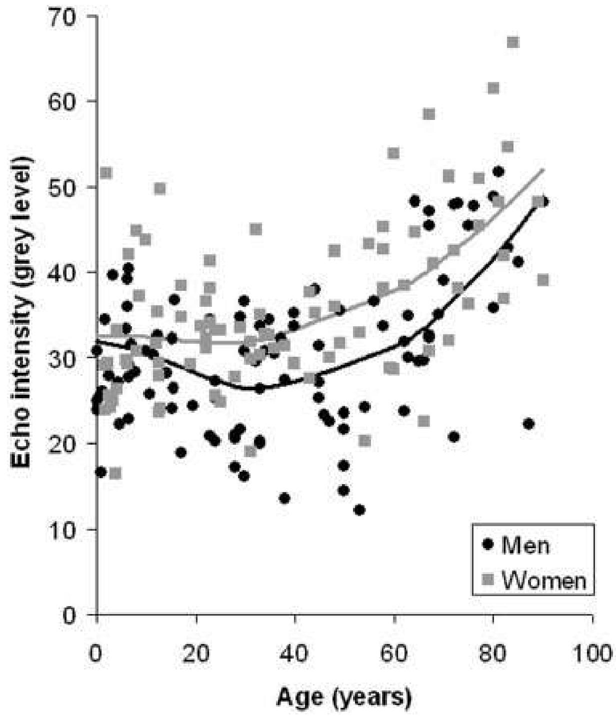

FIGURE 5. Age-related changes in muscle echo intensity of the biceps brachii muscle, based on measurements in 194 healthy volunteers. Muscle echo intensity is expressed as a value between 0 (black) and 255 (white). The values presented are specific for the ultrasound device used at our center. Other ultrasound devices will result in different values, but the shape of the figure will be the same. The line represents the best non-linear fit. In childhood, boys and girls have approximately the same muscle echo intensity. After the age of 16 years, males have a lower echo intensity than females. Muscle echo intensity increases after the age of 40 years in both men and women.

During childhood, muscle thickness increases rapidly. The main variable to predict muscle thickness in this age group is weight.[86] Gender differences do not influence muscle thickness until puberty, when men start to develop thicker muscles than women.[2,46,47] After puberty, muscle thickness increases further, until a peak is reached between 25 and 50 years of age. Thereafter, muscle thickness declines (Fig. 4).[2,22,46,47,75] The influence of age and gender is different for each muscle group and should be taken into consideration when evaluating muscle ultrasound scans of individual patients.

Muscle Echo Intensity. Muscle structure can also be evaluated with muscle ultrasound by measuring muscle echo intensity. Normal muscles are relatively black, but different muscles have specific appearances on ultrasound, because of the variability in proportion of fibrous tissue and the orientation of muscle fibers. For example, the anterior tibial muscle is generally whiter than the rectus femoris.[86]

Muscle echo intensity increases with age, which may be due to age-related muscle replacement by fat and fibrous tissue.[55,74] Figure 5 shows an example of this age-related increase in muscle echo intensity of the biceps brachii muscle, based on our database of 194 healthy volunteers (unpublished data). Fat and fibrous tissue have a different acoustical impedance. An increased number of reflecting interfaces in the muscle gives the muscle a whiter appearance (Fig. 1B). Essentially, the same mechanism causes increased muscle echo intensity in neuromuscular disorders.[38,64] To describe muscle echo intensity, Heckmatt and co-workers developed a visual grading scale in which grade I represented normal muscle and grade IV a severely increased muscle echo intensity with total loss of bone echo (Table 1).[39] Additionally, the distribution of increased echo intensity within the muscle can be described, being either homogeneous or inhomogeneous. This feature can give additional information about the presence of specific neuromuscular disorders. Moreover, the visibility of

Table 1. Heckmatt score: visual grading scale to classify muscle echo intensity.[39]

Grade	Ultrasound appearance
Grade I	Normal
Grade II	Increased muscle echo intensity with distinct bone echo
Grade III	Marked increased muscle echo intensity with a reduced bone echo
Grade IV	Very strong muscle echo and complete loss of bone echo

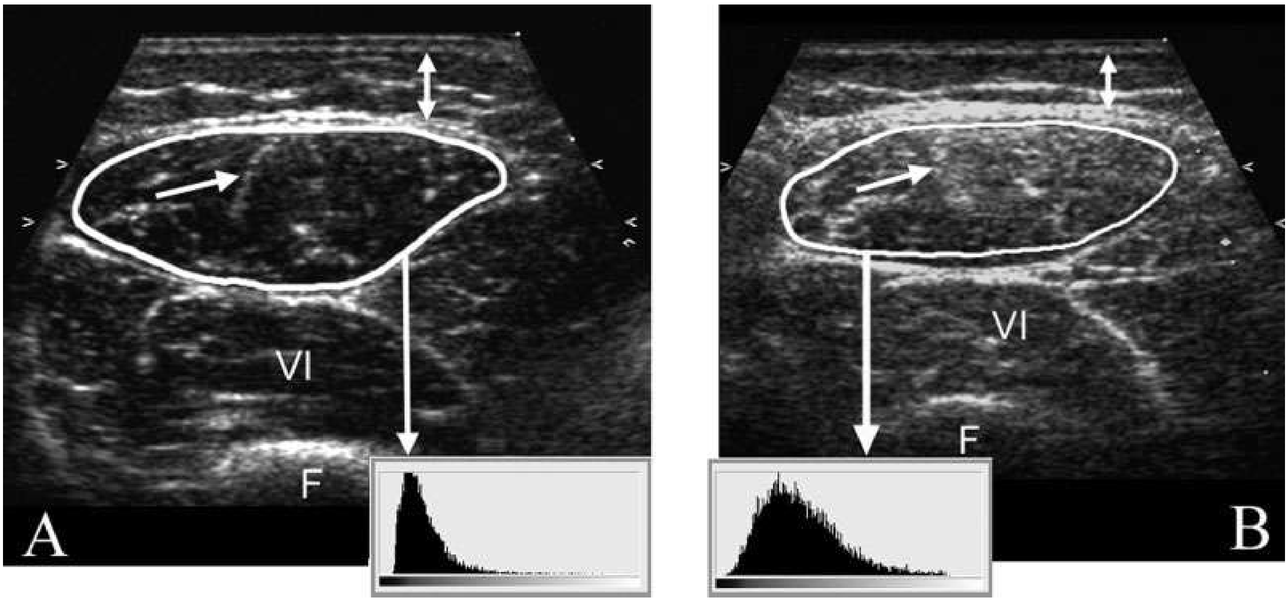

FIGURE 6. Transverse ultrasound image of a normal left quadriceps muscle **(A)** and of a patient with Duchenne muscular dystrophy (DMD) **(B)**. Both are 3.5 years of age. The rectus femoris muscle is encircled. The mean echo intensity is measured for this region, as shown in the histograms below (scale: black = 0; white = 255). The rectus femoris of the DMD patient has increased muscle echo intensity, with the corresponding histogram being displaced to the right. Note the fine granular pattern of echo intensity, homogeneously spread among the muscle with attenuation of the ultrasound beam; that is, the echo intensity in deeper areas of the muscle is decreased compared to the superficial areas. Fascia within the muscle, such as the central fascia in the anterior part of the rectus femoris (single arrow), are more difficult to recognize in the DMD patient. VM, vastus medialis; VL, vastus lateralis; VI, vastus intermedius; F, femur; double arrow, subcutaneous tissue. The quadriceps muscle was measured halfway along the line from the anterosuperior iliac spine to the patella.

structures in and surrounding the muscle can provide additional clues about the presence of structural muscle changes. In several neuromuscular disorders, such as muscular dystrophies and spinal muscular atrophy, this finding can be as prominent as the increase in muscle echo intensity.[4,5,24]

Visual detection of subtly increased muscle echo intensity can be difficult, and its accurate interpretation depends on the experience of the observer. Different muscles have different appearances, and muscle echo intensity increases with age. Moreover, changes in system settings, such as increased gain, can give muscles a whiter appearance that can be mistaken for pathologically increased echo intensity. Visual evaluation of muscle ultrasound has shown relatively low interobserver agreement (kappa = 0.53), which further deteriorated when an inexperienced observer interpreted the images.[62] For this reason, computer-aided techniques have been introduced in image interpretation. Quantification of muscle echo intensity can be achieved with gray-scale analysis (Fig. 6).[5,35,54,55,64,69,74] Because this is more objective and allows for statistical analysis, it is a robust clinical technique and is also very suitable for research purposes. Quantitative techniques improve the interobserver agreement (kappa = 0.86).[62]

An often-mentioned objection to quantitative gray-scale analysis is that it is more time-consuming. However, in our experience, quantification of echo intensity can be done quickly. Evaluation of our standard screening protocol (comprising four muscles) takes less than 5 minutes. Before quantitative muscle echo intensity can be used with different ultrasound devices, system settings have to be adjusted and correction models have to be made in order to use previously established normal values. Otherwise, if a correction model is unavailable, a completely new set of normal values for various age groups has to be assembled.

In addition to quantitative echo intensity analysis, visual evaluation still has its value. Focal changes in a muscle that has a normal overall muscle echo intensity can easily be detected visually. Moreover, visual evaluation also provides information on the distribution of echo intensity within a muscle, that is, whether it is homogeneous or inhomogeneous. New developments in digital image analysis, such as texture analysis, are being designed to quantify these alterations in muscle,[55,69] as they are already used for detecting focal changes in other tissues as well, such as breast and prostate.[16,51]

Sarcopenia. In healthy people, dramatic changes take place in muscle during aging. This age-related decline in muscle mass (sarcopenia) is thought to result from a complex interplay between neurological, metabolic, hormonal, nutritional, and physical activity–related changes.[80] It is associated with an increased tendency to falling, dependency, nursing home admission, and mortality.[44,70] As muscle ultrasound can assess muscle thickness and quantify structural muscle changes such as fibrosis, it can be used to evaluate the effects of sarcopenia. After the age of 40 years, muscle thickness gradually decreases, accelerating with increasing age. The rate of decline is gender-dependent and different for each muscle group, as shown in Figure 4.[2,22,46,47,75] For example, at the age of 90 years, quadriceps muscle thickness in men has decreased by 50% compared to its maximum muscle mass, which is a muscle thickness comparable to children under the age of 10 years.[2]

Measurement Errors. Care must be taken to avoid measurement errors. A generous amount of contact gel should be used to ensure optimal acoustic coupling and to prevent pressure on the underlying tissues. Occasionally, a water bath (i.e., immersion of the limb) is necessary when imaging superficial structures, such as muscles of the hand and foot.[5,45,87] To compare muscle thickness or muscle echo intensity between subjects and over time, all measurements have to be performed at the same anatomically defined locations, with the subject in a standardized position. For example, bending the knee will cause an alteration of the direction of the muscle fibers in the quadriceps muscle, resulting in an increased muscle echo intensity.[38,98] Contraction of a muscle results in an increased muscle diameter and a decreased echo intensity, so it is necessary that patients keep their muscles completely relaxed during the examination.[41] Especially when measuring in a transverse plane, it is important to place the transducer perpendicular to the underlying tissue, as oblique scanning will not only overestimate muscle thickness[41] but will also result in a decrease of muscle echo intensity.[13,42,76] Placing the transducer in a way that an optimal bone echo and delineation of the surrounding fascia is ensured can avoid this problem.

ULTRASOUND IN NEUROMUSCULAR DISORDERS

Neuromuscular disorders usually lead to changes in muscle morphology that can be visualized with ultrasound. Both atrophy and changes in muscle architecture can be assessed, the latter by measuring echo intensity. Previous studies by Reimers and co-workers have shown a strong correlation between the disruption of normal muscle architecture and muscle echo intensity.[74,79] From their studies, fat seems to be especially responsible for the increased echo intensity. However, in a recent study by our group, we also established a significant and robust correlation with fibrous tissue content.[65]

Currently, muscle ultrasound is predominantly used as a screening tool during the initial diagnostic phase of patients with suspected neuromuscular disorders. An abnormal ultrasound, and especially increased muscle echo intensity, is indicative of such a disorder. Other investigations, such as electromyography (EMG) and muscle biopsy, are then necessary to determine the type of neuromuscular disorder, but specific muscle ultrasound findings can give additional clues that may help in directing the differential diagnosis.

Prospective studies in children have shown that, with visual evaluation of muscle echo intensity, the presence of a neuromuscular disorder can be detected with a sensitivity of only 67%–81% and a specificity of 84%–92%.[10,42,98] Quantification of muscle echo intensity improved the sensitivity to 87%–92%.[35,62,64,67] With this high sensitivity, muscle ultrasound is very suitable for screening purposes.[62] In adults, no prospective studies investigating the diagnostic value of muscle ultrasound have yet been performed.

The aforementioned sensitivities and specificities represent the general ability of muscle ultrasound to detect neuromuscular disorders. However, in specific neuromuscular disorders or in specific age groups these values differ (Table 2). For example, the sensitivity of ultrasound in detecting Duchenne muscular dystrophy (DMD) in clinically affected patients approaches 100%,[68] whereas mitochondrial myopathies will only be detected by ultrasound in 25%–45% of the symptomatic cases.[63] The diagnostic value of muscle ultrasound has not been investigated prospectively in other specific neuromuscular disorders, and only small series of patients have been reported. In children younger than 3 years of age, muscle ultrasound shows a lower sensitivity (approximately 75%).[42,63,98] This is largely explained by the fact that structural changes within the muscle can still be minor in the early stages of a neuromuscular disorder. However, because the specificity of muscle ultrasound for the presence of a neuromuscular disorder is high in these children (approaching 100%), an abnormal ultrasound has major implications in directing further—more invasive—investigations.

With muscle ultrasound one can also describe the pattern of muscle involvement, which may help in the differential diagnosis (Fig. 7).[37,50,59] When

Table 2. Ultrasound appearance in specific neuromuscular disorders.

Type of disorder	Echo intensity: amount of increase	Muscle thickness: amount of atrophy	Remarks	Studies on sensitivity: Age	Assessment	Sensitivity (no. of patients)*
General	N to ↑↑↑	N to ↓↓↓	EI often more abnormal than muscle thickness	0-21 0-18 0-18	v v q	67% (130)[42] 81% (134)[10] 89% (65)[68]
Myopathy						
Dystrophy	↑↑↑	N/↓	Homogeneous fine granular increases EI. Normal or decreased EI in deeper areas of affected muscle because of increased attenuation. Preclinical cases can be normal, except for congenital dystrophies.	1-15 3-7 3-9	v v q	88% (25)[39] 95% (22)[42] 100% (11)[68]
Congenital myopathy	N to↑↑↑	↓/↓↓	Homogeneous increased EI	4-32 0-9 1-13	v v q	80% (5)[39] 57% (7)[42] 100% (3)[68]
Inflammatory myopathy						
Dermatomyositis	↑↑	N/↑ (acute) ↓ (chronic)	Slight increase of EI in acute phase, more severe in chronic phase. EI is often focally increased.	7-14 2-18 21-77	v q q	60% (5)[42] 100% (7)[68] 67% (18)[74]
Polymyositis	↑↑	N/↑ (acute) ↓ (chronic)	Slight increase of EI in acute phase, more severe in chronic phase. EI is often focally increased.	22-82	q	83% (30)[74]
Inclusion-body myositis	↑↑↑	↓↓/↓↓↓	Focal muscle involvement, asymmetrical, especially distal muscles. Homogeneous increase of EI in affected muscles	52-81	q	100% (13)[74]
Metabolic myopathy	N/↑	N/↓	Normal or only slightly increased EI with homogeneous distribution within muscle; normal structures within muscles remain visible.	0-14 0-18 0-9	v q q	50% (4)[42] 46% (28)[63] 70% (7)[68]
Neurogenic						
Anterior horn cell						
SMA	↑↑↑	↓↓↓	Inhomogeneous, moth-eaten pattern. May be normal in very young patients.	0-14 0-6	v v	70% (27)[42] 92% (12)[68]
ALS	↑↑	↓↓↓	Fasciculations most prominent feature. EI more abnormal than atrophy.		No data available	
Polyneuropathy	↑/↑↑	↓↓ (distal)	Inhomogeneous, coarse granular increase of EI, distally more severe than proximally.	2-16 3-15	v q	63% (8)[42] 100% (11)[68]
Focal neuropathy	N to↑↑	↓↓↓ (affected muscle)	First ultrasound abnormalities visible after 10 days. EI more abnormal than atrophy.	8-83 14-70	q q	~70% (255)[87] ~70% (100)[5]

Abbreviations: q, quantitative gray-scale analysis; v, visual assessment of muscle echo intensity; N, normal echo intensity/muscle thickness; ↑, slight increase of echo intensity/muscle thickness; ↑↑, moderately increased echo intensity; ↑↑↑, severe increased echo intensity; ↓, slight atrophy; ↓↓, moderate atrophy; ↓↓↓, severe atrophy; EI, echo intensity; SMA, spinal muscular atrophy; ALS, amyotrophic lateral sclerosis.
Reference indicated as numerical superscript.

there is selective muscle involvement, muscle ultrasound can identify diseased muscles and, subsequently, direct muscle biopsy.[36] It is important, however, to avoid too severely affected muscles, as pronounced atrophy or fibrosis can also lead to sampling errors and difficulties in interpreting the results.[50] Ultrasound is also used in guiding of botulinum toxin injection of hypertonic muscles

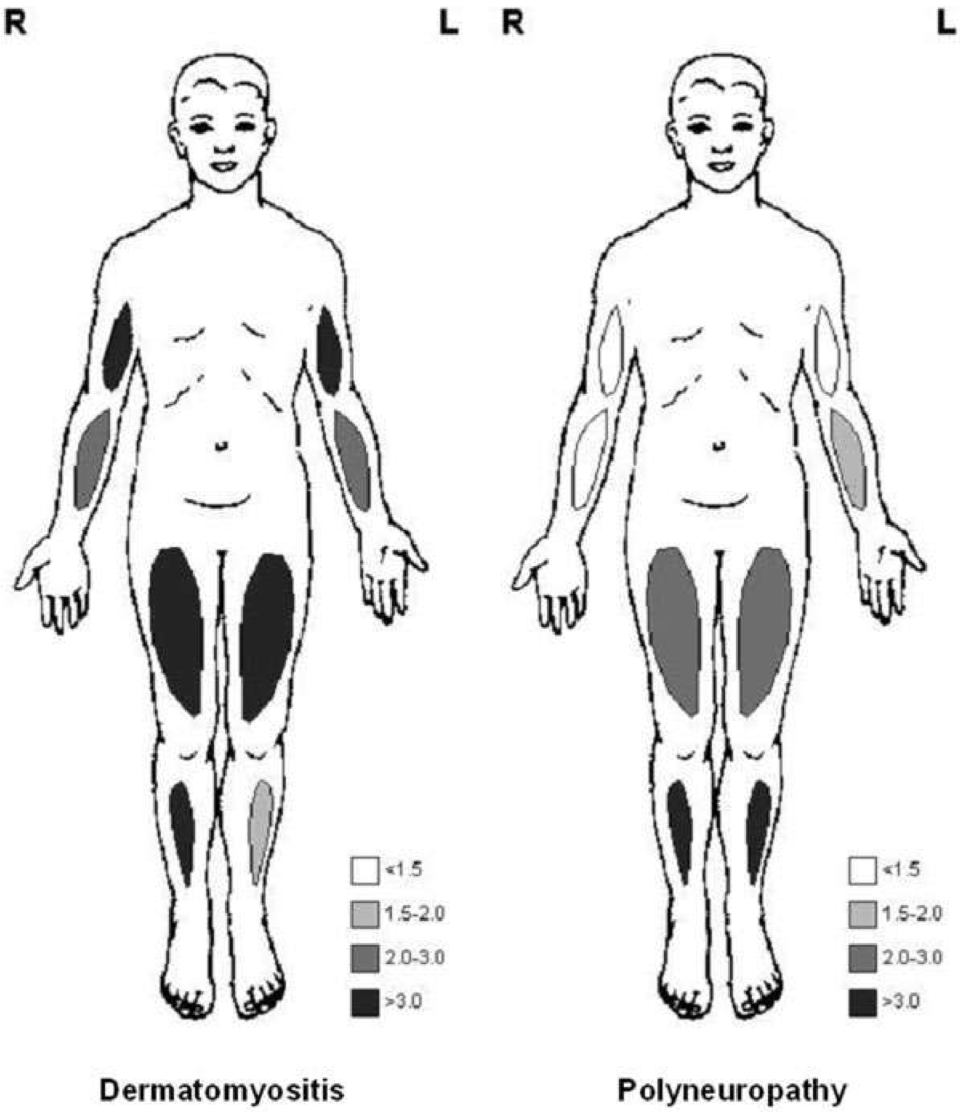

FIGURE 7. Schematic overview of the distribution of muscle echo intensity of a 49-year-old patient with dermatomyositis and a 35-year-old patient with a polyneuropathy. The gray values correspond to the amount of standard deviations above normal, after correction for age and gender. Presenting ultrasound investigations in this manner helps in the differential diagnosis and in selecting muscle biopsy location.

in cerebral palsy, as deep or small muscles may otherwise be difficult to inject.[8,96] Electromyography and electrical stimulation of muscle can also be used for this purpose, but, as they are painful and require cooperation, they have limited use in children.[8]

Dynamic Muscle Ultrasound. In contrast to other imaging modalities, muscle ultrasound is not confined to static images but can also be used for dynamic imaging, such as in contracting muscles. It also provides quantitative data about changes in muscle configuration during movement.[17] This feature has been used in patients with myositis, who were shown to have less thickening of the muscles during contraction than healthy controls. Fasciculations can also be visualized dynamically as local thickening and twisting in axial sections of relaxed muscle.[93,94] They can easily be distinguished from other movements like arterial pulsations (unifocal, rhythmic movements) or voluntary muscle contractions (involving the entire muscle),[83,84,93,94] although this can be challenging in patients who are unable to lie still. Ultrasound actually appears to be more sensitive in detecting fasciculations than EMG, probably because larger areas of muscle are sampled than with an EMG needle.[78,84,93,94] Moreover, with ultrasound it is possible to see fasciculations during voluntary mus-

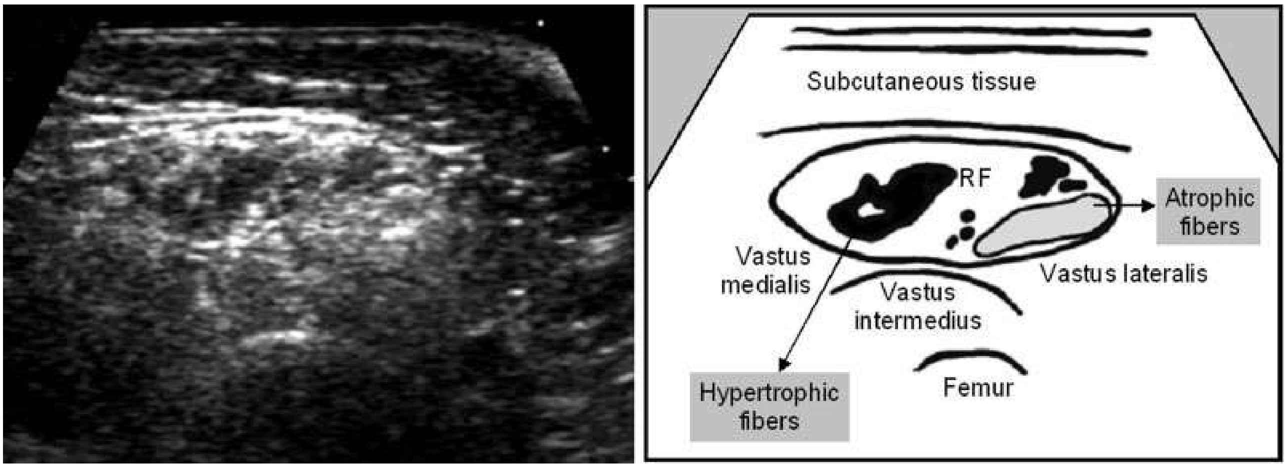

FIGURE 8. Left quadriceps muscle of a 2-year-old boy with spinal muscular atrophy type 2 measured halfway along the line from the anterosuperior iliac spine to the patella. The echo intensity is very inhomogenously spread among the muscle, with a moth-eaten pattern, probably representing atrophic and hypertrophic muscle fibers. Normal structures within and surrounding the muscle are difficult to distinguish. Muscle thickness is diminished. The right panel depicts the different structures schematically. RF, rectus femoris muscle.

cle contraction, which is impossible with EMG because of the summation of voluntary electrical potentials recorded by the needle electrodes.[93] The cross-sectional area of a fasciculation is different for smaller and larger muscles, with mean areas of 5 mm^2 and 60 mm^2, respectively, whereas in post-polio patients this area can be even larger.[93]

Muscle Ultrasound for Discriminating Neurogenic Disorders and Myopathies. Although the main ultrasound feature of both myopathies and neurogenic disorders is an increased muscle echo intensity, their appearance is different on muscle ultrasound. Neurogenic disorders usually show an inhomogeneous increase of echo intensity with atrophy and, in young children, an increased subcutaneous tissue diameter.[4,24,39] The latter is especially prominent in floppy infants suffering from spinal muscular atrophy (Fig. 8).[40,85] Myopathies generally result in a homogeneous increase of muscle echo intensity, often accompanied by a preserved muscle bulk, as in DMD (Fig. 6b).[4,24,39] In a study of 40 floppy infants, ultrasound showed a 92% concordance with EMG findings in differentiating between myopathies and neuropathies.[4] Another study investigated the distribution of quantitatively determined echo intensity and muscle thickness in children's muscles with various neuromuscular disorders. In neuropathies, the legs "not unexpectedly" showed more atrophy and a higher echo intensity than the arms. Patients with myopathies showed a more equal distribution of muscle thickness and echo intensity throughout their body. These features appeared to be very specific and made it possible to differentiate between neuropathies and myopathies with a positive predictive values of 86% and a negative predictive value of 84%.[67] In adults, Maurits and co-workers also successfully distinguished between myopathies and neurogenic disorders using digital image analysis.[55] They used muscle inhomogeneity and white area index (which measures the presence of patches of high echo intensity) as well as muscle echo intensity of two proximal muscles. In children with various neuromuscular disorders, however, this analysis was not found effective.[54]

Muscle Ultrasound in Specific Neuromuscular Disorders. The value of ultrasound in the detection of specific neuromuscular disorders and differentiation from other neuromuscular disorders has never been investigated prospectively. Most studies are confined to descriptions of ultrasound appearances. In what follows we summarize the main ultrasound findings in specific disorders, as presented in Table 2, which also provides an impression of the possible sensitivity of ultrasound in these disorders.

Muscular Dystrophies. Muscle ultrasound changes in neuromuscular disorders were first described in patients with DMD,[38] and these patients show the most striking abnormalities on muscle ultrasound. In preclinical cases, muscle ultrasound can be normal,[39,42,67] but when the first clinical signs become apparent, muscle ultrasound is abnormal in almost every patient, showing normal muscle thickness with increased muscle echo intensity.[24,39,40] Within the muscle, the echo intensity has an homogeneous (fine granular) distribution.[24,39] Proximal muscles have the highest echo intensities, which can become so high in advanced cases that the bone echo is diminished or absent (Fig. 6B).[39,42,67] Similar findings were reported in children with Becker and limb-girdle muscular dystrophies; the severity of the ultrasound findings were found to be related to age and clinical severity.[42] The latter is in contrast to children with congenital muscular dystrophies (CMDs), where muscle echo intensity is severely increased in almost all instances, but has shown no relation to age or disease severity.[23,39] CMD is associated with extensive histopathological muscle changes with an extensive replacement of muscle by fat and connective tissue, often appearing much more severe than the clinical picture.[23,39] In some CMD cases, ultrasound imaging may show striking differential involvement of the quadriceps muscle with sparing of the rectus femoris and a marked increase in echo intensity in the vasti, which corresponds to needle biopsy and MRI findings.[37,57] In Bethlem myopathy, muscle ultrasound has revealed a peculiar echo density in the anterior middle of the rectus femoris muscle, the "central shadow sign," centered around the central fascia that is normally seen in this muscle.[9] This corresponds to the myopathic process, which proceeds in an unusual outside-in fashion, that is, from the fascia inwards.

Congenital Myopathies. Congenital myopathies are a heterogenic group of inherited myopathies. Only a few reports of ultrasound findings of these patients are available, and in most the ultrasound examination was abnormal, but with highly heterogeneous findings and selective muscle involvement corresponding to the wide range of clinical phenotypes.[42,67]

Patients with nemaline myopathy can show marked selective muscle involvement (Fig. 9), although the ultrasound scan can also still be normal at clinical presentation.[39,42] Three patients with a central core or minicore myopathy have been described. All showing increased muscle echo intensity.[39]

Inflammatory Myopathies. Inflammatory myopathies show specific changes on muscle ultrasound.[42,67,74] Muscle echo intensity is increased with focal alterations within the muscle, which makes it possible to differentiate them from other myopathies (Fig. 10A). In the acute phase of an inflammatory myopathy, edema is present, resulting in slightly increased muscle thickness with mild to moderately increased echo intensity. As the disease progresses, muscle echo intensity further increases, and muscle thickness declines.[74]

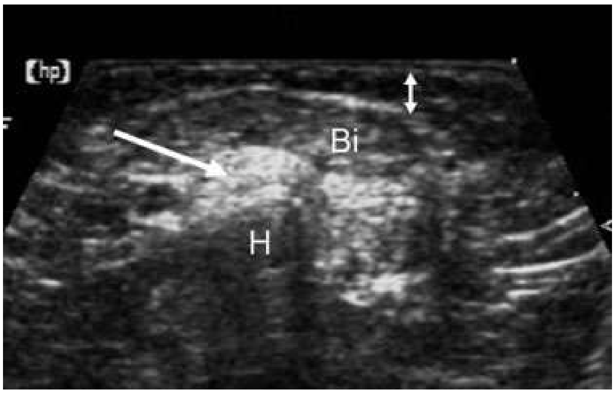

FIGURE 9. Transverse ultrasound scan of the upper arm of a 1-year-old child with nemaline myopathy. The muscle echo intensity is slightly increased in the biceps brachii muscle (Bi). The brachialis muscle, however, shows a very high echo intensity (arrow). H, humerus; double arrow, subcutaneous tissue.

In general, ultrasound findings in adult polymyositis and dermatomyositis do not differ much from those in childhood.[73] In polymyositis, muscle atrophy and increased muscle echo intensities are usually more pronounced in the lower extremities, whereas in dermatomyositis the upper and lower extremities are involved equally.[74] Subcutaneous and intramuscular calcifications, which are more often seen in children, are easily visible as highly echogenic structures with dorsal shadowing (Fig. 11). Inclusion-body myositis shows more atrophy compared to other inflammatory myopathies and a strongly increased muscle echo intensity (Fig. 10B). These findings can be focal and are often asymmetrical and most pronounced in the distal muscles.[73,74]

As not only muscles, but also surrounding fascia are visible on ultrasound, a fasciitis can also be detected with ultrasound, showing its fascial thickening. The borders of the muscle and surrounding fascia are less well demarcated in fasciitis, and this condition is often accompanied by myositis of adjacent muscles. In these muscles an increased muscle echo intensity may be present (Fig. 12).[66]

Metabolic and Mitochondrial Myopathies. Metabolic and mitochondrial disorders usually have normal or only slightly elevated muscle echo intensity.[24,42,63,67] Sensitivities of 25%–45% have been reported in children with mitochondrial myopathies, with even lower sensitivities in children below the age of 5 years.[63] Consequently, normal ultrasound findings do not exclude the presence of a mitochondrial myopathy. Higher sensitivities can probably be

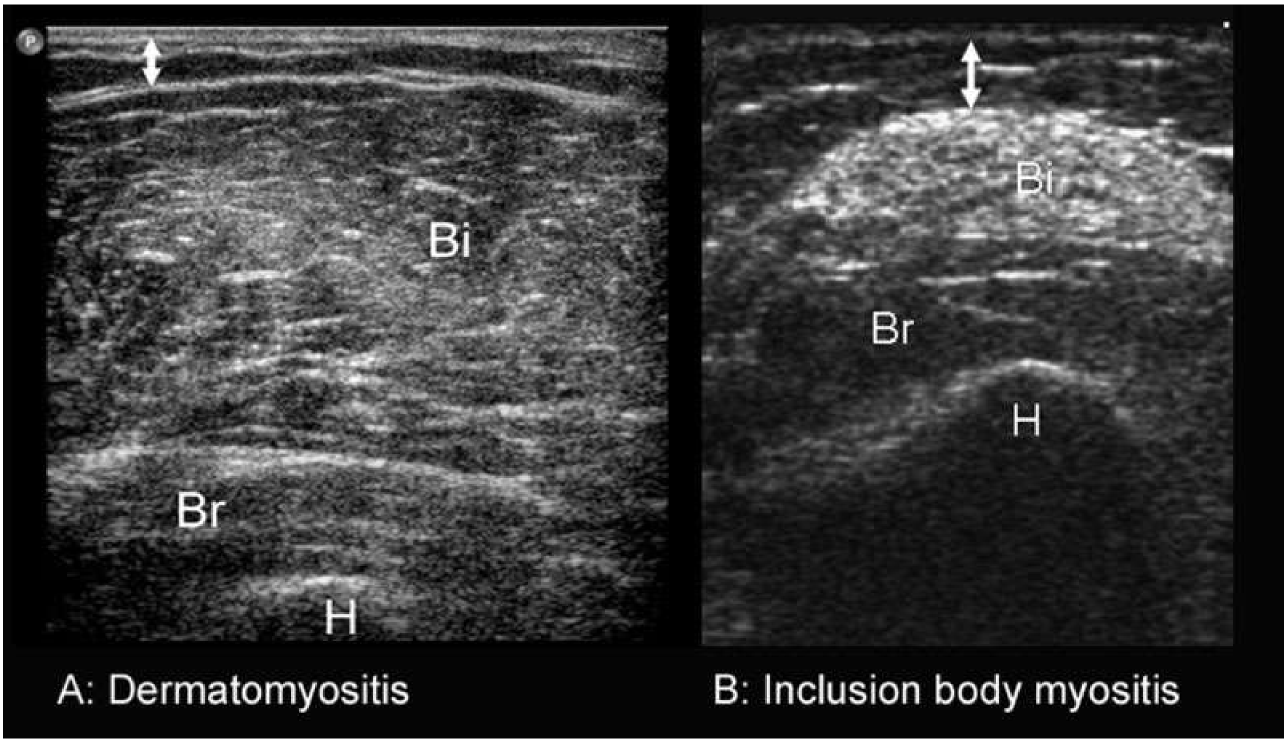

FIGURE 10. Ultrasound image of the biceps brachii and brachialis muscle at two thirds of the distance from the acromion to the antecubital crease in a 55-year-old man with acute, untreated dermatomyositis **(A)** and a 65-year-old man with inclusion-body myositis (IBM) **(B)**. In **(A)**, a moderately increased echo intensity is visible with an inhomogeneous, patchy appearance. The muscle thickness is normal. Conversely, the IBM patient **(B)** has severe atrophy and selective muscle involvement. The biceps brachii muscle shows a very high echo intensity, whereas the brachialis muscle appears normal. The difference in resolution of both images is caused by a difference in transducers: the left image is made with a broadband 5–17-MHz transducer, whereas in the right image a phased-array 7.5-MHz transducer was used. Bi, biceps brachii muscle; Br, brachialis muscle; H, humerus; double arrow, subcutaneous tissue.

found in older children and adults with mitochondrial myopathies, as more structural muscle abnormalities are seen with increasing age.[63] Muscle thickness is often decreased.[27,48,60,63,72]

Motor Neuron Disorders. Spinal muscular atrophy (SMA) causes severe muscle atrophy that is visible on ultrasound, accompanied by increased echo intensity, although early in the course of the disease the ultrasound scan can be normal.[24,39,40,42,67] The distribution of ultrasound abnormalities is distinct in SMA. The lower limbs, and especially the quadriceps muscle, show most abnormalities, whereas the biceps brachii muscle is relatively spared.[42,67] Muscle echo intensity has an inhomogeneous, moth-eaten pattern, corresponding to areas with atrophic fibers (bright areas) and groups of hypertrophic fibers (black areas), as also seen in muscle biopsy (Fig. 8).[24,90] The structures normally seen within the muscle (e.g., the central fascia in the rectus femoris) are often not visible. Muscle outlines are well visible in patients with a low to moderate elevation of the echo intensity, but fade and disappear in severely affected patients, whereas the bone echo is preserved or slightly decreased.

Muscle ultrasonography in patients with amyotrophic lateral sclerosis (ALS) shows a combination of increased echo intensity, decreased muscle thickness, and extensive fasciculations, even in the early stages of the disease.[3,20,21,31,97] In patients with suspected ALS a higher degree of diagnostic certainty can be reached when more body regions are affected.[11] Ultrasound is capable of detecting fasciculations and increased intramuscular fibrous tissue.[3] As these are early signs of lower motor neuron degeneration, ultrasound examination can help to strengthen the diagnostic certainty of ALS in patients with a limited disease presentation.

Peripheral Nerve Disorders. EMG is the investigation of choice in detecting peripheral neuropathies, with high diagnostic accuracy even in young children (88%–100%),[19,43] and ultrasound of nerves can detect common nerve entrapments.[6,7,29,53,91,92] Muscle ultrasound, however, can also detect the consequences of

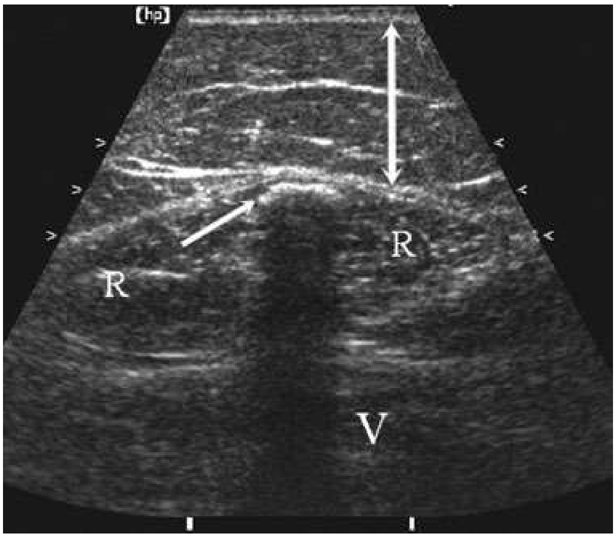

FIGURE 11. Muscle ultrasound investigation of the quadriceps muscle, at two thirds along the line from the anterosuperior iliac spine to the patella of a 15-year-old, who had suffered from juvenile dermatomyositis with a monocyclic course when she was 2 years old. One year after diagnosis she developed severe subcutaneous and intramuscular calcifications, especially in the right leg, causing a flexion contracture of her right knee. Muscle ultrasound of the quadriceps muscle in a transverse plane revealed multiple subfascial plaques of calcification, visible as echogenic structures casting a shadow (white arrow). R, rectus femoris; V, vastus intermedius; double arrow, subcutaneous tissue.

nerve damage by showing atrophy and increased echo intensity in muscles innervated by the affected nerve.[5,33,42,67,87] Polyneuropathies thus result in muscle ultrasound changes, with involvement being more severe distally than proximally (Fig. 7).[42] Muscle ultrasound appeared to be equally or slightly less capable of detecting focal neuropathies than EMG, with a sensitivity estimated at 70%. Increased echo intensity was the most distinctive feature on ultrasound, and atrophy was present in only one third of the patients. Muscle echo intensity was strongly correlated with the presence of spontaneous activity on EMG. The earliest ultrasound abnormalities appear 10–14 days after nerve injury, which is when spontaneous activity appears on EMG.[5,33,87]

MUSCLE ULTRASOUND COMPARED TO OTHER DIAGNOSTIC TECHNIQUES

Besides ultrasound, other imaging techniques, such as computed tomography (CT) and MRI, as well as EMG, are frequently used in the diagnosis of neuromuscular disorders. Each approach has its specific advantages and disadvantages compared to ultrasound. The use of muscle MRI has been researched extensively in patients with neuromuscular disorders, especially in adults and in patients with inflammatory myopathies.[28,52,73] In children, MRI is capable of detecting neuromuscular disorders,[15,56] but no prospective studies have yet been performed. An advantage of both MRI and CT compared to ultrasound is their ability to visualize deeper muscles, especially when overlying muscles are severely affected.[1] Similar to ultrasound, MRI was less capable of detecting pathological changes in early or pre-symptomatic disease, and in metabolic or mitochondrial myopathies.[15,26] However, the major disadvantages of MRI are its cost and the necessity of sedation in young children. CT is also capable of detecting fatty infiltration caused by neuromuscular disorders and appears to be superior to MRI in detecting calcifications caused by inflammatory myopathies,[32] but it has the disadvantage of ionizing radiation. There are no data on the predictive value of muscle CT in the diagnosis of neuromuscular disorders.

The non-invasiveness of ultrasound as a screening tool in suspected neuromuscular disorders is in sharp contrast to another frequently used tool, EMG, which is far more uncomfortable. In a study of 498 children, 17% of the EMG investigations were hampered by lack of cooperation because of fear or pain.[43] The sensitivity of EMG in detecting neurogenic disorders was very high in every age group (88%–100%).[12,19,43] EMG has more problems in detecting myopathies, especially in children. In floppy

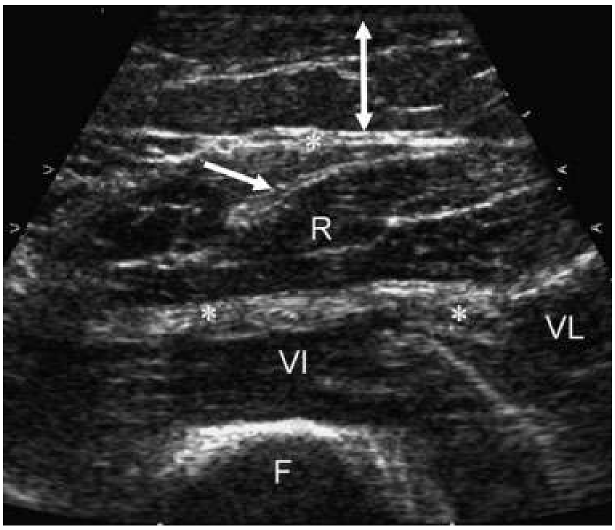

FIGURE 12. Transverse measurement of a quadricps muscle from a patient with eosinophilic fasciitis. The fascia surrounding the rectis femoris is clearly thickened (*). The central fascia separating the anterior part of the rectus femoris muscle is also thickened and less well demarcated (arrow). F, femur; VI, vastus intermedius; VL, vastus lateralis; R, rectus femoris. The measurement was made halfway along the line from the anterosuperior iliac spine to the patella.

infants with myopathies, the EMG results correctly predicted the final diagnosis in only 10%, whereas in older children and adults sensitivities of 80% have been reported.[12,19,43,81] As EMG is a measurement of function, and ultrasound is concerned with structure, the use of both techniques is complementary for the most part. Application of dynamic muscle ultrasound can provide a bridge between the study of muscle structure and function.[89]

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What is the diagnostic accuracy of single nerve conduction studies and muscle ultrasound to identify critical illness polyneuromyopathy: a prospective cohort study

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Abstract

Background: Critical illness polyneuromyopathy (CIPNM) is a major cause of weakness in intensive care unit (ICU) patients, but current diagnostic tests are limited. We evaluated the generalizability and validity of single nerve conduction studies (NCS) and muscle ultrasound testing to identify CIPNM, and we also assessed the ability of muscle ultrasound to prognosticate patient outcomes.

Methods: This was a prospective cohort study of mechanically ventilated medical, cardiac, surgical, and neurosurgical ICU patients. We performed weekly strength testing, NCS, electromyography (EMG), and muscle ultrasound. We calculated the sensitivity, specificity, and other test characteristics of single NCS and muscle ultrasound, and we used multivariable regression models to assess the prognostic ability of muscle ultrasound.

Results: Ninety-five patients were enrolled. The incidence of probable CIPNM was 18% and did not differ significantly by type of ICU ($p = 0.49$). For diagnosing probable CIPNM, the peroneal motor NCS had a sensitivity of 94% (95% confidence interval (CI) 71–100%) and specificity of 91% (95% CI 82–96%), the sural sensory NCS had a sensitivity of 100% (95% CI 80–100%) and specificity of 42% (95% CI 31–54%), and abnormal muscle ultrasound echogenicity had a sensitivity of 82% (95% CI 48–98%) and specificity of 57% (95% CI 43–70%). Abnormal echogenicity was associated with reduced likelihood of discharge to home (9% vs 50%, $p = 0.0001$), fewer ICU-free days (median 3 (interquartile range 0–15) days vs 16 (9.3–19.3) days, $p = 0.0002$), and increased ICU mortality (42% vs 12%, $p = 0.004$).

Conclusions: In a diverse cohort of critically ill patients, single NCS and muscle ultrasound achieved diagnostic accuracy for patients at risk for CIPNM. The routine utilization of these tests could be beneficial for all critically ill patients at risk for CIPNM.

Keywords: Critical care, Critical care outcomes, Critical illness, Muscle weakness, Muscular diseases, Polyneuropathies

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Background

Each year, approximately 1 million critically ill mechanically ventilated patients worldwide develop intensive care unit-acquired weakness (ICUAW) [1]. The prevalence of ICUAW varies widely depending on factors such as the presence of sepsis and multi-organ failure [2–14]. Weakness may be related to deconditioning (weakness without electrophysiologic abnormalities) or critical illness polyneuromyopathy (CIPNM; weakness with electrophysiologic abnormalities) [6, 9, 10, 15, 16]. Differentiating deconditioning from CIPNM is clinically important, as these two groups of patients have different outcomes and distinct courses of recovery [17].

The diagnosis of CIPNM can be challenging. Muscle strength testing is difficult to perform in acutely ill patients and does not differentiate CIPNM from deconditioning [18]. Although nerve conduction studies (NCS) and needle electromyography (EMG) can delineate CIPNM from deconditioning, these tests are time-consuming, mildly invasive (for EMG), use expensive equipment, and require specialized training.

A number of simplified screening tests for CIPNM have been proposed. NCS of a single motor nerve (such as the peroneal, also known as fibular, nerve) or sensory nerve (such as the sural nerve) may be a relatively accurate screening test for CIPNM [11–13]. The advantages of single NCS include shorter testing duration (5–10 min vs 60–90 min for full NCS/EMG), noninvasiveness, and no need for volitional patient movement. Electrophysiologic abnormalities are associated with deleterious outcomes in critically ill patients, even in the absence of weakness [17, 19]. However, a prior study examining the accuracy of single peroneal and sural NCS as screening tests for CIPNM focused almost exclusively on patients with severe sepsis [11]. Therefore, the generalizability of the accuracy of single NCS in screening for CIPNM is relatively unknown. Muscle ultrasound is also a promising technique to diagnose weakness by examining decreases in muscle thickness or changes in appearance (increased echogenicity) [20–34]. Muscle ultrasound has the potential advantage of being a relatively quick and noninvasive test that utilizes equipment present in most intensive care units (ICUs). However, the accuracy of ultrasound changes in muscle thickness or echogenicity to diagnose CIPNM remains unclear, and it is unknown if ultrasound provides prognostic information beyond that obtained from NCS/EMG.

The main purposes of our study were to determine the generalizability of unilateral peroneal and sural NCS for screening for CIPNM in a broader population, including critically ill cardiac, surgical, and neurosurgical patients, and to evaluate the accuracy of muscle ultrasound in screening for CIPNM and prognosticating outcomes in critically ill patients.

Methods

This was a prospective observational cohort study conducted at the University of Colorado Hospital, a tertiary academic institution. We enrolled patients from the medical, cardiac, surgical, and neurosurgical ICUs. The study was approved by the Colorado Multiple Institutional Review Board. All subjects or their proxies provided written informed consent prior to inclusion in the study. If a proxy was used for the initial consent, re-consent of the subject was attempted during the hospital course. Some of these data was previously presented as an abstract at the American Thoracic Society International Conference 2018.

We identified potentially eligible patients using daily screening for mechanically ventilated patients in the electronic health record of our hospital. For medical, cardiac, and surgical ICU patients, the study inclusion criteria were: 1) intubation for > 48 h with hypoxemia or hypercarbia in conjunction with severe sepsis or septic shock; or 2) ICU stay for > 48 h with multi-organ dysfunction and acute respiratory failure ($PaO_2/FiO_2 <$ 250) requiring mechanical ventilation. For neurosurgical ICU patients, the inclusion criterion was intubation for > 48 h with nontraumatic subarachnoid or intracerebral hemorrhage. Exclusion criteria for all ICUs included age < 18 years, pre-existing neuropathy or myopathy, pharmacologic paralysis, pregnancy, being a prisoner, time on mechanical ventilation and ICU stay of > 7 days, inability to perform NCS/EMG on at least one arm and one leg (e.g., due to amputation or overlying equipment), or patient/physician refusal to participate in the study.

After enrollment, we collected baseline information on demographics, comorbidities, and Sequential Organ Failure Assessment (SOFA) score. Each week, patients underwent Glasgow Coma Scale (GCS) scoring, and muscle strength testing was attempted using Medical Research Council (MRC) scoring of six bilateral muscle groups with a maximum score of 60. ICUAW was defined as an MRC score of less than 48 [6].

Weekly NCS/EMG testing was performed with a Natus Neurology Nicolet Viking EDX (Middleton, WI, USA) according to previously described standard procedures [11, 35]. Repetitive stimulation of the median motor nerve was performed to exclude neuromuscular junction defects, and F-waves were recorded from the tibial nerves to screen for proximal nerve root disease (e.g., Guillain-Barre Syndrome). The bilateral sural, radial, and median sensory NCS were recorded using standard procedures [11]. The bilateral peroneal, tibial, and median motor NCS were recorded using surface electrodes over the extensor digitorum brevis, abductor hallucis brevis, and abductor pollicis brevis muscles, respectively. The compound motor action potential (CMAP) responses were elicited from standard distal and proximal sites of stimulation to calculate a conduction velocity and to assess for the presence of conduction block or temporal dispersion. After reviewing the studies and excluding patients with defects in neuromuscular transmission or primary/acquired demyelination, the sensory nerve action potential (SNAP) and CMAP amplitudes were analyzed for abnormalities. Unilateral concentric needle EMG examination was then performed on two upper extremity and two lower extremity muscles, one proximal and one distal in each limb, assessing insertional activity, spontaneous activity, activation, motor unit potential morphology, and recruitment pattern. NCS and EMG are prone to differences in interexaminer reliability but maintain high intraexaminer reliability [36]. Therefore, all NCS/EMG examinations were performed by one electrophysiology-trained physician, who was not blinded to the results of the index tests or reference standard.

For muscle ultrasound, we used a Philips Sparq machine (Amsterdam, Netherlands) with a linear-array transducer with standardized gain and varying depth based on the amount of overlying soft tissue and muscle size. The patients were examined in the supine position with extended limbs and relaxed muscles. We performed bilateral scans at standardized sites on the mid-biceps (halfway between the tip of the acromion and antecubital skin crease with forearm supinated), anterior mid-forearm (halfway between the antecubital skin crease and ulnar styloid with forearm supinated), and mid-thigh (halfway between the anterior superior iliac spine and superior midline border of the patella). We measured muscle thickness and echogenicity in the axial plane (perpendicular to the underlying bone or interosseous membrane) while avoiding compression of overlying soft tissues. To quantify muscle echogenicity, we utilized the visual four-point Heckmatt score that correlates with clinical and histologic neuromyopathy [29, 33]. All muscle ultrasounds were performed before NCS/EMG by one trained examiner to minimize issues of interexaminer reliability. Only medical, cardiac and surgical ICU patients underwent weekly muscle ultrasound due to machine availability. Weekly NCS/EMG/ultrasounds stopped once the patient left the ICU, died, developed CIPNM or completed four weekly examinations.

The primary outcomes for this study were the sensitivity and specificity of the unilateral peroneal motor and sural sensory nerves for diagnosing CIPNM, using the previously reported most accurate cutoff amplitudes to define test positivity for the peroneal and sural nerves (below 0.65 mV for peroneal and 4 μV for sural) and a reference standard electrophysiologic definition of CIPNM based on established criteria [11]. Patients were diagnosed with CIPNM if they had: 1) SNAP amplitudes less than 80% of the lower limit of normal in two or more nerves; and 2) CMAP amplitudes less than 80% of the lower limit of normal in two or more nerves without conduction block. NCS were categorized as normal or abnormal using standard normal values for the electrophysiology laboratory (normal amplitude > 1 mV for the peroneal nerve and > 10 μV for the sural nerve). We used this purely electrophysiologic definition of CIPNM (hereafter referred to as probable CIPNM) as our reference standard as we anticipated that most patients would not be awake and able to participate in voluntary MRC and EMG testing [8]. If the patient could participate in testing, MRC and EMG were used to classify the diagnosis definitively as neuropathy, myopathy, both, or neither. For patients diagnosed with probable CIPNM, the electrophysiological testing results at the time the diagnostic criteria were fulfilled were used in all analyses. For the remaining patients who did not meet the diagnostic criteria for probable CIPNM, data from their last electrophysiological tests were used in all analyses. Muscle ultrasound does not have established cutoffs to define abnormal changes in muscle thickness or echogenicity that are associated with CIPNM. We thus evaluated whether decreased muscle ultrasound thickness or increased echogenicity were accurate screening tests for probable CIPNM and if these muscle ultrasound abnormalities added prognostic information on patient outcomes to that obtained from NCS/EMG. We built a multivariable regression model with selected predictors of age (continuous variable), gender (binary variable), SOFA score for disease severity (continuous), CIPNM status (probable CIPNM vs none, binary), and muscle ultrasound echogenicity (abnormal vs normal, binary). The main predicted outcome for assessing the incremental prognostic information conveyed by muscle ultrasound was hospital discharge disposition (home vs not home) using a nominal logistic regression model with coefficient statistical significance assessed using a Wald test. We also examined the outcomes of ICU-free days and ICU mortality in secondary analyses.

We followed the Standards for Reporting Diagnostic Accuracy (STARD) 2015 guidelines for reporting diagnostic accuracy studies [37]. For our sample size calculation, since prior studies showed ~ 95% sensitivity of the peroneal motor and sural sensory nerves for CIPNM diagnosis [11–13], for a test with 95% sensitivity, two-sided 95% confidence interval (CI) width of 10%, and probable CIPNM prevalence of 20%, 92 patients would be needed [38]. Although our focus for these screening tests was sensitivity, these same prior studies showed ~ 75% specificity of the peroneal nerve for CIPNM diagnosis and for a test with 75% specificity, two-sided 95% CI width of 10%, and probable CIPNM prevalence of 20%, 91 patients would be needed [38]. Baseline data are presented as counts and percentage or medians and interquartile range (IQR). We used chi-square tests for categorical variables and *t* tests or Wilcoxon tests for continuous variables. Outcomes are presented as percentages for binary outcomes and medians and IQR for continuous outcomes. All analyses were performed using JMP Pro 13 (Buckinghamshire, England). A p value less than 0.05 was considered statistically significant and all significance tests were two-sided. There was no adjustment performed for multiple comparisons.

Results

From December 2015 to April 2018, 255 mechanically ventilated patients met inclusion criteria and 155 were excluded (Fig. 1), with the most common reasons including an inability to obtain informed consent or refusal to participate ($n = 98$, usually from lack of available proxy), pre-existing neuromyopathy ($n = 29$), and pharmacologic paralysis ($n = 4$). We initially enrolled 100 patients. After enrollment and initial NCS/EMG were performed, five subjects were discovered to have a history of pre-existing neuromyopathy so they were excluded from further analysis. Thus, the final cohort included 95 patients (Table 1). No patients withdrew from the study and outcomes were collected on all patients.

Patients were awake, following commands, and able to participate in MRC strength testing at only 35% of study visits. A total of 17 patients (18%) were diagnosed with probable CIPNM, and only 1 of these 17 patients could participate in voluntary EMG and MRC testing before discharge to determine definitively if they had neuropathy, myopathy, or both. Of the 17 patients diagnosed with probable CIPNM, 15 were diagnosed at their first study visit (the other 2 were diagnosed at study day 14 and day 21, respectively). Patients who developed probable CIPNM had fewer 28-day ICU-free days (0 (IQR 0–1.5) vs 8 (0–17), $p = 0.007$), were less likely to be discharged home (6% vs 32%, $p = 0.03$), and were more likely to die in the ICU (47% vs 18%, $p = 0.01$) or hospital (53% vs 19%, $p = 0.004$) when compared with patients who did not develop CIPNM. There was no difference in days on mechanical ventilation (10 (IQR 6.5–14.5) vs 9 (6–17), $p = 0.67$). The incidence of probable CIPNM did not differ significantly by admitting ICU ($p = 0.49$), and there was a similar probable CIPNM incidence in the medical (18%) and neurosurgical (21%) ICUs.

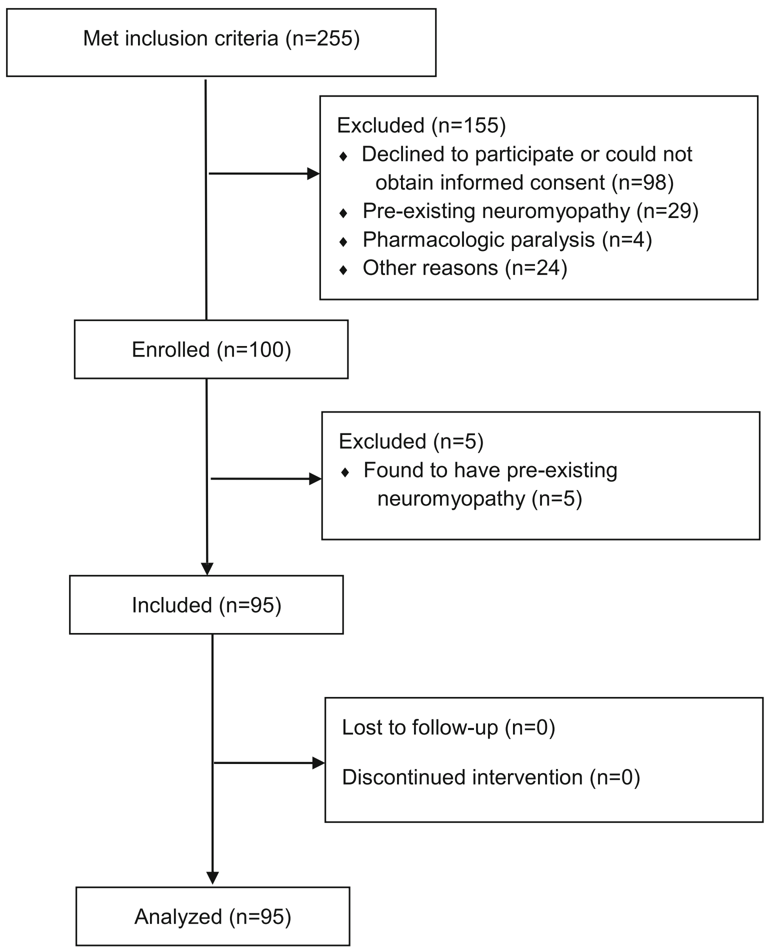

Fig. 1 Study flow chart

Table 1 Baseline demographic and clinical characteristics

Variables	Subjects (*n* = 95)	No CIPNM (*n* = 78)	Probable CIPNM (*n* = 17)
ICU location			
Medical	45 (47)	37 (47)	8 (47)
Cardiac	9 (9)	9 (12)	0 (0)
Surgical	13 (14)	10 (13)	3 (18)
Neurosurgical	28 (29)	22 (28)	6 (35)
Age, years	59 (43–70)	56 (43–65)	72 (59–77)
Gender, female	42 (44)	37 (47)	5 (29)
Race			
White	68 (72)	56 (72)	12 (71)
Black	13 (14)	12 (15)	1 (6)
American Indian or Alaska Native	3 (3)	2 (3)	1 (6)
Asian	1 (1)	1 (1)	0 (0)
Other or not reported	10 (11)	7 (9)	3 (18)
Ethnicity, Hispanic	13 (14)	10 (13)	3 (18)
Body mass index, kg/m^2	28.7 (25–32.3)	28 (24.6–31.9)	29.4 (27.7–37.9)
Primary reason for admission			
Subarachnoid hemorrhage	19 (20)	14 (18)	5 (29)
Pneumonia	17 (18)	15 (19)	2 (12)
Encephalopathy	9 (9)	7 (9)	2 (12)
Intracerebral hemorrhage	8 (8)	7 (9)	1 (6)
Postoperative	7 (7)	7 (9)	0 (0)
Nonpulmonary sepsis	7 (7)	4 (5)	3 (18)
Gastrointestinal bleed	5 (5)	2 (3)	3 (18)
Congestive heart failure	3 (3)	3 (4)	0 (0)
ARDS	3 (3)	3 (4)	0 (0)
Myocardial infarction	2 (2)	2 (3)	0 (0)
Other	15 (16)	14 (18)	1 (6)
Hospital length of stay, hours	108 (66–157)	108 (66–152)	116 (76–162)
Time on mechanical ventilation, hours	83 (63–133)	83 (63–134)	84 (69–135)
Central nervous system disease	11 (12)	8 (10)	3 (18)
Alcohol use disorder	23 (24)	16 (21)	7 (41)
Diabetes	12 (13)	10 (13)	2 (12)
HIV	0 (0)	0 (0)	0 (0)
Total SOFA score	9 (6–12)	9 (6–11)	12 (8–14)
Total GCS score (eyes + motor)	4 (2–9)	7 (2–9)	2 (2–7)

Data are presented as count (percentage) or median (interquartile range)
ARDS acute respiratory distress syndrome, *CIPNM* critical illness polyneuromyopathy, *GCS* Glasgow Coma Scale, *HIV* human immunodeficiency virus, *ICU* intensive care unit, *SOFA* Sequential Organ Failure Assessment

There were no statistical differences in the distribution of the right and left CMAP amplitudes for the peroneal nerve (0 mV (IQR −0.6 to 0.4)) and SNAP amplitudes for the sural nerve (0 μV (0–0)), and so the right and left amplitude values were averaged when they were both obtained. Using the previously reported most accurate cutoff amplitudes for the peroneal and sural nerves (0.65 mV for peroneal and 4 μV for sural) [11], the peroneal motor nerve had a sensitivity of 94% (95% CI 71–100%) and specificity of 91% (95% CI 82–96%) for diagnosing probable CIPNM compared with the reference standard, while the sural sensory nerve had a sensitivity of 100% (95% CI 80–100%) and specificity of 42% (95% CI 31–54%). The peroneal motor nerve had a positive predictive value of 70% and negative predictive value of 99%, whereas the sural sensory nerve had a positive predictive value of 27% and negative predictive value of 100% (Table 2; Additional file 1: Figure S1 and Additional file 2: Figure S2). The sensitivities were unchanged when using cutoff amplitudes of 80% of the lower limit of normal for our laboratory (Table 3). The global accuracy of each test (the sum of true positives and true negatives divided by the total population) was 92% for the peroneal motor nerve and 53% for the sural sensory nerve.

The 67 patients in the medical, cardiac, and surgical ICUs who underwent muscle ultrasound had a median of one study performed per patient; 33 patients (49%) had the worst echogenicity score in any muscle of 2, and no muscles had scores of 3 or 4. A muscle ultrasound echogenicity score in any muscle of at least 2 out of 4 had a sensitivity of 82% (95% CI 48–98%) and specificity of 57% (95% CI 43–70%) for diagnosing probable CIPNM compared with the reference standard, along with a positive predictive value of 27% and negative predictive value of 94% (Additional file 3: Figure S3). The global accuracy of the test was 61%. In all of the patients with probable CIPNM and abnormal echogenicity, the sural and peroneal single NCS were both abnormal. Increased echogenicity was associated with a reduced likelihood of discharge to home (9% vs 50%, p = 0.0001) and fewer ICU-free days (3 (IQR 0–15) vs 16 (9.3–19.3), p = 0.0002) along with increased ICU mortality (42% vs 12%, p = 0.004). We then determined if ultrasound added prognostic information to that obtained from NCS/EMG. For the main outcome of hospital discharge disposition, abnormal muscle ultrasound echogenicity was associated with a lower chance of discharge to home (odds ratio 0.42 (95% CI 0.2–0.86), p = 0.02) after adjustment for all the other predictors in the multivariable regression model. For the secondary outcomes, there were no significant associations between abnormal muscle ultrasound echogenicity and ICU-free days or ICU mortality. Only 13 patients had repeated studies of muscle thickness, so we could not examine changes in muscle thickness in this cohort.

The only adverse event was one thigh hematoma after EMG that did not expand after holding pressure and did not require further treatment intervention.

Discussion

In this prospective observational cohort study, we enrolled 95 heterogeneous critically ill intubated patients and performed serial NCS, needle EMG, and muscle ultrasound to examine simplified screening tests for probable CIPNM. Individual peroneal CMAP and sural SNAP amplitudes had good sensitivity for identifying patients with probable CIPNM, and abnormal muscle echogenicity was a good screening test for probable CIPNM and a predictor of prognosis.

CIPNM is associated with a number of adverse patient outcomes, including prolonged time on mechanical ventilation, longer ICU and hospital stays, increased hospital mortality, higher hospital costs, and a lower likelihood of discharge to home [6, 7, 10, 11, 15, 16, 39–42]. Following hospital discharge, CIPNM is also associated with increased 1-year mortality [17, 41]. Furthermore, in survivors of acute respiratory distress syndrome (ARDS) examined 5 years after their initial illness, physical function was diminished whereas pulmonary function largely returned to normal [43].

Our group previously published a prospective observational cohort study of medical ICU patients with severe sepsis and/or acute respiratory failure requiring mechanical ventilation to determine which specific motor or sensory nerves accurately screened for CIPNM [11]. Using an amplitude cutoff value from receiver operating characteristic (ROC) curves of 0.65 mV for the peroneal CMAP and 4 μV for the sural SNAP, the unilateral peroneal motor nerve was 94% sensitive and 74% specific and the sural sensory nerve was 94% sensitive and 70% specific for diagnosing CIPNM. Latronico et al. also explored the use of unilateral peroneal motor NCS as a screening test for CIPNM in a diverse ICU population and validated the results in a primarily neurological ICU population. This group also found the peroneal nerve to have excellent sensitivity (100%) for CIPNM diagnosis with good specificity (67–85%) [12, 13]. Our study validates those prior results and demonstrates their generalizability to a broader critically ill patient population including patients with sepsis, neurologic emergency, and postoperative respiratory failure. As one of the longest nerves in the body, the utility of the peroneal nerve for diagnosing CIPNM may be partially explained by its vulnerability to tissue ischemia [13].

Table 2 Results of index tests and reference standard

Peroneal motor < 0.65 mV	Sural sensory < 4 μV	No CIPNM	Probable CIPNM
No	No	32	0
No	Yes	39	1
Yes	No	1	0
Yes	Yes	6	16

CIPNM critical illness polyneuromyopathy

Table 3 Sensitivity and specificity of each nerve amplitude for the diagnosis of probable CIPNM

Nerve	Cutoff amplitude	Normal amplitude	Sensitivity (95% CI)	Specificity (95% CI)
Peroneal motor	0.65 mV	1 mV	94% (71–100%)	91% (82–96%)
Peroneal motor	0.8 mV	1 mV	94% (71–100%)	90% (81–95%)
Sural sensory	4 μV	10 μV	100% (80–100%)	42% (31–54%)
Sural sensory	8 μV	10 μV	100% (80–100%)	31% (21–42%)

CI confidence interval, *CIPNM* critical illness polyneuromyopathy

Critically ill patients experience both muscle wasting and a change in muscle appearance on ultrasound (increased echogenicity) [20–24]. Measurements of muscle ultrasound thickness and echogenicity have high inter-rater reliability in both healthy [25–27] and critically ill patients [28, 29]. Even in the presence of critical illness and edema, muscle thickness measurements at the biceps, mid-forearm, and mid-thigh correlate well with lean body mass [27, 30]. Muscle thickness decreases faster in critically ill patients with multi-organ failure [31]. Increased muscle echogenicity may be caused by intramuscular inflammation, necrosis, edema, fatty deposition, and/or fibrosis [29, 32, 33]. Our study demonstrates that increased echogenicity is a good screening test for probable CIPNM and is associated with deleterious outcomes.

Strengths of our study include generalizability through enrollment of a broad population of critically ill patients with a variety of diagnoses from multiple ICUs. We excluded patients with known pre-existing neuromyopathy through medical record searches and questioning of patients and proxies, supporting the validity of our findings. Single nerve screening tests for CIPNM should only be used in patients without pre-existing neuromuscular disease.

Our study has a number of limitations. The physician performing the electrophysiologic tests was unblinded, although muscle ultrasound was always performed before NCS/EMG at each weekly visit so that electrophysiologic testing results would not influence ultrasound interpretation. Since peroneal and sural NCS results were included as part of the reference standard criteria for probable CIPNM and both the index and reference tests were performed by the same specialist, the study was at risk of incorporation bias, which may lead to overestimation of diagnostic accuracy of our screening tests. We did not perform nerve or muscle biopsies, but it is impractical to perform these invasive procedures in most critically ill patients. It is possible that some of the changes in muscle echogenicity were due to edema, but fluid overload itself may still be harmful [44]. The prevalence of probable CIPNM in our study was 18%, which was slightly lower than the 20% prevalence we expected in our sample size calculations and led to wider confidence intervals for index test sensitivity. We could not perform MRC strength testing due to altered mental status in the majority of study visits, consistent with prior literature demonstrating that most prolonged mechanically ventilated patients are unable to perform manual muscle testing [18]. The inability to perform manual muscle testing gives NCS and muscle ultrasound a potential advantage, as these tests require no active patient cooperation.

There are a number of implications of our study for clinical management. Compared with full four-limb NCS/EMG, unilateral single nerve NCS is quicker, less painful for the patient, and could facilitate the diagnosis of CIPNM. The peroneal CMAP amplitude is 100- to 1000-times larger than the sural SNAP amplitude and is thus easier to find in ICUs that frequently have electrical interference. However, an abnormal peroneal or sural NCS requires follow-up with full NCS/EMG (and ideally muscle strength testing) to confirm a CIPNM diagnosis. Abnormal muscle echogenicity is a good screening test for probable CIPNM and provides additional prognostic information to NCS/EMG. Simplifying the diagnosis of CIPNM with single nerve NCS or muscle ultrasound would have a dramatic impact on clinical practice, leading to earlier diagnosis and increased recognition of CIPNM, better prognostication for patients and families, and more targeted use of treatments such as physical therapy.

Conclusions

Peroneal motor and sural sensory single NCS are accurate diagnostic tests for probable CIPNM, and muscle ultrasound echogenicity adds value for outcome prediction. Future studies should examine whether these simplified tests can identify good candidates for early ICU physical therapy or be used to monitor therapeutic response.

Additional files

Additional file 1: Figure S1. STARD flow diagram for 95 patients undergoing sural NCS index test. (DOC 43 kb)

Additional file 2: Figure S2. STARD flow diagram for 95 patients undergoing peroneal NCS index test. (DOC 43 kb)

Additional file 3: Figure S3. STARD flow diagram for 67 patients undergoing muscle ultrasound echogenicity index test. (DOC 44 kb)

Abbreviations

ARDS: Acute respiratory distress syndrome; CI: Confidence interval; CIPNM: Critical illness polyneuromyopathy; CMAP: Compound motor action potential; EMG: Electromyography; GCS: Glasgow Coma Scale; ICU: Intensive care unit; ICUAW: Intensive care unit-acquired weakness; IQR: Interquartile range; MRC: Medical Research Council; NCS: Nerve conduction studies; ROC: Receiver operating characteristic; SNAP: Sensory nerve action potential; SOFA: Sequential Organ Failure Assessment

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Availability of data and materials

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Authors' contributions

MM originated the concept for this study. DAK collected, analyzed, and interpreted the patient data. DQ reviewed electrophysiologic data for accuracy. MM, DAK, and DQ were major contributors in writing the manuscript. All authors read and approved the final manuscript.

Ethics approval and consent to participate
The study was approved by the Colorado Multiple Institutional Review Board. All subjects or their proxies provided written informed consent prior to inclusion in the study.

Consent for publication
Not applicable.

Competing interests
The authors declare that they have no competing interests.

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Rehabilitative Ultrasound Imaging: Understanding the Technology and Its Applications

From an historical perspective, ultrasound imaging (USI) has been used for medical purposes since the 1950s. The primary use of USI continues to be for traditional radiological goals, which consider the morphological characteristics and structural integrity of various organs and tissues. However, as the technology has been embraced as a safe, portable, objective, and relatively inexpensive means of examination, the ingenuity and diversity of applications has extended beyond these realms.

Ultrasound imaging related to musculoskeletal rehabilitation has been developing rapidly since the 1980s. The first report of muscle imaging linked to rehabilitation was in 1968, when Ikai and Fukunaga[63] related the size of the upper arm muscles to strength. However, it was the work of Dr Archie Young and colleagues at the University of Oxford in the 1980s that sowed the seeds for the use of USI by physical therapists. A striking finding of their work was how dramatic limb muscle wasting is underestimated with a tape measure.[144] Several studies of the quadriceps muscle followed, including investigation of the effect of knee joint injury, strength-training protocols, and aging on muscle size, and the relationship between muscle size and strength in different populations (see Stokes and Young[122] for a review). This early research used compound B-scanning, which enabled whole cross sections of large muscles to be captured, because the image could be built up as the transducer was moved over the skin. The compound technique, which was expensive, was phased out as a routine tool and replaced by real-time USI (definitions are provided in the **APPENDIX**) both in general medical and musculoskeletal settings.

A recent (1990s) resurgence in the interest of rehabilitative applications of USI has been seen amongst clinical therapists. This stems from a series of studies in which USI was used to detect atrophy of the lumbar multifidus (isolated to the side and spinal level of symptoms) in individuals with acute low back pain (LBP),[51] as well as to determine that recovery of this muscle was not automatic when pain subsided,[49] thus required specific training to reduce risk of future episodes.[47] In addition, these studies

SYNOPSIS: The use of ultrasound imaging by physical therapists is growing in popularity. This commentary has 2 aims. The first is to introduce the concept of rehabilitative ultrasound imaging (RUSI), provide a definition of the scope of this emerging tool in regard to the physical therapy profession, and describe how this relates to the larger field of medical ultrasound imaging. The second aim is to provide an overview of basic ultrasound imaging and instrumentation principles, including an understanding of the various modes and applications of the technology with respect to neuromusculoskeletal rehabilitation and in relation to other common imaging modalities. *J Orthop Sports Phys Ther 2007;37(8):434-449. doi:10.2519/jospt.2007.2350*

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suggested that the biofeedback provided by USI might facilitate the relearning process. Since that time, applications of USI with respect to many other muscles of the trunk and limbs continue to be investigated.[119]

Current applications of USI in rehabilitation essentially fall into 2 distinct areas of musculoskeletal imaging: rehabilitative USI (RUSI) and diagnostic imaging. The former, which is the topic of this special issue, includes evaluation of muscle structure (morphology) and behavior, as well as the use of USI as a biofeedback mechanism. Specifically, this includes the measurement of morphological features (morphometry), such as muscle length, depth, diameter, cross-sectional area, volume, and pennation angles; changes in these features and the impact on associated structures (fascia and organs such as the bladder) with contraction; tissue movement and deformation (eg, high-frame-rate USI and elastography); and qualitative evaluation of muscle tissue density. Alternatively, diagnostic USI involves examining the effects of injury or disease on ligament, tendon, and muscle tissues, which requires different skills and training than those needed for RUSI.[14]

In May 2006, the first international meeting on RUSI was hosted by the US Army-Baylor University Doctoral Program in Physical Therapy in San Antonio, TX. The purpose of the symposium was to develop best practice guidelines for the use of USI for the abdominal, pelvic, and paraspinal muscles, and to develop an international and collaborative research agenda related to the use of USI by physical therapists. At that symposium the participants agreed on the use of the term *RUSI*. In addition, a position statement (below) was created to help define this emerging tool in the field of physical therapy.[128] This statement, along with a visual representation of how the practice of RUSI fits into the larger field of medical USI, was endorsed by delegates (**FIGURE 1**):

"RUSI is a procedure used by physical therapists to evaluate muscle and related soft tissue morphology and function during exercise and physical tasks. RUSI is used to assist in the application of therapeutic interventions aimed at improving neuromuscular function. This includes providing feedback to the patient and physical therapist to improve clinical outcomes. Additionally, RUSI is used in basic, applied, and clinical rehabilitative research to inform clinical practice. Currently, the international community is developing education and safety guidelines in accordance with World Federation for Ultrasound in Medicine and Biology (WFUMB). Dated: 10 May, 2006."[128]

In addition to defining the scope of USI with respect to physical therapy, the position statement and diagram are intended to guide therapists in acknowledging professional boundaries, as ultimately the delegates' goal is to see RUSI accepted within the medical-imaging field. However, as the use of USI (both rehabilitative and diagnostic) by physical therapists is in its infancy, the need to establish training facilities for therapists in conjunction with other imaging disciplines, including their professional bodies, where possible, is recognized as a priority.

This commentary aims to provide an overview of basic USI and instrumentation principles as they relate to RUSI. This will include an introduction to the various modes of imaging, how USI fits with respect to other more commonly known imaging technologies, the type of information that USI applications can provide, how these applications may be of value to the researcher and clinician, as well as potential future lines of investigation.

BASIC PRINCIPLES OF SOUND WAVE PROPAGATION AND INSTRUMENTATION

This section is intended to provide a basic understanding of the principles that underlie USI. The generic characteristics of USI units and the physical properties of sound wave propagation will be discussed. As a complete appraisal of these topics is not possible in this forum, the reader is encouraged to refer to more thorough resources for further discussion.[73,138]

The Physical Properties of Sound

Ultrasound is defined as sound with a frequency greater than 20 000 Hz, which is the upper limit of the range registered by the human ear. USI uses sound waves primarily in the range of 3.5 to 15 MHz. Ultrasound waves behave according to

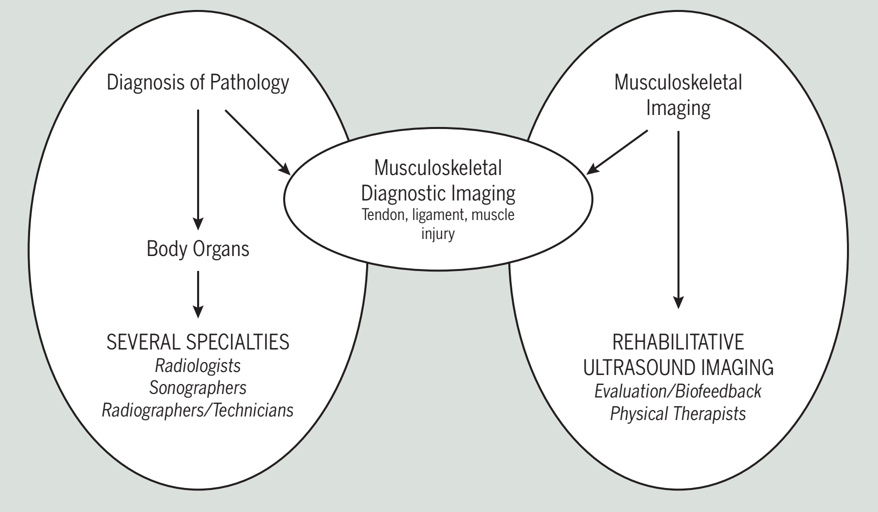

FIGURE 1. Fields of medical ultrasound imaging. Reproduced from Teyhen (2006)[128] with permission. Adapted from Stokes (2005)[118] with permission from University of Southampton.

principles that apply to all sound waves, which at the most fundamental level are mechanical waves that travel via particle vibration. Specifically, the source of a sound creates oscillatory vibrations that affect particles in the medium that lies adjacent to it. These particles, in turn, affect their adjacent particles, and so on. This process is referred to as wave propagation.[81] How far a sound wave propagates and whether an echo is produced depends on the strength of the sound source, the properties of the media through which the sound has to travel, and the number, shape, and properties of the objects it encounters.[73] These behaviors can be summarized by the principles of penetration and attenuation.

Penetration Penetration refers to the ability of sound to travel (depth) and is influenced by the intensity (strength or loudness), frequency, and speed of a sound wave. The intensity of an ultrasound wave refers to the rate at which energy is delivered per unit area and is determined by the total power output (W) of an ultrasound transducer, divided by its area (cm^2), and is expressed in units of mW/cm^2. As the intensity of an ultrasound wave increases, so does the depth it can penetrate, the strength of the echo that it can generate, and the potential it has to induce biological effects (heat and cavitation) within the tissues it is traveling through.

Frequency is defined as the number of oscillations that a wave undergoes in 1 second and is expressed in hertz (Hz). The higher the frequency of sound, the less the emerging wave will diverge. Due to their relatively high frequency, ultrasound waves are cohesive and can be used to selectively expose a target area. The frequency of an ultrasound wave is determined in the construction of the transducer assembly. As a general rule, the lower the frequency of a sound wave the farther it will penetrate.

The speed at which an ultrasound wave travels is determined by the density and stiffness of the structure or medium it is traversing. The more rigid the media the faster sound will travel through it. The average speed at which sound travels through soft tissue is 1540 m/s, which is similar to the velocity that it would travel through water (1485-1526 m/s).[85] Fat is less stiff than most soft tissue. Hence sound traverses it at a slightly slower speed (1450 m/s). Muscle and bone are stiffer and consequently sound propagates faster through them (1585 m/s and 3500m/s, respectively).

Attenuation As an ultrasound wave propagates, it encounters changes in tissue densities, or interfaces. Each tissue or medium has a characteristic resistance to sound referred to as acoustic impedance. This value is dependent upon the density of the medium and the speed at which sound can travel through it. At each interface between media of dissimilar impedance, an ultrasound wave will react and lose energy. Consequently, the energy within a sound wave decreases as it penetrates, until it is completely dispersed. This phenomenon, referred to as attenuation, occurs through the processes of reflection, scattering, refraction, and absorption. Although the first 3 processes contribute to the dispersion of an ultrasound wave, most of its energy is absorbed by the surrounding tissue in the form of heat.[73]

When a sound wave encounters an interface, the portion that is reflected back to its source is referred to as "reflection" and serves as the basis for image formation. The strength of a reflection depends on the size of the reflecting medium, the roughness of its surface, the incident angle of the sound wave, and the difference in impedance of the 2 media that create the interface.[73] The more regular the surface, the greater the difference in impedance between tissues and the more perpendicular the incidence angle; hence the greater the reflection and brighter (more white) the interface appears within the ultrasound image. An obvious example of this is the interface between bone and muscle (**FIGURE 2**). Not only is there a significant difference in the impedance of these 2 tissues, but bone attenuates a high percentage of the incident sound wave and, consequently, obscures the view of deeper structures.

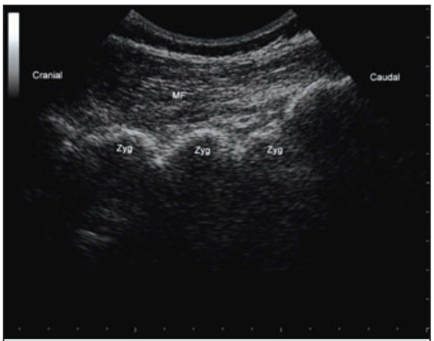

FIGURE 2. A parasagittal ultrasound image of the multifidus (MF) muscle in the plane of the zygapophyseal joints (Zyg). Note the increased echogenicity at the muscle-bone interface. Reproduced with permission Whittaker 2007.[142]

A sound wave can also scatter or refract when it encounters an interface between heterogeneous media. If, for instance, the structures that comprise an interface are very small, portions of the wave will be scattered. Those portions that travel back to the transducer are used in image formation, while those that scatter (the majority) are not. Alternatively, if there is either a significant difference in the speed that sound can travel though the 2 tissues or if the interface is not at a right angle to the ultrasound wave, the wave will change its direction when it crosses the boundary. This is referred to as refraction and it too can be a detriment to image formation through production of positional errors.

The practical implication of attenuation is that it limits penetration and consequently the depth of the images that can be generated.[73] Attenuation and frequency have a direct relationship: the higher the frequency of an ultrasound wave, the greater the attenuation and the more shallow its penetration. Conversely, the more attenuation, the more reflection and the better the detail resolution (ability to show detail) demonstrated in the ultrasound image. Consequently, the choice of frequency used for an imaging application will be dependent upon the depth of the region or structures of interest. Higher frequencies (7.5-10.0 MHz) are more valuable for ex-

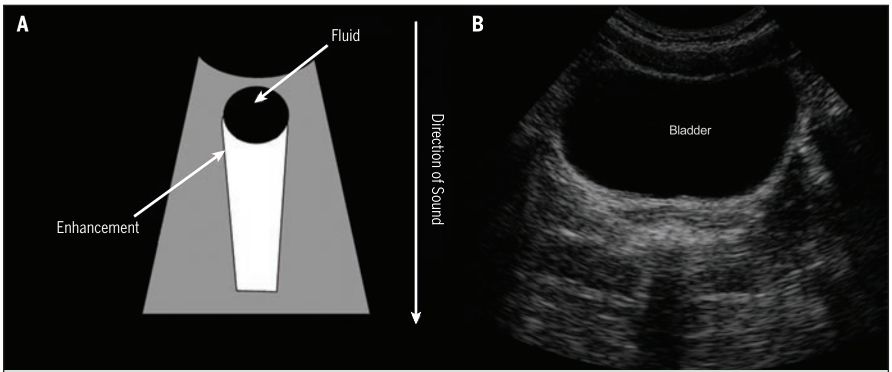

FIGURE 3. (A) Depiction of the enhancement of a region deep to a fluid-filled structure. Enhancement occurs as there is less attenuation of the propagating sound wave as it travels through a fluid-filled structure. (B) A transverse ultrasound image demonstrating enhancement of the midline pelvic floor structures deep to the bladder. Reproduced with permission Whittaker 2007.[142]

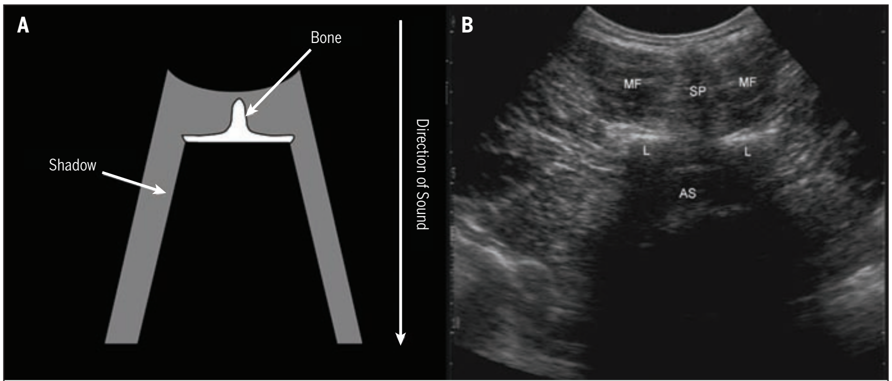

FIGURE 4. (A) Depiction of how an acoustic shadow forms behind a strongly attenuating (hyperechoic) structure such as bone. (B) A transverse ultrasound image demonstrating acoustic shadowing (AS) caused by the posterior elements of a lumbar vertebra. Abbreviations: L, lamina; MF, multifidus; SP, spinous process. Reproduced with permission Whittaker 2007.[142]

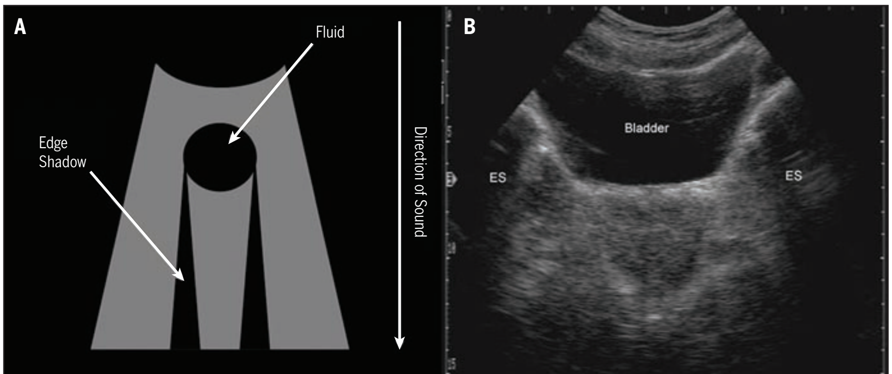

FIGURE 5. (A) Depiction of an edge shadow produced when a sound wave is refracted (bent) around the edges of a fluid filled structure. (B) A transverse ultrasound image demonstrating edge shadowing (ES) caused by the bladder. Reproduced with permission Whittaker 2007.[142]

amining superficial structures (superficial muscles, ligament, and tendons) and lower frequencies (3.5-5.0 MHz) for deeper structures (deeper muscles, the bladder, and contents of the abdominal/pelvic cavities). As a general rule, the highest frequency transducer that can image an area of interest should be used.[138]

Artifact USI devices generate images based upon several assumptions: sound travels in straight lines, echoes only originate from objects located in the 2 dimensions of the sound beam, the amplitude of an echo is directly related to the reflecting or scattering properties of the objects it encounters, and the speed at which sound travels through all the tissues is a constant 1540 m/s.[73] If any of these assumptions are violated, incorrect representations of anatomy can occur. These incorrect representations are referred to as "artifacts" and can also be the result of improper equipment operation or imaging technique. Artifacts can be both a help and a hindrance, and result in situations in which structures are either not real, missing, improperly located, or of improper brightness, shape, or size. Those which have a greatest impact on RUSI include enhancement, shadowing, and reverberation.

Acoustic enhancement refers to an increase in the amplitude of the ultrasound echo coming from a structure that lies behind a weakly attenuating structure, such as a fluid-filled cavity (eg, bladder [**FIGURE 3**]).[73] As the ultrasound device assumes that there is uniform attenuation of the ultrasound wave as it propagates, the tissues on the far side of the transmitting structure appear brighter than they should, as they are being exposed with a less attenuated beam. When this occurs, gain settings can be manipulated to compensate.

Acoustic shadowing is the opposite of enhancement. It refers to a reduction in the sound wave echo from structures that lie behind a strongly attenuating structure, such as bone (**FIGURE 4**).[110] Specifically, ultrasound waves hit something that blocks their path and everything behind the blocking structure appears black, as if it were within an "acoustic shadow." A shadow can also occur as a sound beam is refracted (bent) from its original path by passing close to a large, curved, fluid-filled structure (**FIGURE 5**).[43,61]

Reverberation refers to multiple reflections and is a result of ultrasound echoes bouncing between tissue layers and the transducer. Specifically, when an echo from a highly reflective surface that lies parallel to the transducer face returns to the transducer, a portion may be reflected back into the tissue to meet the same interface, where it again is reflected back to the transducer. Due to the time delay of the echoes being registered at the transducer, the depth of that interface is portrayed progressively deeper within the tissue. As the reflective echoes become weaker, the artifact fades out (**FIGURE 6**).

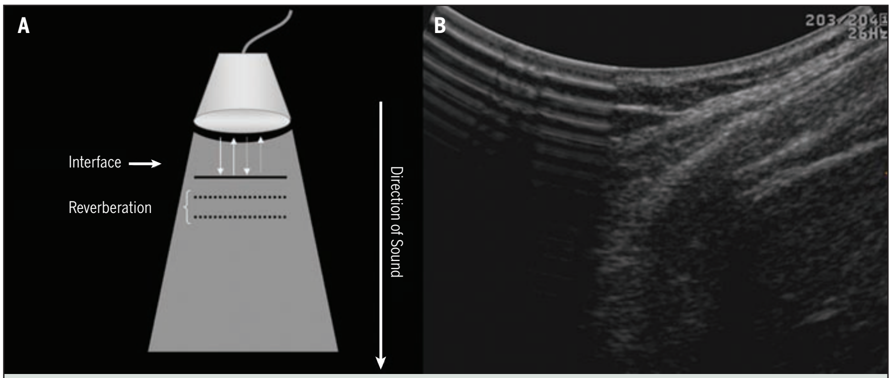

FIGURE 6. (A) Depiction of reverberation which is caused when a portion of the ultrasound echo from a highly reflective surface, lying parallel to the transducer, is reflected back into the tissue to meet the same interface where it again is reflected back to the transducer. The time delay falsely portrays that interface at 1 or more levels deeper in the tissue structure. (B) An ultrasound image demonstrating reverberation (lines on the left side of the image) produced by the interface between the transducer and air at the skin surface (inadequate use of gel).

Instrumentation

A typical USI device is a pulsed-echo (generates a series of short ultrasound waves at regular intervals) instrument consisting of 2 components: a transducer assembly (commonly referred to as a "transducer" or "probe"), and an imaging system. The transducer is responsible for generating ultrasound waves, as well as receiving the ultrasound echoes returning from the tissues and converting them into electrical signals. The imaging system is the component of the technology that receives the electrical signals representing the echo from the transducer and processes them so that they can be displayed as a digital image.

Imaging System A USI system consists of 4 generic components: the beam former, signal processor, image processor, and visual display.[73] In general terms, the beam former is responsible for generating the electrical impulses that drive the transducer assembly, as well as for amplifying and digitizing the electrical signal returning from the transducer assembly that represents the ultrasound echo. The signal processor is responsible for filtering and compressing the electrical signal before the image processor converts the signal into an image presented on the instruments display.[73]

Transducer Assembly (Probe) A transducer assembly houses an array of crystals (transducers), their electrical connections, an acoustic lens, and damping material. By definition, a transducer is a device that converts one form of energy to another.[73] Ultrasound transducers (also referred to as "elements" or "crystals"), commonly a ceramic formulation of lead zirconate titanate, are piezoelectric elements that produce voltage (electrical energy) when deformed by an applied pressure such as a sound wave (acoustic energy).[73] Although not technically accurate, a transducer assembly is generally referred to as simply a transducer or probe (the term transducer will be used throughout this commentary). The arrangement and the operating frequency of the crystal elements, as well as the width of the field of view (in metric) produced, are all taken into consideration when describing a transducer.

The arrangement, or array, of the elements within a transducer can be linear or curved (also referred to as "curvilinear"). A linear transducer contains many small rectangular crystal elements mounted side by side across its face. By triggering the elements sequentially, a rectangular image is built up from many vertical, parallel scan lines with a width that approximates the length of the array.[73] The advantage of a linear array is its wide near field, which is appropriate for imaging small superficial structures (**FIGURE 7**). A curved transducer is similar except that the crystal elements are formed into a curve rather than a straight line, which results in a diverging (pie or sector shaped) image (**FIGURE 8**). The advantages of a curved array is its wide far field, coupled with a small "footprint," which is suitable for imaging deep abdominal structures.

A typical ultrasound transducer produces a range of frequencies around a preferred (maximum efficiency) frequency that is referred to as the "operating frequency" or "resonance frequency." The operating frequency of an ultrasound transducer is predetermined by the thickness of the crystal elements. It is commonplace that a transducer may have 2 distinct operating frequencies (eg, 3.5 and 5.0 MHz, or 7.5 and 10.0 MHz) and, indeed, some are multifrequency.

BRIGHTNESS MODE AND MOTION MODE USI

There are several options (modes) available to display the electrical signal representing the ultrasound echo that returns from the tissues. The most common modes of display employed in rehabilitative settings are "B" (brightness, brilliance) and "M" (motion, movement) modes (b-mode and m-mode, respectively).

B-Mode USI

B-mode displays the ultrasound echo as a cross-sectional grey-scale image and is the mode of display most typically associ-

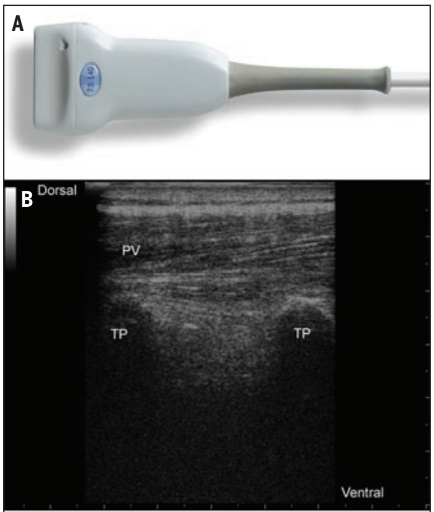

FIGURE 7. (A) A linear array ultrasound transducer. (B) A sagittal ultrasound image of the thoracic spine generated using a 7.5- to 10.0-MHz linear array transducer. Abbreviations: PV, paravertebral musculature; TP, transverse process. Note the linear footprint and the rectangular nature of the image.

ated with USI (**FIGURE 9A**). B-mode images provide information gathered from the entire length of the transducer and consist of visible dots or pixels of varying degrees of brightness that represent the location and density of structures encountered by the ultrasound beam. The brightness of each pixel depends on the strength of the echo, which in turn is determined by the location and characteristics of the echo-generating structure. The position or plot of a pixel is established by considering the direction of an ultrasound wave when it enters the body, the length of time it takes for the echo to return to the transducer, and the speed at which sound can travel through soft tissue.[138]

In contrast to other modes of display (eg, m-mode), the relatively large field of view available to b-mode, combined with the real-time nature of USI, presents an opportunity to view several structures at once and, if warranted, over time. Consequently, it can be used to depict the morphology (eg, shape, size, composition, and resting state) of a structure (eg, muscle, nerve), the positional relationship of several structures (eg, muscle, nerve, bone, or organs such as the bladder), as well as the characteristics (simultaneous versus independent, or phasic versus sustained increase in muscle thickness) and the influence of a dynamic event, such as a muscle contraction, on structures within the field of view. Hence, it has been speculated that b-mode USI may be able to enhance clinical rehabilitative outcomes by contributing previously unavailable information about the structure and behavior of muscle to the examination process[33,70,105,106,120] and by providing useful feedback about the behavior of muscle during therapeutic interventions.[27,45,93] Furthermore, because of its advantages and capabilities, b-mode USI may have a role to play in basic, applied, and clinical rehabilitative research.[9,20,52,57,88,124]

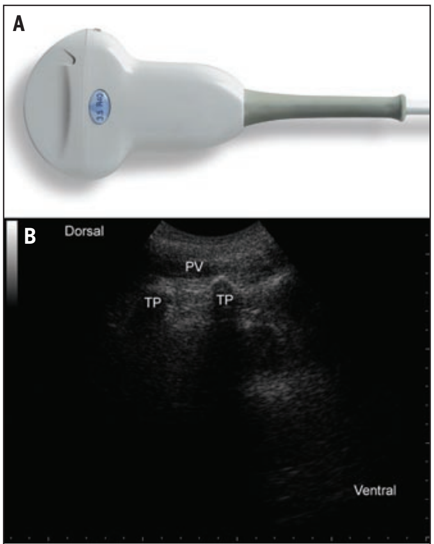

FIGURE 8. (A) A curved or convex array transducer. (B) A sagittal ultrasound image generated from the same location as in Figure 7B, using a 3.5- to 5.0-MHz curved or convex array transducer. Abbreviations: PV, paravertebral musculature; TP, transverse process. Note the curved footprint and the pie or sector nature of the image.

Clinical Applications of B-Mode USI: Evaluation Although used extensively in the laboratory, the clinical use of b-mode USI and the evidence base supporting it are in their infancy. That said, clinicians may look to related and emerging research to speculate on the kinds of information able to contribute to the examination process.[142]

B-mode USI is well established as a tool for measuring the static architectural features of a muscle, the positional relationships between muscles and/or other structures, as well as changes in these features and relationships over time. For instance, measurements of assorted muscle parameters (length, depth, cross-sectional area) for a wide variety of muscles, including the biceps brachii,[6] masseter,[102] cervical[77] and lumbar[48] multifidus, transversus abdominis,[52] rectus abdominis,[19] rectus femoris,[6] supra and infraspinatus,[65] as well as the vastus lateralis,[107] have been validated through comparison to magnetic resonance imaging (MRI). Furthermore, USI has been used to describe the relationship between the pelvic floor muscles and the bladder wall,[131,133] the bladder neck and symphysis pubis,[106] the bladder neck and anorectal angle,[98,99] as well as the bladder base and the urethrovesical neck.[21] As an extension of this work, investigators have been able to demonstrate acceptable interrater and intrarater reliability for various measurement applications,[18,74,88,117,129] to generate normal reference ranges,[104,105,120] to demonstrate differences in these parameters over time between normal and various patient cohorts[51,100,130,133] as a result of therapeutic interventions,[50] and to investigate the relationship between the size and strength of specific muscles in varied populations.[4,67,88,145,146]

Recently, the role that b-mode USI has played in detecting the presence of muscular degeneration resulting from aging and/or chronic dysfunction has been investigated. As muscular degeneration is associated with a decrease in water and an increase in fat and fibrous content,[10,136] it results in greater echogenicity and a loss in the demarcation of a muscle's architectural features (muscle contour, pennate pattern, and the central tendon).[66,124] Although MRI is considered the gold standard for identifying these changes, examples of these findings have been reported with b-mode USI for several muscles, including the cervical[74] and lumbar[120] multifidus, the rectus abdominis,[19] and the rotator cuff.[124] Furthermore, with the use of a qualitative evaluation tool that has incorporated both the degree of demarcation of architectural characteristics and muscle echogenicity with respect to a reference muscle at a set level of gain, Strobel et al[124] have concluded that b-mode USI is moderately accurate for the detection of significant levels of fatty atrophy in the supraspinatus and infraspinatus muscles when compared against MRI.

B-mode USI has also been used to comment on changes in architectural features of muscle, as well as the positional relationships of muscles or other structures in both normal and patient populations during dynamic events, such as a muscle contraction (voluntary and automatic) or increases in intra-abdominal pressure. Specifically, changes in architectural features of biceps brachii, tibialis anterior, transversus abdominis, and the internal and external oblique muscles have been investigated and compared to the amount of muscle activity present with electromyography (EMG) during voluntary contractions.[57,82] Furthermore, automatic changes in these parameters have also been monitored during specific tasks. For instance, Ferreira et al[33] described changes in the depth and length of the lateral abdominal wall muscles during a lower extremity lifting task, while Kiesel et al[70] have described changes in the depth of the lumbar multifidus with a prone arm lift movement. B-mode display has also been used to monitor the position of the bladder base,[131] the bladder wall,[114,132,133] the bladder neck,[20,106,133] and the anorectal angle[98,99] during voluntary pelvic floor muscles contractions, increases in intra-abdominal pressure (Valsalva maneuver),[130] and lower extremity lifting tasks.[94]

Although this work is valuable and has provided insight into mechanisms of neuromuscular dysfunction, it has also highlighted the limits to the information that USI can provide when considered in isolation. Specifically, as the relationship between actual muscle activity (measured with indwelling EMG) and changes in the architectural features of a muscle (seen with USI) is nonlinear,[53,57] a change in muscular dimensions may or may not indicate an increase in muscle activity. The relationship of these 2 factors is unique to each muscle; however, there is generally a rapid increase in muscle thickness associated with lower levels of muscle activity (approximately less than 25% of maximal voluntary contraction), which tapers as activity increases.[57] The discrepancy exists due to limitations of 2-dimensional imaging and the factors related to the length, pennation pattern, and extensibility of a muscle, as well as to the potential for a change in architecture in the presence of a competing force on the muscle (eg, contraction of an adjacent muscle or an increase in intra-abdominal pressure).[53] Similar issues arise when describing the relative change in position of a structure. Due to these considerations, investigators must take care during both the interpretation and reporting process. Ultimately, investigators must be adequately trained and experienced to be able to detect, reliably measure, and interpret the causes behind a change in one of these previously mentioned parameters. Furthermore, care must be taken to limit reporting to a change in the parameter measured (eg, thickness) and acknowledge that any conclusions regarding muscle activation or the mechanisms behind these changes are an extrapolation of these findings. Nevertheless, if these issues are considered and appropriate care is taken, accurate analysis and measurement are possible.[9,33,52,57,70,104,105,120]

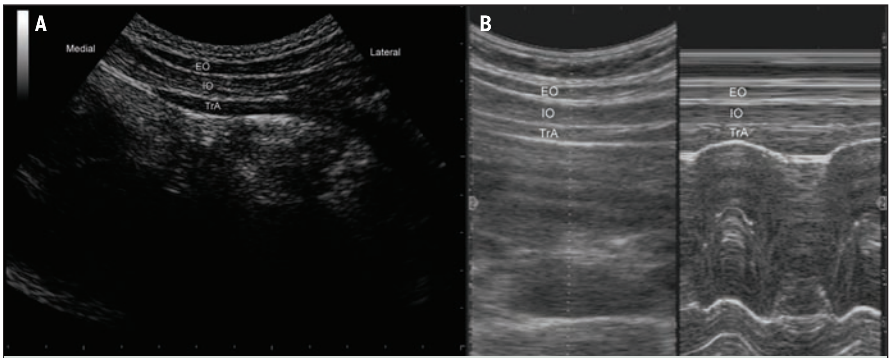

FIGURE 9. (A) A brightness mode (b-mode) image of the lateral abdominal wall. Abbreviations: EO, external oblique; IO, internal oblique; TrA, transversus abdominis. (B) A split-screen image with b-mode on the left and motion mode (m-mode) on the right. The m-mode image represents the information from the dotted line on the b-mode image displayed over time (*x*-axis). Static structures produce straight interfaces while structures that change in thickness or depth (in this case the TrA) create curved interfaces. The increase in depth of the TrA correlates to a contraction. Reproduced with permission Whittaker 2007.[142]

Clinical Applications of B-Mode USI: Biofeedback The importance of coordinated muscle effort (neuromuscular control) has received considerable attention with respect to the rehabilitation of cervical and lumbopelvic dysfunction, as well as incontinence, in recent years. This is due to an accumulation of evidence pointing to altered neuromuscular control in individuals with persistent and recurring symptoms.[5,15,24,56,60,62,126] Moreover, investigations indicate that these deficits do not consistently recover with the resolution of pain[49,51] and are not addressed with traditional exercise programs focused on increasing strength and functional capacity.[125] The extrapolation of this work is that the initial focus of rehabilitation may need to address these motor control alterations through a therapeutic intervention rooted in motor learning.[64,134,135]

As the real-time nature of b-mode USI allows a patient and therapist to view a muscle contraction and its impact on surrounding structures directly, it is a unique tool that may be a novel and previously unavailable resource to the learning process. First, it may serve as a tool that allows a therapist to explain and physically demonstrate to a patient the subtleties of specific motor control impairment; second, it may serve as a comprehensive form of biofeedback providing knowledge of results and performance and enabling the modification of motor response. Although the literature is unclear as to how this knowledge might enhance motor learning or the permanence of these effects, recent findings[27,45,93,139] suggest that real-time b-mode USI may enhance motor learning.

Research Applications of B-Mode USI Research applications of b-mode USI primarily involve assessment of the morphological characteristics of muscle (length, depth, diameter, cross-sectional area, volume) and changes in these characteristics, and the corresponding effect on associated structures (fascia and organs such as the bladder) with contraction, dysfunction, or therapeutic interventions, in an attempt to provide insight into the mechanisms that underlie alterations in the neuromuscular system. Paramount to the investigative process is the understanding that various factors influence the robustness and reporting of these measurements.

At the most fundamental level, this involves the need for standardization of imaging and measurement procedures. This includes definition of measurement site, definition of muscle borders, as well as matters related to repeated measurements, such as consistent patient positioning (eg, joint angle alters muscle cross-sectional area and length), transducer location, orientation, and inward pressure. Ideally, a repeatable transducer location is achieved through the use of bony or fascial landmarks that serve as standard reference points from which measurements can be taken at different points in time. If such reference points are not available within the ultrasound image, then carefully defined surface transducer locations generic between subjects[33,105,129] or regions of the greatest visualized displacement of a structure (eg, the region of the bladder wall that exhibits the greatest displacement during a pelvic floor muscles contraction)[114,133] may be used. Relocation of the ultrasound transducer can also be aided by external markers (eg, freckles or scars) that can be traced onto a transparent sheet to form a map of the site and stored for future use.[122] Furthermore, the sonographic convention in terms of positioning the ultrasound device on the right side of a supine subject (or left side of a prone subject) is recommended during research applications to aid in standardizing the orientation of the resulting images.[16] However, this protocol may not always be feasible when assessing dynamic functional activities.

To facilitate comparisons between studies and the development of reference data for clinical purposes, it is suggested that future reports related to muscles size and other characteristics include mean, standard deviation, range, and 95% confidence intervals. Moreover, as these values have been found to vary based on gender and body mass index,[105,117,120] comparison between individuals may be enhanced by standardizing the values across subjects by normalizing the postevent by the pre-event measurement and expressing this as a percentage.[129]

With respect to statistical analysis, different tests have been used to investigate the reliability of USI measures, most commonly intraclass correlation coefficients (ICC)[115] with standard error of measurement (SEM) and minimal detectable change (MDC).[28] Bland and Altman tests also provide a clinically meaningful measure of the magnitude of agreement (95% limits of agreement) independent of the true variability in the observations.[7] These tests have their individual strengths and weaknesses, and no single test is sufficient to reflect reliability fully.[101,103,115] It is recommended that future studies use all of these methods of analysis to enable comparison between reliability studies.

Although b-mode USI has limitations, it nonetheless appears to provide an opportunity to gather novel information. Hence, future work should focus on determining its clinical utility as both an evaluative and therapeutic tool. Further, investigation should be undertaken into its ability to predict symptomatology, appropriateness for intervention, as well as categorization of subjects into homogeneous cohorts for interventional studies.

M-Mode Ultrasound Imaging

Unlike b-mode, which generates a cross-sectional image of an anatomical region using information gathered from the entire length of the transducer (**FIGURE 9A**), m-mode displays information collected from the midpoint of the transducer as a continuous image over time (as represented as the dotted line on **FIGURE 9B**). With time on the x-axis, and the depth of the underlying anatomical structure on the y-axis, the m-mode image represents changes in thickness, or depth of a structure, over time and is, therefore, referred to as "time-motion" mode. For example, the image in **FIGURE 9B** displays the change in thickness of the transversus abdominis muscle from a resting to contracted state over time.

Investigators have found m-mode USI to be a reliable technique to measure muscle thickness.[9,69,82] Further, changes in muscle thickness measured by m-mode have been correlated to those generated by b-mode.[82,137] McMeeken et al[82] found acceptable agreement between the 2 display modes for measuring changes in thickness of the lateral abdominal wall muscles. The intrarater ICC value for b-mode was 0.989, for m-mode 0.981, and the between-mode reliability was 0.817.

M-mode also provides an opportunity to assess the depth of a structure over time and allows for the calculation of the relative timing of muscular thickness changes. For example, Mittal et al[86] used m-mode USI to assess the temporal relationships between circular and longitudinal muscle contractions during esophageal peristalsis. More applicable to physical therapy, Vasseljen et al[140] used high-frame-rate m-mode USI to detect the onset of lumbar multifidus activity associated with limb motion, while Bunce et al[8,9] found that m-mode USI was able to assess functional components of the lateral abdominal muscles during treadmill walking.

Until recently, m-mode has been a mode of display used almost exclusively in echocardiography to assess the structure and motion of the myocardium and the heart valves.[34,87,143] Specifically, it has been used to assess morphological and functional changes in the myocardium during isometric exercise[12] and endurance training,[38,42,112] as well as comparison of these changes between different populations (athletes,[96] nonathletes,[96] and obese individuals[116]) and as a function of age.[97]

In addition to the above applications, m-mode USI has been used to assess pulmonary function, specifically diaphragm excursion, motility, and paralysis.[2,32,39,78,113] Furthermore, it has been found to be beneficial in assisting and guiding treatment in those with muscular dystrophy. Researchers assessing diaphragmatic motion using m-mode USI have found that gender, body mass index, waist circumference, and age influence the amount of excursion.[68] These findings highlight the need to further assess the effects of these variables on measurement of muscular function when using m-mode for RUSI.

Although the use of m-mode USI in the assessment of muscle behavior is relatively new,[8,9,69,82,140] it appears to have the potential to provide unique information. Specifically, it may assist investigators in describing changes in the function of the lateral abdominal wall, posterior spinal, and pelvic floor muscles associated with dysfunction.

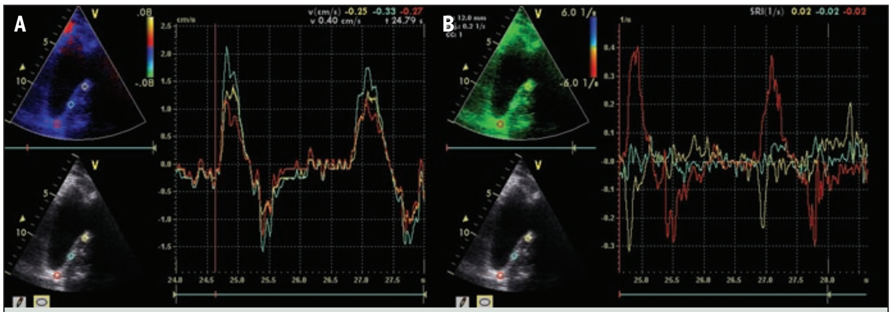

FIGURE 10. (A) Tissue velocity imaging. In the bottom left of the figure is a grayscale brightness mode ultrasound image of the bladder base during subsequent pelvic floor contractions. It is used to navigate and localize 3 measuring points (red, green, and yellow circles). Above this is the same image with tissue velocity analyzed via colour Doppler for the 3 sites. By plotting the velocity (cm/s) of the sites (*x*-axis) against time (*y*-axis), it can be determined that in this example there is no difference in velocity between the points. Scanner: Vivid 7, GE-Vingmed Ultrasound, Horten, Norway. Note the bladder is sparingly filled to better demonstrate displacement. (B) Strain rate imaging. Strain rate analyses (the rate by which strain occurs) of the same data involve plotting the strain rate period (1/s) against time (s). In this example strain rate differs at the 3 sites. The tissue marked by the yellow point has a negative strain rate, indicating that the tissue is compressed at the beginning of the contraction. The tissue marked by the red point initially exhibits a positive strain rate, indicating elongation; it then exhibits a negative strain rate indicating compression. The tissue marked by the green point undergoes mild compression and elongation (Scanner: Vivid 7, GE-Vingmed Ultrasound, Horten, Norway).

HIGH-FRAME-RATE USI

Conventional m-mode ultrasound images are constructed from data updated approximately 25 to 50 times per second. Although these frame rates are capable of detecting deformation (thickness) and changes in the depth of a muscle, they are not high enough to provide information related to the normal anticipatory response demonstrated by certain muscles[23,54,60,89] and the loss of this response with dysfunction.[24,55,58,79] In fact, to be able to record anticipatory muscle response (defined as a contraction occurring from 100 milliseconds before and up to 50 milliseconds after activation of a prime mover[3,59,89]), frame rates need to be on the order of 500 frames per second.[140]

Although intramuscular EMG is considered the gold standard for evaluating onset of muscle activity, high-frame-rate m-mode USI is a promising noninvasive alternative, as it allows for the visualization of the onset of deformation of muscle as it starts to contract. For instance, Vasseljen et al[140] demonstrated that high-frame-rate m-mode USI, captured at 500 frames per second, has comparable accuracy (when based on averaged values of repeated trials) to intramuscular EMG in detecting the onset of lumbar multifidus activity in healthy individuals. The superficial location of multifidus and the use of a high-frequency (12-MHz) transducer made the high frame rate and ultimately the investigation possible.

High-frame-rate m-mode USI, alongside methods such as tissue Doppler, falls into a category of imaging aimed at investigating tissue deformation, motion, and strain. As indicated above, high-frame-rate m-mode USI can be used to detect the onset of muscle deformation, as it shortens and thickens with a contraction. In contrast, tissue Doppler can be used to calculate tissue strain and strain rates,[44] as well as tissue velocity (**FIGURE 10**). Both deformation and velocity imaging can be derived from conventional ultrasound or tissue Doppler data; however, strain and strain rate require postprocessing.

Limitations of high-frame-rate USI vary across scanning devices. In general, the limitations of high-frame-rate m-mode are similar to b-mode in that they detect the earliest onset of motion induced by muscle contraction, whether as a result of actual contraction or the displacement of surrounding tissue. Furthermore, although contraction of a muscle produces displacement in 3 dimensions, m-mode applications are only capable of providing information about movement towards or away from the transducer.[53]

Although the majority of studies employing high-frame-rate m-mode USI are focused on describing the cyclic motions and deformation of the heart,[123] developments and experiences in the field of echocardiology hold potential for the description of a variety of parameters related to the contraction of skeletal muscles in rehabilitation. Specifically, research is required to determine whether high-frame-rate m-mode USI is helpful in investigating the location of the onset of a contraction within a muscle, differences in the onset of muscle activity within and between individuals or populations (symptomatic versus asymptomatic), and these at different points in time, as well as the sequence, timing, and patterns of muscle activation. These insights may provide valuable information to our understanding of automatic and voluntary muscle activity.[141]

ELASTOGRAPHY

It is possible to postprocess the electrical signal produced from the echo returning from the tissues to the transducer in such a way as to quantify tissue movement and deformation in response to internal or external mechanical forces.[13,92] In the last decade, several of these techniques (elasticity imaging and speckle tracking), including elastography, have been developed.

Elastography was initially conceived with a goal of quantifying the subjective information conveyed by palpation of harder areas within softer tissues, such as in the clinical detection of tumors (eg, breast, prostate).[17,35] In the classical elastography method, the ultrasound transducer is used to slightly compress the tissue, while a rapid series of successive ultrasound images is acquired. Using cross-correlation methods to postprocess the ultrasound data, displacement and strain images are calculated and represent the amount of movement that small segments of individual A-lines (the electrical signal coming from a single transducer) undergo during the tissue compression.[92] A-line segments with more relative motion correspond to softer tissue (assuming a uniform strain distribution within the tissue).

The technique has since been extended to other applications, including the use of external sources of tissue motion (such as vibration), as well as naturally occurring internal motions (such as breathing, cardiac wall motion, and arterial pulsation).[72,108] Furthermore, increased availability of high-frame-rate USI devices has allowed for the use of handheld transducers, which has simplified the frame-suspended setups used in earlier applications.[71] Due to these advancements, clinical applications have expanded to include the detection of liver fibrosis and deep-vein thrombosis.[36,109] Musculoskeletal applications include the quantification of soft tissue displacement and strain in response to a variety of externally applied mechanical inputs such as tension, compression, and acupuncture needle manipulation.[37,41,76]

To date, tissue elasticity imaging techniques have not been used for rehabilitation purposes; however, they hold potential for the detection of differences in the biomechanical properties of muscle and its associated connective tissue in response to physical tasks. It is important to keep in mind that elastography images do not directly represent tissue elasticity but, rather, tissue displacement and strain. However, in conditions in which local tissue stress can be calculated (or estimated), strain and stress values can be used to map local tissue stiffness.

Although these elastic imaging techniques hold potential for rehabilitation, some practical difficulties need to be overcome. These include access to the raw electrical ultrasound signal (not available on most commercially available USI equipment) and the need for postprocessing of the ultrasound data, which preclude real-time feedback. Despite these limitations, the dynamic spatial mapping of tissue strain over time offers exciting new possibilities for quantifying the behavior of soft tissues in response to externally or internally generated perturbations.

USI VERSUS OTHER IMAGING METHODS

The identification, evaluation, and monitoring of various musculoskeletal disorders is expanding due to technological advancements associated with MRI, CT, and USI. Specifically, new and innovative applications are improving clinical understanding of the underlying mechanisms and sequelae common to musculoskeletal disorders.[11,30,40,47,66,84] As such, it is important to consider how USI and the information that it can provide compares to these other imaging technologies.

MRI, CT, and USI provide insight into various features of the muscular system, both in asymptomatic as well as symptomatic individuals.[31,49,70,77,105,120] In particular, they provide useful qualitative/quantitative measures concerning the muscular system, including the consequential muscular degeneration (atrophy and fatty infiltrate) shown to be common in patients with low back pain,[11,22,47,51,66,75,84,95] neck pain,[1,30,40,74,83] and other peripheral musculoskeletal disorders.[124] Although MRI is considered the gold standard for musculoskeletal imaging, emerging applications of USI and CT are capable of providing insight into in vivo features of the musculoskeletal system. Each imaging method has strengths as well as weaknesses (**TABLE**).

Magnetic Resonance Imaging

MRI, unlike USI, has multiplanar and multislice imaging capabilities. It is considered the gold standard for the evaluation and quantification of soft aqueous muscular degeneration, as it provides reliable measures of degenerative changes in muscle such as fatty infiltration and atrophy.[1,11,30-31,40,52,66,83,84,90,95] There are 2 conventional MRI sequences: T1 and T2 weighted. Images from T1-weighted scans demonstrate excellent anatomical contrast of fat and other soft aqueous tissues (eg, skeletal muscle).[90] Alternatively, T2-weighted scans provide outstanding detail related to the features of inflammation that are suggestive of neopathological conditions. The drawbacks of MRI remain cost, accessibility, constraints in the number of joints that can be investigated per session, limited real-time imaging capacity, and variable patient tolerance (eg, claustrophobia, metallic implants, pacemaker, and pregnancy).

Computerized Tomography

CT, like MRI but unlike USI, permits multislice imaging and can offer better scan resolution and shorter imaging times than MRI. However, it is not without the inherent risks associated with exposing a patient to ionizing radiation. CT is useful in diagnosing traumatic musculoskeletal injuries, such as fractures, and has been effectively used to evaluate and quantify cross-sectional area of paraspinal musculature in patients with low back pain.[22,75] While CT produces high-quality images, they are dependent on tissue densities in order to provide contrast. When tissue densities between pathologic and adjacent anatomy are similar, contrast media may be required for differentiation, rendering CT inadequate if a patient has a history of contrast reaction.[80]

Ultrasound Imaging

USI, although less sophisticated in terms of resolution than MRI and CT, has advantages as a safe, cost-effective, portable, and clinically accessible method for gathering information about the static characteristics of muscle,[47,51,70,74,105,120,124] as well as muscle behavior during dynamic events.[50,77] As such, it shows promise as a tool in musculoskeletal examination and treatment. Moreover, unlike CT, USI does not expose the patient to ionizing radiation and is well tolerated by patients. A feature unique to USI is its dynamic capability of scanning in real time, which makes it superior to MRI and CT for evaluating mobile structures such as tendons, nerves, and muscles, and it may become an important tool for directing appropriate physical therapy treatment decisions.[127] However, as highlighted throughout this commentary, USI is not without disadvantages and is highly operator dependent. Perhaps the most promising feature of USI is its accessibility and the feasibility for physical therapists to acquire the skills needed to incorporate its use into clinical practice. However, evidence for its use in different applications within rehabilitation is needed before widespread routine clinical use can be promoted.

Comparisons Between Different Imaging Modalities Used in the Assessment of Musculoskeletal Disorders*

	MRI	USI	CT
Cost	Expensive	Inexpensive	Intermediate
Ease of accessibility	Difficult	Easy	Difficult
Ionizing radiation	None	None	Yes
Supports intervention	Yes	Yes	Yes
Operator-dependent	No	Yes	No
Imaging capability			
Planes	Multi	Variable axes to joint surface	Multi
Anatomy			
Muscle	Excellent	Good	Fair
Fat	Excellent	Fair	No role
Tendons and sheaths	Good	Excellent	No role
Ligaments	Good	Excellent	No role
Synovial membrane	Good	Excellent	No role
Bone	Excellent	Good	Good
Cartilage	Good	Excellent	Fair
Inflammation	Excellent	Good	No role
Number of joints/session	Few	Many	Few
Real-time scanning	Cardiac only	Yes	No
Patient tolerance	Variable	Good	Variable

**Adapted from Tan et al[127] with permission.*
Abbreviations: CT, computerized tomography; MRI, magnetic resonance imaging; USI, ultrasound imaging.

FUTURE CONSIDERATIONS

It is unclear whether the evaluation of muscular and motor control abnormalities differs across imaging technologies, muscle, body regions, body side, varying diagnoses, and assorted anthropometric variables. Further, the value of USI from a pathoanatomical and pathophysiological perspective, although under investigation, has yet to be determined. Although innovations in muscular imaging research are enhancing our understanding of muscle dysfunction, degeneration, and control, and slowly influencing clinical practice, there is a need to standardize techniques that are cost effective, reliable, easily accessible, and well tolerated by both patients and clinicians in order to ensure their appropriate use.

Future research efforts should address the diagnostic and prognostic validity of USI in patients with acute musculoskeletal pain and a wide variety of musculoskeletal disorders by comparing USI, MRI, EMG, and perhaps CT results. Randomized control trials are also needed that include comparison of interventions incorporating RUSI to those that do not to examine whether USI biofeedback improves outcomes. Ultimately, such studies could provide appropriate evidence-based evaluation and treatment strategies that incorporate RUSI as an outcomes measure. Routine adoption of RUSI in physical therapy requires appropriate training programs.

CONCLUSION

The goal of this commentary has been to provide an overview of basic USI and instrumentation principles, including an understanding of the various modes and applications of the technology with respect to neuromusculoskeletal rehabilitation and in relation to other common imaging modalities. In doing so, we hope that the reader has gained a greater understanding of the value of this tool both from a clinical as well as an investigative perspective. Although other imaging modalities may be superior in providing some, although not all, of the information available with USI, there is growing access to, and evidence in support of, its use by physical therapists. As such, it is imperative that there is support for further investigation with regard to its potential and also a greater understanding of its limitations, as it is likely that the full significance of USI in relation to rehabilitation has yet to be established.

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APPENDIX

GLOSSARY OF TERMS

Acoustic shadowing—The reduction of sound wave echoes from structures that lie behind a strongly reflecting or attenuating structure (eg, bone)[73]

A-line—An electrical signal corresponding to the scattering and reflection of ultrasound from tissue or other media, generated from a single ultrasound transducer either used alone, or as part of a linear (brightness-mode) array

A-line segment—A small portion of an A-line used in elastography cross-correlation analysis

Artifact—Incorrect representations of anatomy or motion (eg, situations that result in structures that are not real, missing, improperly located, or of inaccurate brightness, shape, or size). Examples include acoustic shadowing, edge shadowing, enhancement, and reverberation[142]

Attenuation—The reduction in the intensity or amplitude of a sound wave, expressed in decibels ($dB/cm^1/MHz^1$) and caused by absorption, scattering, and reflection of the sound wave as it travels. As attenuation increases, penetration decreases[73]

B-mode—Brightness or brilliance mode

Cavitation—Refers to the production and behavior of gas bubbles within a liquid when exposed to the sound wave. This behavior can be variable (eg, oscillation or collapse) and depends upon factors such as the size of the cavity, and the nature of the immediate environment[91]

Doppler imaging—The basic principle of Doppler ultrasound lies in the observation that the frequency of a sound beam reflected back to its source is altered when it encounters a moving object.[138] As the change in frequency is proportional to the velocity of the object, Doppler imaging can be used to display flow (blood) or tissue velocity related information

Echogenic—A structure or material that produces echoes (eg, reflection of ultrasound waves). The more echogenic a structure or substance is, the whiter it will appear within an ultrasound image[142]

Edge (refractile) shadowing—Refers to specific type of acoustic shadow that is generated when a sound wave encounters an object with a curved surface (eg, bladder or cyst). The shadow is observed at the lateral margins of the object where the sound beam contacts the interface at a very oblique angle. As a result of both refraction and reflection, none of the incident sound returns to the transducer from this region and a shadow results

Enhancement—The strengthening of a sound wave echo distal to a weakly attenuating structure (eg, a fluid-filled organ such as the bladder)[73]

Far-field—The bottom half of the ultrasound screen, which represents that part of the body furthest from the ultrasound transducer[142]

Field of view (FOV)—Refers to what is visible on the ultrasound display FOV and is dictated by the shape (curvilinear versus linear) and width of the transducer, as well as the depth setting of the image display. The ultimate depth of the FOV is determined by the frequency of the transducer, the power setting of the ultrasound device, as well as the characteristics of the medium that is being imaged

Frame rate—The number of frames of echo information stored each second[73]

Frequency—The number of oscillations a molecule or a sound wave undergoes in 1 second. Frequency is expressed in Hz[142]: 1 Hz = 1 cycle per second; 1 kHz = 1000 cycles per second; 1 mHz = 1 000 000 cycles per second

Gain—Refers to amplification (expressed in dB) of the echoes returning from the tissues back to the transducer. The degree of amplification is under the voluntary control of the operator[73,142]

Hyperechoic—A structure or substance that is more echogenic (whiter and brighter on the ultrasound screen) than surrounding tissue. The surface of bone and dense fascia are examples of hyperechoic media[142]

Hypoechoic—A structure or substance that is less echogenic (darker on the ultrasound screen) than surrounding tissue. Fluids such as blood and urine are examples of hypoechoic media[142]

Impedance—The resistance that a tissue or medium has to sound. Acoustic impedance depends upon the density of the medium and the speed at which sound can travel through it. It is expressed in rayls[73]

Incidence angle—The angle between the sound coming from the transducer (incident sound) and a line perpendicular to the boundary of a medium[73]

Intensity—The rate at which energy is delivered per unit area.[73] The intensity of an ultrasound wave is determined by the total power output of the transducer (W) divided by its effective radiating area (cm^2) and expressed in units of mW/cm^2

M-mode—Motion mode, sometimes referred to as time-motion (TM) mode

Morphology—The study of form and structure.[25] With respect to muscle, this refers to describing characteristics of its dimensions (eg, cross-sectional area, length, shape ratios, and depth/thickness), as well as tissue composition

Morphometry—The quantitative measurement of form.[111] With respect to muscle, this refers primarily to measurement of its dimensions (eg, cross-sectional area, length, shape ratios, and depth/thickness). Morphometry does not consider tissue composition

Motor control—"An area of study dealing with the understanding of the neural, physical, and behavioral aspects of movement."[111] Relates to the timing, magnitude, and sequencing of muscle activation and relaxation

Motor learning—A set of internal processes associated with practice or experience leading to relatively permanent changes in the capability for motor skill[111]

Muscle behavior—Observable activity or the response of muscle during a specific event or given set of circumstances. The behavior of muscle can be described by changes in its electrical properties over time or architectural characteristics (cross-sectional area, length, depth/thickness, or relationship to adjacent structures)

Muscle cross-sectional area (CSA)—A quantitative 2-dimensional measure of the plane of a structure created by cutting through it transversely.[25] Anatomical CSA refers to the CSA at 90° to the long axis (or direction) of the muscle fibers. Physiological CSA is not measured 90° from the long axis of the muscle fibers. Physiological CSA is commonly generated with rehabilitative ultrasound imaging (RUSI), for instance with muscles that have complex internal architecture such as the lumbar multifidus in which the fascicles pass in a caudal-lateral direction over the vertebrae

Muscle inhibition—Reflex inhibition is the reduction or elimination of muscle activity associated with afferent stimuli from joint receptors that reduce activation of alpha motor neurons in the anterior horn of the spinal cord (eg, reflex inhibition of quadriceps has been demonstrated in the presence of knee joint damage in the absence of pain).[121] Voluntary inhibition refers to an unwillingness to contract a muscle due to pain or fear of pain

Muscle thickness (depth)—A quantitative linear measure from the superficial to deep aspects of a muscle.[26] Baseline or resting thickness refers to the thickness of a muscle in a perceived resting state

Near-field—The top half of the ultrasound screen, which represents that part of the body closest to the ultrasound transducer[142]

Operating frequency—The preferred (maximum efficiency) frequency of operation of a transducer.[73] The operating frequency can also be referred to as the resonance or main frequency

Penetration—Refers to the ability for sound to travel through media, thereby influencing image depth. Penetration is dependent upon the strength (intensity) and frequency of the sound wave, as well as the compressibility of the medium that it travels through. In descriptive purposes, penetration refers to image depth[73,142]

Pixel—An abbreviation of "picture element." A pixel refers to the smallest unit of a digitized, 2-dimensional image. A pixel can be described by its location (a set of x and y coordinates), as well as its brightness[73]

Piezoelectric effect—A phenomenon in which some materials (ceramic, quartz, etc) produce a voltage or electrical current when deformed by an applied pressure, such as sound[73]

Real-time ultrasound imaging (RTUS)—The rapid sequential display of ultrasound images resulting in a moving presentation[73,142]

Reflection—As a sound wave propagates it attenuates (loses energy). Reflection is one form of attenuation and refers to the portion of the sound wave that is reflected back towards the source of the sound. This reflected wave is received and processed to generate an ultrasound image[73,142]

Refraction—Refers to the change in direction of a wave when it crosses a boundary. It comes from the modification of a Latin term meaning "to turn aside"[73]

Resolution—A measure of the ability of an instrument to show detail[138]

Scatter—Describes the generation of secondary waves (fractions) in response to the primary sound wave encountering a rough surface or heterogeneous media. Scattering is often referred to as diffusion[73,142]

Sonography—The term used to describe imaging resulting from ultrasound. The Latin word sonus is sound, and the Greek word graphien is to write[73]

Sound—Mechanical energy that propagates through air, water. or any other matter in an orderly, rhythmic fashion, as determined by the molecular makeup of the transmitting medium[73,138]

Strain—Mechanical deformation of a structure as the result of stress

Strain rate —Strain rate refers to the instantaneous strain (or change in strain) per time unit. The strain rate has the same direction as the strain (eg, negative strain rate during shortening, positive strain during elongation)

Transducer—Any device that converts one form of energy into another. The piezoelectric crystal is a transducer that converts electrical energy into sound energy and vice versa[73]

Transducer assembly (commonly referred to as a transducer)—Consists of the transducer elements, their associated casing, and dampening material[73,138]

[GUEST EDITORIAL]

Rehabilitative Ultrasound Imaging: The Roadmap Ahead

DEYDRE S. TEYHEN, *PT, PhD, OCS*[1]

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Over the past decade, researchers have identified associations between neuromusculoskeletal disorders such as low back pain and underlying neuromuscular control deficits.[8] However, reliable and valid noninvasive measurement strategies that could be employed in a clinical setting have been scarce. Evidence for the use of ultrasound imaging as a strategy to assist with these patient populations is growing. The use of ultrasound technology for medical applications began in the 1950s and it has proven to be an effective, safe, and relatively inexpensive tool for assessing morphologic characteristics and structural integrity of visceral organs and soft tissues. Specifically related to physical therapy practice, the use of ultrasound to assess muscle morphology and guide rehabilitation decision making can be traced back to the late 1960s.[23] Over the last decade there has been rapid development of this technique, with reliable and valid noninvasive measurement procedures that can be employed in a clinical setting.

The use of ultrasound imaging in the rehabilitation of neuromusculoskeletal disorders has been coined *rehabilitative ultrasound imaging* (RUSI). RUSI has been defined as "a procedure used by physical therapists to evaluate muscle and related soft tissue morphology and function during exercise and physical tasks...and is used to assist in the application of therapeutic interventions aimed at improving neuromuscular function."[20] RUSI has been advocated to improve the understanding of the relationship between motor control and function, to determine which patients may benefit from a specific exercise treatment approach, to enhance treatment efficacy via augmented feedback, and to document the benefits of specific exercise treatment approaches. Early RUSI research has been promising.

In an effort to more thoroughly define the role of RUSI, the US Army-Baylor University Doctoral Program in Physical Therapy hosted an international symposium on RUSI in May 2006. Previously published symposium abstracts[20] speak to the goals of the meeting, which among others included the development of a set of RUSI measurement standards for the assessment of muscle function and the exploration of future applications of RUSI.[20] This special issue of the *JOSPT* and another to be published in October 2007 represent an additional product of the symposium: a collection of commentaries, case reports, and research reports that document current applications and evidence for RUSI in patients with neuromusculoskeletal disorders, with a goal of providing a roadmap for future research in this area. Between the 2 special issues on RUSI, 5 manuscripts were written by the symposium delegates to provide an overview of RUSI technology,[23] how RUSI has been applied in both clinical and research settings to study the musculature of the abdominal wall,[21] posterior spine,[19] and pelvic floor,[24] and the potential of RUSI as a biofeedback tool to help with rehabilitation.[4]

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Additionally, in these special issues, researchers and clinicians report on the following areas of particular interest:

- *Assessment and Analysis of Altered Motor Behavior in Individuals With Neuromuscular Dysfunctions* Researchers have used RUSI to assess the lateral abdominal musculature behavior during the abdominal drawing-in maneuver,[6,18,21] and pelvic floor function[12] during the active straight-leg-raise test. In this special issue, the behavior of the lateral abdominal musculature during a simulated weight-bearing lower extremity task will be described,[7] demonstrating similar findings to a previous investigation using a non–weight-bearing lower extremity task.[3] Additionally, authors describe the morphometry and behavior of the deep trunk muscles among different populations, such as those with unilateral lower extremity amputations[17] and a case report assessing an individual with both low back pain and stress urinary incontinence.[13] However, research to identify changes in altered motor function associated with improvements or deterioration in the associated neuromuscular disorder as measured by RUSI remains lacking.
- *Identification of a Subgroup of Patients Who Would Benefit From a Specific Exercise Strengthening Program* In the October 2007 issue on RUSI, Kiesel and colleagues[9] will provide preliminary evidence comparing changes in muscle behavior based on the treatment-based classification system for patients with low back pain.[1] Although preliminary evidence has suggested that those that met the stabilization clinical prediction rule may have altered motor behavior during the abdominal drawing-in maneuver,[21] more research is needed to prospectively address this relationship. Additionally, future research is required to determine if specific measurements obtained by RUSI may be helpful in further identifying those predicted to succeed with a stabilization exercise approach.[5]
- *Use of Visual Feedback to Assist With Lumbar Stabilization Exercises* A Case Report is presented in this special issue describing the role of RUSI as a feedback device in a patient with both low back pain and stress urinary incontinence.[13] In the October 2007 special issue, a commentary[4] outlining the literature to date and future research directives will be presented. Although preliminary evidence is encouraging, researchers should focus on whether RUSI can not only enhance motor learning but also improve outcomes. Further, it is theorized that RUSI may be a helpful training tool for a certain subgroup of patients with low back pain; however, it is currently unknown how to identify patients who may benefit from a RUSI-enhanced treatment approach.
- *The Influence of Treatments on Muscular Behavior* A Case Report[2] and case series[14] within these 2 special issues on RUSI will describe changes in muscular behavior immediately following spinal manipulation. Researchers are currently evaluating the ability of RUSI to assess change in muscular behavior associated with spinal manipulative therapy using randomized control trials to better understand how manipulation influences neuromuscular control.
- *Other Applications* Although RUSI has been mostly used to assess muscular behavior of the lumbopelvic region, its use in other areas is promising. For example, the use of RUSI to assess the muscles of the cervical spine is a growing field of inquiry.[10,15] In these 2 special issues researchers will describe new techniques to assess the lower trapezius muscle[11] and the plantar foot fat pad.[16] Other applications, such as assessment of the vastus medialis morphometry, the rotator cuff muscles, and other extremity muscles, may eventually also prove to be helpful in the assessment and treatment of associated neuromuscular dysfunctions.

Initial evidence for the use of RUSI for research and clinical practice to assess neuromuscular dysfunction is encouraging. It is our hope that these 2 special issues will increase interest in further exploring its research and clinical applications to enhance the delivery of effective interventions for our patients. As this area of research evolves and we are able to achieve an international consensus on RUSI measurement standards, we will be able to develop normative databases and more readily compare data across studies. We look forward with anticipation to the realization of the ideas and research generated from these 2 special issues. We hope that the manuscripts and specifically the commentaries, which outline internationally agreed-upon research priorities, will help inspire future lines of research because "scientific research consists in seeing what everyone else has seen, but thinking what no one else has thought" (Albert Szent-Gyorgyi). Finally, I would like to thank the other delegates of the international symposium (Dr John Childs, Dr Jim Elliott, Dr Timothy Flynn, Dr Julie Fritz, Dr Norman Gill, Ms Haldis Haug Dahl, Dr Sharon Henry, Dr Maria Stokes, Dr Judith Thompson, Dr Julie Whitman, and Ms Jackie Whittaker) and the authors in these special issues for helping to establish the roadmap ahead.

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ULTRASSONOGRAFIA MUSCULOESQUELÉTICA — BASES TEÓRICAS PARA AVALIAÇÃO DA ARQUITETURA MUSCULAR EM PACIENTES CRITICAMENTE ENFERMOS

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KARINA LIVINO DE CARVALHO
LUANA MELO
LUCIANA VIEIRA

INTRODUÇÃO

A perda de massa muscular com consequente deterioração da função é um achado comum em pacientes internados na unidade de terapia intensiva (UTI). Em pacientes criticamente doentes, **imobilização, sepse e falência de múltiplos órgãos**, entre outros, estão associadas à significativa perda de massa muscular. Esses fatores são independentes para o surgimento da fraqueza muscular adquirida na UTI — uma consequência da doença crítica.[1]

A fraqueza adquirida na UTI é um preditor importante de morbidade e mortalidade e de incapacidades funcionais durante a internação e após a alta hospitalar.[1] Nos casos não tratados, essas disfunções podem permanecer por anos, mesmo após o período de internação.[2] Algumas intervenções, como a **reabilitação precoce,** têm sido propostas para prevenir ou atenuar a perda de massa muscular e a subsequente fraqueza adquirida na UTI. Contudo, até pouco tempo, a avaliação da arquitetura muscular, à beira leito, era difícil de ser realizada na prática clínica, tornando-a pouco viável.

Tentativas iniciais para avaliação da massa muscular por meio de medidas antropométricas (por exemplo, perimetria) mostraram grandes limitações. A perimetria sofre importante influência do balanço hídrico do paciente e não se mostrou acurada quando comparada aos métodos não invasivos considerados padrão–ouro, como a tomografia computadorizada (TC), o escaneamento com *dual-energy X-ray absorptiometry* (DEXA) e/ou a ressonância nuclear magnética (RNM).[3,4]

Por outro lado, avaliações por meio de TC, DEXA e/ou RNM não são viáveis para realização diária à beira do leito. Nesses exames, os pacientes precisam ser transportados para o setor de radiologia, o que envolve riscos significativos, além de grande demanda operacional.

Em função do impacto da fraqueza muscular adquirida na UTI sobre os desfechos clínicos, pesquisas recentes têm se concentrado em desenvolver métodos não invasivos capazes de avaliar a arquitetura muscular à beira do leito.[3,5–7] Nesse cenário, a **ultrassonografia (USG)** é considerada uma ferramenta confiável, acurada e viável para a avaliação muscular de pacientes na UTI.[6,8] Com o avanço tecnológico, os dispositivos para USG se tornaram portáteis e com capacidade equivalente aos equipamentos de maiores dimensões e menor mobilidade.

Por meio dos dispositivos de ultrassom (US), é possível avaliar a arquitetura muscular, que é definida pelas seguintes variáveis:

- espessura;
- área de secção transversa;
- ecointensidade ou ecogenicidade;
- ângulo de fascículo ou de penação;
- comprimento do fascículo.

Com esses parâmetros é possível medir a perda de massa,[5,9] inferir a diminuição da força muscular[10,11] e detectar a presença de necrose com deposição de colágeno e gordura no músculo,[12] além de realizar o diagnóstico de doenças neuromusculares.[13,14]

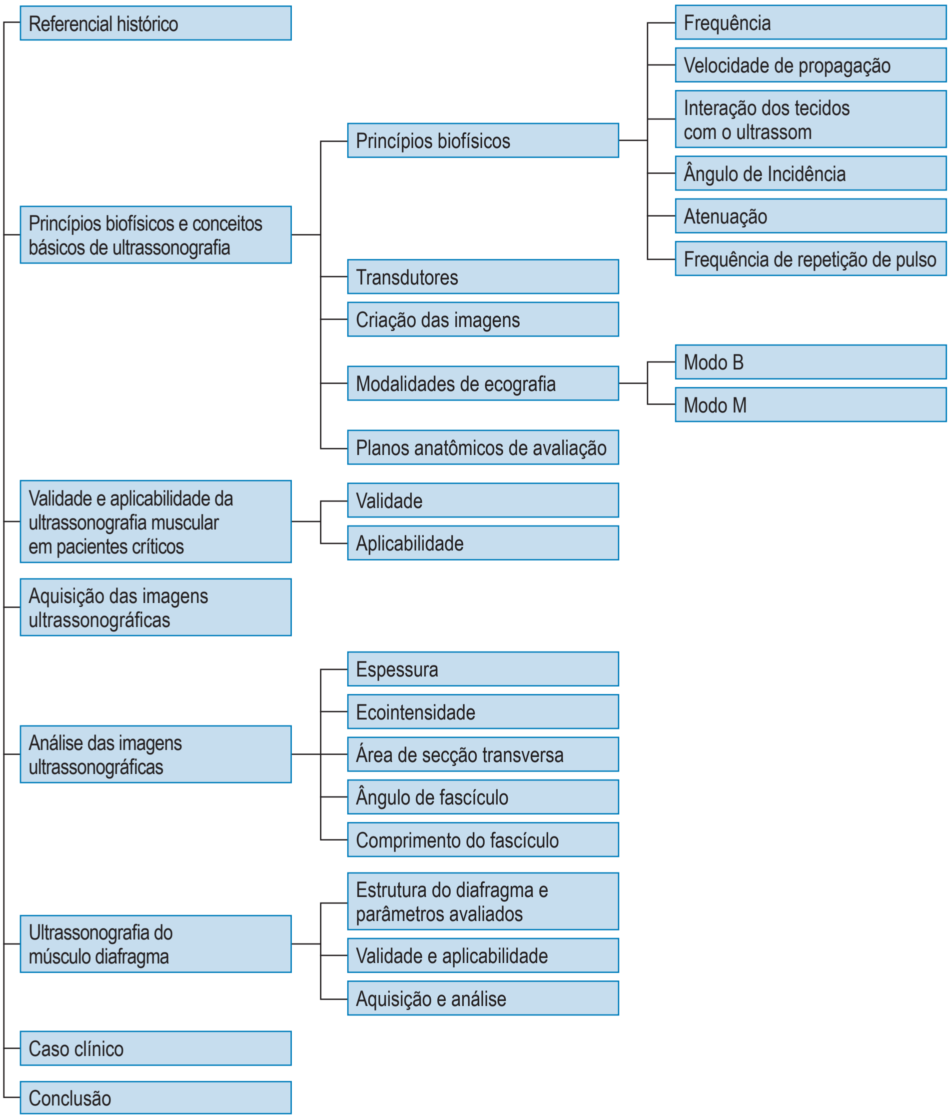
Em virtude de suas características, a USG para avaliação da arquitetura muscular na UTI emerge como uma importante ferramenta diagnóstica e para mensuração de resultados. É um método não invasivo, sem emissão de radiação e capaz de gerar diagnósticos funcionais. Assim, considerando a lei federal 12.842, de 10 de julho de 2013,[15] a Resolução do Conselho Federal de Fisioterapia e Terapia Ocupacional (COFFITO) 381/2010[16] e a Resolução COFFITO 400/2011[17] (artigo 3º), o fisioterapeuta especialista está habilitado para utilização da USG não só no campo da pesquisa, mas também na prática clínica.

OBJETIVOS

Ao final da leitura deste artigo, o leitor será capaz de:

- descrever os princípios biofísicos e os conceitos básicos da utilização da USG na avaliação da arquitetura muscular em pacientes críticos;
- reconhecer as bases para determinação da validade, da reprodutibilidade e da aplicabilidade da USG para utilização na avaliação musculoesquelética de pacientes críticos;
- identificar o processo de aquisição das imagens de USG para a avaliação musculoesquelética de pacientes críticos;
- caracterizar os principais processos de análise das imagens de USG para avaliação da espessura, da área de secção transversa, da ecointensidade, do ângulo de fascículo e do comprimento do fascículo muscular;
- reconhecer a importância do uso da USG para avaliação do músculo diafragma.

ESQUEMA CONCEITUAL



REFERENCIAL HISTÓRICO

O impacto da doença crítica no **sistema musculoesqueltico** tem sido estudado há séculos, mas só em 1984 Bolton e colaboradores[18] publicaram o primeiro *landmark*. O dano muscular é comum e está associado a consequências em longo prazo que afetam a recuperação de forma drástica,[19] além de ocorrer precoce e rapidamente durante a primeira semana após admissão na UTI.

LEMBRAR

Mesmo em indivíduos jovens saudáveis, curtos períodos de imobilização e desuso muscular levam à perda substancial de massa muscular acompanhada por uma sinalização molecular catabólica precoce.[20]

Como já descrito, a avaliação da atrofia muscular esquelética tipicamente necessita de equipamentos de alto custo, com técnicas complexas de imagem ou de métodos invasivos, como a **biópsia muscular**. Esses métodos, com frequência, não estão disponíveis no cenário da terapia intensiva;[21] por isso, há um crescente interesse pelo uso da USG para avaliação da arquitetura e da função musculares (Figura 1).[14]

Figura 1 — *Tipos de equipamentos de USG em suas proporções reais. É possível ver a grande diferença nas dimensões de um US portátil (à esquerda) e de um US convencional, destinado predominantemente para um posicionamento fixo (à direita).*
Fonte: *Adaptada de Sonarmed (2018).*[22]

O primeiro ensaio clínico a utilizar a USG para a avaliação musculoesquelética de pacientes críticos data de 1995.[23] Desde então, vem crescendo o número de publicações nessa área,[24] representado na Figura 2.

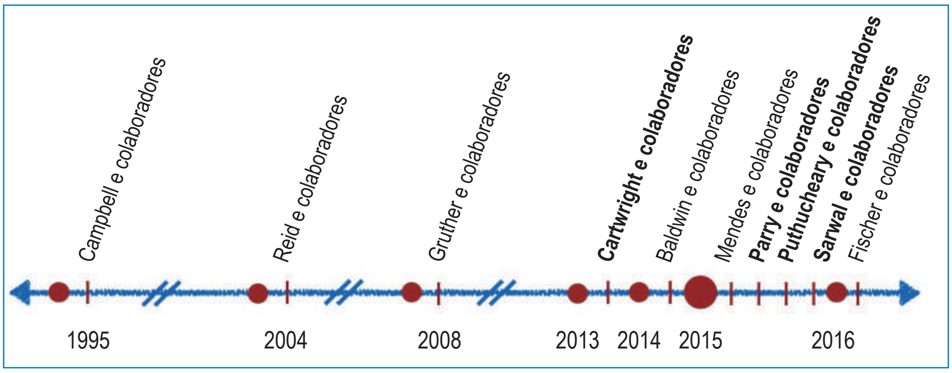


***Figura 2** — Linha do tempo com os principais ensaios clínicos que utilizaram medidas de USG para avaliação da arquitetura muscular em doentes críticos com desfecho.*
***Fonte:** Adaptada de Gruther e colaboradores (2008);[5] Sarwal e colaboradores (2015);[6] Parry e colaboradores (2015);[9] Campbell e colaboradores (1995);[23] Reid e colaboradores (2004);[25] Cartwright e colaboradores (2013);[26] Baldwin e Bersten colaboradores (2014);[27] Mendes e colaboradores (2015);[28] Puthucheary e colaboradores (2015);[29] Fischer e colaboradores (2016).[30]*

PRINCÍPIOS BIOFÍSICOS E CONCEITOS BÁSICOS DE ULTRASSONOGRAFIA

PRINCÍPIOS BIOFÍSICOS

A fim de compreender e interpretar devidamente um exame ultrassonográfico, é necessário o conhecimento básico sobre os princípios físicos envolvidos nesse método diagnóstico. Essa técnica de imagem é baseada na **emissão e recepção de ondas ultrassônicas**, e as imagens são obtidas por processamento eletrônico de feixes de US refletidos de maneira singular pelas diversas estruturas do corpo humano.[31] O conhecimento e o ajuste de alguns parâmetros durante a USG são fundamentais para a melhor aquisição das imagens.

O som é a sensação percebida pelo ouvido provocada por ondas mecânicas geradas pela vibração de um corpo elástico e propagadas por meio material (gás, líquido ou sólido). O US define-se, então, como uma série de ondas mecânicas causadas pela vibração de um corpo elástico (cristal piezoelétrico) e propagadas por um meio material (exemplo: tecido corporal), cuja frequência excede a de um som audível pelo ouvido humano — maior do que 20 quilo-Hertz (20kHz).[31]

Entre os parâmetros que são frequentemente usados na USG, estão:

- frequência;
- velocidade de propagação;
- interação dos tecidos com o US;
- ângulo de incidência;
- atenuação;
- frequência de repetição de pulso.

A seguir, serão descritas resumidamente cada uma das variáveis utilizadas na USG.

Frequência

A frequência de uma onda é o número de ciclos de pressão e descompressão que ocorre em um segundo.[31]

A frequência é mensurada em ciclos por segundo ou Hertz, sendo determinada pela fonte de som que a emite e pelos meios através dos quais viaja. As frequências utilizadas na USG para fins de diagnóstico variam de 2 a 28 mega-Hertz (MHz). Para avaliação do tecido muscular, em geral, é utilizada uma **frequência média de 7,5MHz**.[31]

Velocidade de propagação

A velocidade de propagação é aquela com que o som se propaga através de um meio. Em tecidos moles, a onda sonora se propaga a uma velocidade média de 1.540 metros por segundo (m/s). A velocidade de propagação do som varia de acordo com o tipo e as características do material pelos quais o som é propagado.[31]

Os fatores que determinam a velocidade do som através de um material são a densidade e a compressibilidade deste. Materiais com **maior densidade** e **menor compressibilidade** transmitem o som com **maior velocidade**. Dessa forma, essa velocidade varia em cada tecido — por exemplo, no tecido adiposo, as ondas sonoras se movem mais lentamente do que no ósseo e, no meio gasoso, a velocidade de propagação é tão lenta que as partículas que o contém não podem ser avaliadas pela USG.[31]

LEMBRAR

A velocidade de transmissão é inversamente proporcional à compressibilidade; assim, em tecidos em que as moléculas são mais compressíveis, o som é transmitido mais lentamente.[31]

Interação dos tecidos com o ultrassom

Quando a energia acústica interage com os tecidos do corpo, suas moléculas são estimuladas, e a energia é transferida de uma molécula para a outra adjacente. A energia acústica se move através dos tecidos por meio de ondas longitudinais, e as moléculas desses tecidos oscilam na mesma direção. Essas **ondas sonoras** são basicamente rarefações e compressões periódicas do meio em que se propagam.[31]

Quando uma onda de US passa através de um tecido, uma série de eventos ocorre e, entre eles, há a reflexão de feixes de US para o transdutor, que é chamado de **eco**, que ocorre na interface entre os dois materiais e fornece evidências de que um material é diferente do outro. Isso é conhecido como **impedância acústica**, e é o produto da densidade e da velocidade de propagação do som no tecido.[31]

O contato de dois materiais com impedância acústica diferente resulta em uma interface entre os dois. Assim, a impedância (Z) é igual ao produto da densidade (D) de uma velocidade média (V) do referido som, ou seja, $Z = VD$.[31]

Quando dois materiais têm a mesma impedância acústica, esta interface não produz eco. Se a diferença de impedância acústica é pequena, um eco mais fraco irá ocorrer. Por outro lado, se a diferença for grande, um forte eco será gerado e muitos feixes de US serão refletidos.[31]

Nos tecidos moles, a amplitude do eco produzido na interface entre eles é uma pequena porcentagem das amplitudes incidentes. Quando a escala de cinza é utilizada, os ecos mais intensos geram imagens em tom branco (hiperecoicas); os ecos mais fracos são observados em várias tonalidades de cinza (hipoecoicos); e quando não há reflexões, as imagens são observadas em preto (anecoica).[31]

Ângulo de incidência

A intensidade com que o feixe de US é refletido também depende do ângulo de incidência ou insonação. A reflexão é máxima quando a onda sonora incidente é perpendicular à interface entre dois tecidos. Caso o feixe de US se afaste apenas alguns graus a partir da perpendicular, o eco não volta para o centro da fonte emissora (tecido) e será detectado apenas parcialmente pela fonte receptora (transdutor).[31]

Atenuação

Enquanto as ondas de US se propagam através de diferentes interfaces de tecidos, a energia ultrassônica perde potência, e a intensidade diminui progressivamente quando incidem em estruturas mais profundas. Esse fenômeno é conhecido como atenuação e pode ser secundário à absorção ou à dispersão dos feixes. A **absorção** envolve a transformação da energia mecânica em calor, e a **dispersão** é o desvio da direção de propagação da energia.

Os líquidos são considerados não atenuadores, enquanto o osso é um importante atenuador por absorção e dispersão da energia. Já o ar absorve de forma potente a energia e a dispersa em todas as direções.

Frequência de repetição de pulso

A energia elétrica que atinge o transdutor estimula os cristais piezoelétricos nele contidos e estes emitem os pulsos ultrassônicos. Os transdutores não emitem pulsos de maneira contínua, e sim geram grupos ou ciclos de pulsos ultrassônicos, pois o transdutor precisa alternar duas fases — emissão de US e recepção dos ecos.[31]

A frequência com que o gerador produz pulsos elétricos por segundo é chamada de frequência de de repetição de pulso, a qual determina o intervalo de tempo entre as duas fases (emissão e recepção do US). Esse intervalo de tempo deve ser suficientemente preciso, porque os feixes de US precisam alcançar um ponto em determinada profundidade e depois retornar como ecos para o transdutor antes que um próximo pulso elétrico seja emitido. Assim, a frequência de pulso de repetição depende da profundidade da imagem e, em geral, alcança de 1.000 a 10.000kHz.[31]

Cada um dos feixes de US recebido é digitalizado e passado para a memória gráfica, e são ordenados e processados graficamente na forma de pontos brilhantes no monitor. Pelo menos uma sequência de 20 varreduras por segundo é exibida em tempo real.[31]

ATIVIDADES

1. Por meio dos dispositivos de US, é possível avaliar a arquitetura muscular. Com esses exames, pode-se avaliar a perda de massa muscular, inferir a diminuição da força, detectar a presença de necrose com deposição de colágeno e de gordura no músculo. Essa ferramenta vem sendo utilizada em várias pesquisas no campo da fisioterapia. Com base na legislação brasileira e na regulamentação do COFFITO, assinale a alternativa correta.

A) Para a realização de pesquisas com utilização de USG, os fisioterapeutas precisam da supervisão de um médico.
B) Os fisioterapeutas só podem utilizar exames de USG para fins de pesquisa, cabendo a parte do diagnóstico apenas aos médicos.
C) Os fisioterapeutas podem utilizar a USG em qualquer cenário e para qualquer tipo de diagnóstico.
D) Pode ser utilizada por fisioterapeutas não só no campo pesquisa, mas também na prática clínica para fins de diagnóstico funcional.

Resposta no final do artigo

2. Assinale a alternativa correta com relação ao impacto das doenças críticas no sistema musculoesquelético.

A) O dano muscular geralmente ocorre apenas após a terceira semana da admissão na UTI.
B) Enquanto em indivíduos idosos o dano muscular já ocorre em curtos períodos de imobilização e desuso, em mais jovens, tende a ser menos severo e demorar mais tempo para se iniciar.
C) Mesmo em indivíduos jovens saudáveis, curtos períodos de imobilização e desuso muscular levam a uma grande perda de massa muscular acompanhada por uma sinalização molecular catabólica precoce.
D) Os equipamentos para avaliação da atrofia muscular esquelética estão facilmente disponíveis no cenário da terapia intensiva.

Resposta no final do artigo

3. Com relação à velocidade de propagação do som, é correto afirmar que

A) é invariável conforme o material no qual o som se propaga.
B) materiais com menor densidade e maior compressibilidade propagam o som com maior velocidade.
C) a velocidade de propagação das ondas sonoras, no meio gasoso, é bem mais rápida do que em meio adiposo ou em tecido ósseo.
D) as ondas, no tecido adiposo, se movem mais lentamente do que no ósseo.

Resposta no final do artigo

4. Quanto à atenuação da energia ultrassônica nos diferentes materiais, é correto afirmar que

A) os ossos são importantes atenuadores por absorção e dispersão da energia sonora.
B) está relacionada com a dispersão, que é a transformação da energia sonora em calor.
C) o ar é considerado não atenuador da energia ultrassônica.
D) os líquidos absorvem fortemente a energia sonora e a dispersam em todas as direções.

Resposta no final do artigo

TRANSDUTORES

Um transdutor é um dispositivo que transforma um fenômeno físico, como pressão e temperatura, em outros tipos de sinais, geralmente elétricos. No caso de transdutores de US, a energia ultrassônica é gerada no transdutor a partir de um sinal elétrico. Conforme já descrito, os cristais piezoelétricos transformam energia elétrica em potenciais acústicos e vice-versa.

LEMBRAR

O transdutor atua tanto como emissor quanto receptor de US.

Os **quatro tipos básicos de transdutores** são (Figura 3):

- setorial;
- anular;
- convexo;
- linear.

Figura 3 — *Tipos de transdutores de US. Os dois transdutores no centro da imagem são o convexo e o linear e são os mais utilizados para avaliação musculoesquelética.*
Fonte: *Landwind Medical (2014).*[32]

Os transdutores diferem apenas na forma como seus componentes são organizados. Os lineares são os mais comumente utilizados em USG musculoesquelética; contudo, os convexos, com frequências médias de 7,5MHz, também podem ser utilizados para essa finalidade.[31]

Os transdutores lineares são constituídos por um número variável de cristais piezoelétricos, geralmente 64–256, os quais têm formato retangular e estão posicionados uns em frente aos outros. Nesse tipo de transdutores, os cristais trabalham em grupo e, ao serem eletricamente estimulados, emitem simultaneamente feixes ultrassônicos em paralelo (Figura 4A). Em virtude dessa disposição paralela dos feixes, a imagem é gerada **sem distorções nas extremidades**. Já os transdutores convexos apresentam feixes que se distanciam nas extremidades laterais, gerando imagens com **perda de resolução nas extremidades laterais** (Figura 4B).

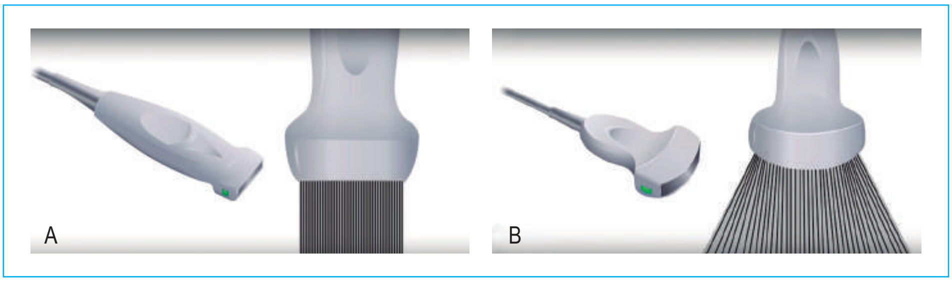


Figura 4 — *Transdutores lineares e convexos. Representação esquemática da disposição dos feixes dos cristais. No transdutor linear* ***(A),*** *os feixes são paralelos e, por isso, não há distorção das imagens nas extremidades laterais. No transdutor convexo* ***(B)****, os feixes divergem na lateral, apresentando imagens com algum grau de distorção nas extremidades laterais.*
Fonte: *Nomura (2016).*[33]

Um tecido pode ser observado com maior definição ultrassonográfica se os feixes de US apresentarem incidência perpendicularmente às interfaces de tecido. Dessa forma, os transdutores lineares que apresentam essas características (Figura 5A) são recomendados para estudo das estruturas retilíneas que formam o sistema musculoesquelético. Ocasionalmente, o uso de transdutores convexos é mais adequado para determinadas áreas anatômicas, como axila ou zona poplítea, por exemplo. Outra empregabilidade do transdutor convexo é no aumento do campo de visão, passando de retangular para trapezoidal (Figura 5B).

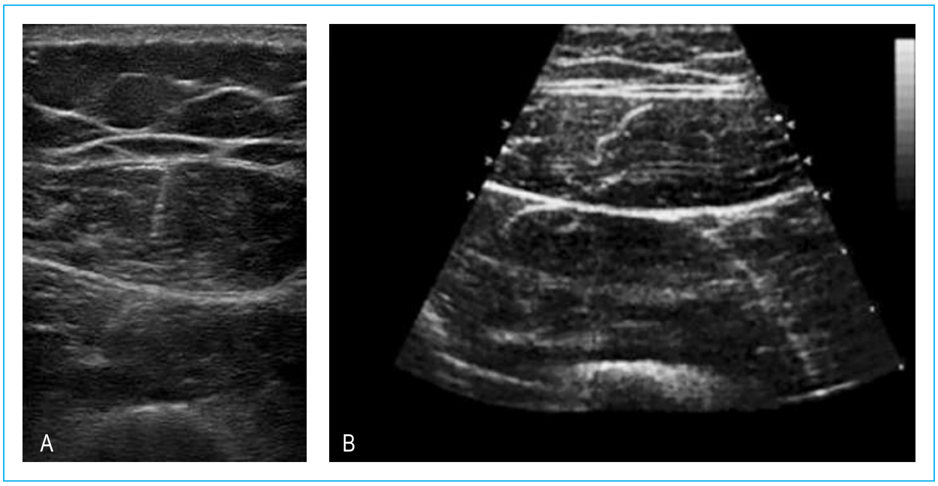


Figura 5 — *Imagens ultrassonográficas musculares geradas pelos transdutores lineares e convexos.* ***A)*** *Imagem ultrassonográfica muscular em formato retangular gerada por um transdutor linear.* ***B)*** *Imagem trapezoidal gerada por um transdutor convexo.*
Fonte: *A: Arquivo de imagens dos autores; B: Arts e colaboradores (2010).*[34]

CRIAÇÃO DAS IMAGENS

As imagens de US são formadas por uma matriz de elementos de imagem. As imagens em escala de cinza são geradas pela exibição dos ecos que retornam ao transdutor como elementos de imagem (*pixels*), e seu brilho depende da intensidade do eco que é captado pelo transdutor.

O transdutor é acoplado na superfície do corpo do paciente, por meio de uma camada de gel, para remover o ar entre as superfícies. Com o estímulo elétrico, os cristais piezoelétricos começam a vibrar e transmitem feixes de US de curta duração, os quais se espalham dentro do paciente, onde são parcialmente refletidos e transmitidos pelos tecidos sem trajeto. A energia ultrassônica refletida no transdutor (eco) produz vibrações nos cristais, que são transformadas em pulso elétrico e, depois de amplificadas e processadas, traduzidas em imagens.

O circuito receptor pode determinar a **amplitude da onda de som** e o **tempo de retorno total de transmissão**, uma vez que acompanha tanto sua transmissão quanto seu retorno. A amplitude do eco determina a tonalidades de cinza.[31]

LEMBRAR

Ecos muito fracos geram imagens com cores próximas do preto na escala cinza, enquanto aqueles mais intensos produzem imagens com tonalidade próxima a cor branca.[31]

MODALIDADES DE ECOGRAFIA

Os equipamentos de USG podem operar em várias modalidades de ecografia e, entre elas, há os modos **A, B, M** e **Doppler**. Cada modalidade tem características peculiares e aplicabilidades bem definidas. Neste artigo, serão explorados os modos B e M, pois são os empregados na avaliação musculoesquelética. A seguir, serão descritas algumas características desses modos.

Modo B

O modo B (B = brilho) ou 2D gera **imagens bidimensionais** na coloração da escala de cinza. É o mais utilizado para diagnóstico em geral, principalmente em função do grande número de regiões anatômicas que podem ser observadas. A Figura 5, apresentada anteriormente, exemplifica imagens nesse modo, que também é o mais utilizado para **avaliação da arquitetura muscular**.

Modo M

O modo M (M = movimento) mescla características dos modos A e B. Essa configuração é utilizada para **analisar qualitativa e quantitativamente o movimento de estruturas**, como válvulas cardíacas.

Para avaliação dos músculos estriados esqueléticos, o modo M vem sendo empregado a fim de verificar a movimentação do diafragma.

Da mesma forma do modo B, o brilho da linha mostrada é modulado de acordo com a amplitude do sinal recebido. O modo M é similar ao A, porque os ecos são coletados em apenas uma direção e apresentados na direção horizontal do monitor. Qualquer movimento da estrutura ao longo do campo ultrassonográfico é representado com movimentos horizontais das linhas da imagem.

A Figura 6, a seguir, apresenta uma imagem ultrassonográfica em modo M.

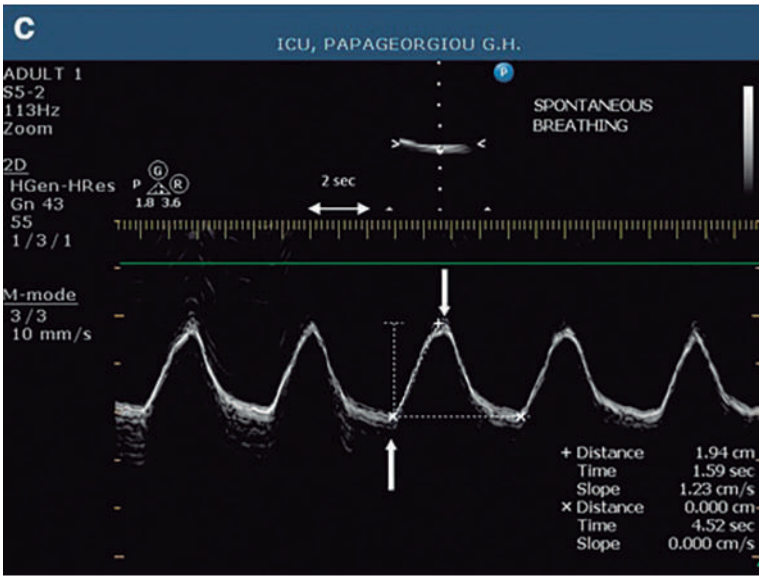


Figura 6 — *Imagem em modo M mostrando a excursão diafragmática durante respiração espontânea. A distância entre as setas mostra a excursão (1,9cm). É possível calcular o tempo inspiratório e o tempo total de duração do ciclo.*
Fonte: *Matamis e colaboradores (2013).*[35]

PLANOS ANATÔMICOS DE AVALIAÇÃO

A USG musculoesquelética é realizada em três planos anatômicos, que são **o coronal, o transversal e o longitudinal** (Figura 7).

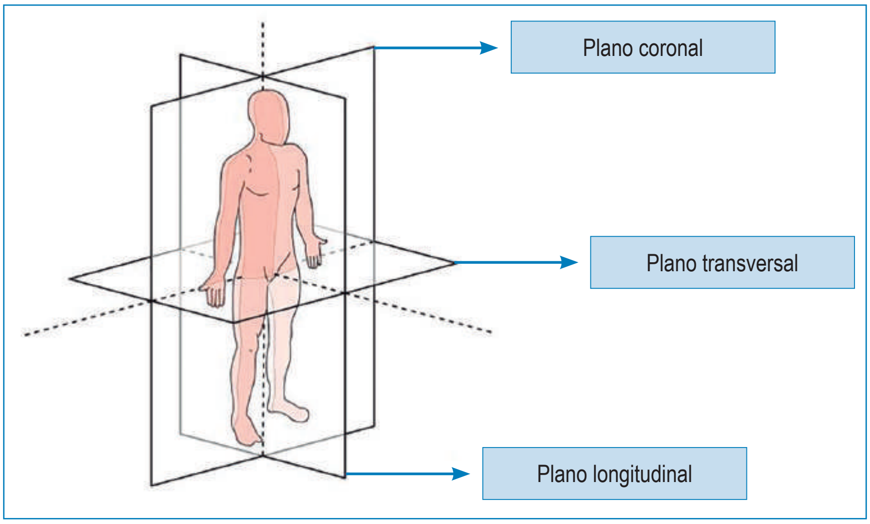


Figura 7 — *Apresentação dos planos anatômicos da USG musculoesquelética.*
Fonte: *Fredrik (2014).*[36]

Para avaliação da arquitetura muscular, em pacientes criticamente enfermos, **os planos transversal e longitudinal** são comumente os escolhidos. A espessura, a área de secção transversa e a ecointensidade podem ser avaliadas tanto no plano transversal quanto no longitudinal. Entretanto, o ângulo e o comprimento do fascículo não podem ser avaliados no plano transversal (Figuras 8ABC).

Figura 8 — *Posicionamento do transdutor nos diversos planos anatômicos. A imagem apresenta o posicionamento do transdutor no quadríceps femoral nos diversos planos anatômicos, com suas respectivas imagens ultrassonográficas em modo B, à direita. As setas azuis descrevem a direção da marca de referência do transdutor.* ***A)*** *Plano longitudinal com a marca de referência do transdutor apontada para a direção cranial.* ***B)*** *Plano transversal com a marca de referência do transdutor apontada para a lateral.* ***C)*** *Plano coronal com a marca de referência do transdutor apontada para a direção cranial.*
Fonte: *Arquivo de imagens dos autores.*

Todos os transdutores apresentam uma marca de referência em alto-relevo na sua borda (Figura 9), a qual tem o objetivo de orientar o posicionamento do transdutor no plano anatômico. Por convenção, nos planos longitudinal e coronal, a marca deve ser apontada em direção cranial; já no plano transversal, deve ser orientada para a lateral do corpo (ver Figura 8B).

Figura 9 — *Marca de referência no transdutor para orientação do posicionamento nos diversos planos. Por convenção, essa marca é sempre apontada para uma direção estabelecida em cada plano anatômico. As setas azuis destacam a marca de referência de um determinado transdutor.*
Fonte: *Arquivo de imagens dos autores.*

ATIVIDADES

5. Assinale a alternativa correta com relação aos transdutores de US.

A) Nos transdutores convexos, a imagem é formada sem distorções nas extremidades.
B) Nos transdutores lineares, os cristais trabalham em grupo e, ao serem eletricamente estimulados, emitem os feixes ultrassônicos em paralelo.
C) Nos transdutores lineares, os feixes de US divergem na lateral, resultando em imagens com distorções nas extremidades laterais.
D) Os transdutores lineares são os mais indicados para áreas anatômicas.

Resposta no final do artigo

6. Assinale a alternativa correta em relação à criação das imagens de USG.

A) A energia ultrassônica recebida pelos transdutores é convertida em pulsos elétricos não amplificados, os quais são diretamente traduzidos em imagens.
B) As tonalidades de cinza na imagem são determinadas pelo tempo de retorno total de transmissão.
C) Enquanto ecos mais fracos resultarão em tonalidades de cinza mais próximas do branco, os mais fortes geram imagens com cores mais próximas do preto na escala de cinza.
D) O circuito receptor pode determinar a amplitude da onda de som e o tempo de retorno total de transmissão, uma vez que acompanha tanto sua transmissão quanto seu retorno.

Resposta no final do artigo

7. Assinale a alternativa correta em relação às modalidades de ecografia utilizadas para a USG musculoesquelética.

A) O modo B gera imagens tridimensionais coloridas.
B) O modo M é utilizado para analisar qualitativa e quantitativamente o movimento de estruturas, como válvulas cardíacas.
C) No modo M, os ecos são coletados em mais de uma direção, sendo apresentados na direção vertical no monitor.
D) No modo B, o brilho da linha muda de acordo com a amplitude do sinal recebido, enquanto no M esse brilho varia conforme a frequência do eco recebido.

Resposta no final do artigo

8. Na avaliação da USG musculoesquelética, é correto afirmar que

A) apenas pode ser realizada no plano transversal e em pacientes criticamente enfermos.
B) a espessura e a área de secção transversa podem ser avaliadas apenas no plano transversal.
C) a espessura, a área de secção transversa e a ecointensidade podem ser avaliadas tanto no plano transversal quanto longitudinal.
D) o ângulo do fascículo pode ser avaliado apenas no plano transversal.

Resposta no final do artigo

9. Assinale a alternativa correta quanto à marca de referência no transdutor, no sentido de orientar o posicionamento nos diversos planos.

A) No plano longitudinal, deve ser apontada na direção cranial.
B) No plano coronal, deve ser apontada para a lateral do corpo.
C) No plano coronal, deve ser apontada para a lateral do corpo e, no transversal, pode ser ignorada.
D) No plano transversal, deve ser apontada na direção cranial.

Resposta no final do artigo

VALIDADE E APLICABILIDADE DA ULTRASSONOGRAFIA MUSCULAR EM PACIENTES CRÍTICOS

A USG musculoesquelética representa uma modalidade atrativa em diferentes cenários, uma vez que é segura, facilmente aplicável, não invasiva e pode ser realizada na admissão hospitalar sem a cooperação do paciente. Por isso, a USG vem sendo utilizada para avaliar a trajetória das mudanças na estrutura dos músculos esqueléticos ao longo da internação.[24] Entretanto, para isso, sua validade e reprodutibilidade precisaram ser determinadas.

VALIDADE

A validade expressa a capacidade de um teste em medir aquilo que se propõe a medir. A **reprodutibilidade**, uma propriedade psicométrica que reflete o grau em que uma medida é consistente e livre de erros, é fundamental para qualquer tipo de avaliação e é um pré-requisito para classificar o quanto adequado é um teste.[37]

Os estudos que compararam a validade da USG com os exames considerados padrão-ouro para avaliação da arquitetura muscular não encontraram diferenças significativas entre ambos.[38,39] A medida da espessura do músculo periférico por USG foi validada tanto em indivíduos saudáveis[40,41] quanto naqueles com distúrbios neuromusculares.[13] Além disso, vem sendo demonstrada excelente reprodutibilidade da avaliação ultrassonográfica quantitativa da espessura muscular[6,27] e da ecointensidade[6,14] em pacientes críticos. Também foi descrita excelente reprodutibilidade inter e intraexaminador, independentemente do nível de experiência do profissional.[5,6,14,40–43]

Vale ressaltar que existem dois momentos distintos na avaliação da arquitetura muscular que podem interferir na validade e reprodutibilidade do método — a **aquisição** e a **análise** das imagens (serão abordadas mais detalhadamente em outra sessão deste artigo).

A variabilidade dos achados durante aquisição das imagens por diferentes avaliadores tem sido sugerida como um dos principais fatores que impedem o uso generalizado da USG em contextos clínicos e de pesquisa. É imprescindível padronizar essas medidas entre os examinadores para conseguir boa reprodutibilidade,[26] o que é possível com breves sessões de treinamento e padronização dos protocolos.[42] Só dessa forma é possível que os fisioterapeutas tomem decisões acertadas sobre seus pacientes a partir das medidas de USG e produzam resultados válidos para comparação de resultados. A padronização dos métodos de USG pode, ainda, viabilizar a publicação de futuras metanálises sobre o tema.[37]

Tanto a avaliação da espessura quanto da ecointensidade precisa seguir rigorosamente um protocolo. Uma particularidade sobre a avaliação da ecointensidade pode ser importante para determinação de medidas válidas e reprodutíveis — a região de interesse (ROI).

A definição da ROI vem sendo conduzida pela **técnica do quadrado**[9] ou pela **técnica do traçado**[34] (ver Figuras 14A e B). Ambas têm demonstrado boa reprodutibilidade, porém a definição da população e a delimitação criteriosa da ROI podem impactar profundamente nos resultados.[13,44]

LEMBRAR

A excelente reprodutibilidade da técnica do quadrado foi mensurada por Caresio e colaboradores[44] em indivíduos saudáveis. Entretanto, reprodutibilidade não é sinônimo de validade.[45] Músculos saudáveis apresentam imagens de USG homogêneas e, assim, qualquer ROI poderá ser definida, desde que excluídas regiões ósseas e fáscias. Contudo, em pacientes com doenças neuromusculares, os músculos podem apresentar heterogeneidades focais nas imagens de USG.[13] Por isso, a escolha da técnica do quadrado pode não ser a mais adequada, dependendo da população estudada.

A técnica do traçado (Figura 14A) possui a vantagem de mensurar a maior quantidade de músculo disponível nas imagens, sendo capaz de avaliar com maior precisão músculos heterogêneos. Contudo, é importante ressaltar que, assim como a técnica do quadrado, é preciso utilizar uma ROI que exclua regiões ósseas e de fáscias na técnica do traçado.

APLICABILIDADE

Os estudos em pacientes críticos utilizam primariamente a **espessura**[5,27,30] ou a **área de secção transversa muscular**.[12,46] Somente há pouco tempo a avaliação da ecointensidade começou a ser utilizada na UTI.[14]

Um estudo recente demonstrou que o aumento na ecointensidade muscular esteve associado à diminuição da força muscular e da capacidade funcional durante o despertar de pacientes criticamente enfermos.[9] Parry e colaboradores[9] sugeriram que a ecointensidade poderia ser utilizada como marcador prognóstico enquanto o paciente não é capaz de cooperar com testes funcionais volitivos.

O aumento na ecointensidade muscular, independentemente da espessura, está correlacionado negativamente com a força muscular.[9,47] Em idosos, a ecointensidade encontra-se aumentada em função da substituição muscular por tecido adiposo e fibroso.[48] Uma forte correlação entre ecointensidade e tecido fibroso/adiposo intramuscular foi descrita previamente em indivíduos saudáveis,[34] em idosos[47] e naqueles com doenças neuromusculares.[13]

Puthucheary e colaboradores[29] demonstraram, por meio de biópsia, que mudanças na ecointensidade refletem a **ruptura da arquitetura muscular em nível celular em doentes críticos**, também observada em pacientes com sepse grave por Grimm e colaboradores.[14]

Parry e colaboradores[9] detectaram uma piora de 9% na qualidade muscular medida pelo aumento na ecointensidade após 5 dias de internação na UTI, enquanto Puthucheary e colaboradores[29] encontraram um aumento na ecointensidade de 8% ao longo de 10 dias, mas apenas em pacientes que desenvolveram necrose muscular.

No despertar da UTI, Parry e colaboradores[9] observaram uma forte correlação positiva entre a espessura e os desfechos funcionais, conforme medido pelo Escore Perme de Mobilidade em UTI (PFIT-s) (r = 0,82) e pela Escala de Mobilidade de UTI (IMS) (r = 0,84) na alta da UTI e descreveram ainda forte correlação negativa entre ecointensidade e desfechos funcionais, também mensurados pelo PFIT-s (r = -0,77) e IMS (r = -0,73) na alta da UTI.

Um estudo retrospectivo com idosos[49] demonstrou que a baixa massa muscular à admissão na UTI era um preditor independente de mortalidade e estava associada a maior incapacidade funcional. No entanto, ainda não está claro se é a mudança no tamanho muscular desde a linha de base ou o tamanho absoluto do músculo à admissão que é o preditor mais importante do desfecho funcional e da mortalidade.[50]

Em indivíduos saudáveis sob imobilização, Wall e colaboradores[20] observaram redução de 3,5% na massa muscular do quadríceps no quinto dia. Em doentes críticos, Puthucheary e colaboradores[12] demonstraram redução de 12,5% na área de secção transversa do músculo reto femoral no sétimo dia após admissão na UTI. Já Parry e colaboradores[9] descreveram redução na espessura do reto femoral de 16,6% no quinto dia. Por outro lado, Fischer e colaboradores[30] observaram um aumento na espessura muscular do quadríceps nos três primeiros dias após cirurgia torácica em indivíduos criticamente enfermos, com uma correlação positiva entre as mudanças na espessura muscular e o balanço hídrico cumulativo.

Esses autores mostraram que o aumento na espessura, na verdade, era líquido dentro do músculo e não hipertrofia.[30] Em indivíduos com sepse grave, a ecointensidade aumentou mesmo na presença de balanço hídrico negativo, com dano estrutural específico na arquitetura muscular.[14] Esses achados sugerem que **a ecointensidade e a espessura são impactadas de forma diferente pelo acúmulo de fluido intramuscular** e podem refletir mudanças diferentes na arquitetura muscular, devendo, portanto, ser avaliadas e acompanhadas em pacientes críticos.

Fica claro que a deterioração da espessura e da ecointensidade muscular inicia-se de forma precoce em indivíduos criticamente enfermos já nas primeiras 24 horas após a internação.[12] Portanto, a avaliação da arquitetura muscular deve ser realizada o quanto antes após a admissão hospitalar; caso contrário, a detecção de mudanças significativas pode ser subestimada.

■ AQUISIÇÃO DAS IMAGENS ULTRASSONOGRÁFICAS

Nesta seção, serão abordadas as técnicas utilizadas para aquisição das imagens de forma precisa e reprodutível em três músculos — bíceps braquial, reto femoral e tibial anterior, pois é o primeiro passo para se obterem resultados acurados.

Para a escolha da frequência do transdutor, vale ressaltar que, **quanto maior, melhor será a resolução das imagens, porém com menor profundidade de visualização**. Na maior parte dos estudos que analisam os músculos, a frequência é ajustada entre 5 e 10MHz[47,51] (com média de 7,5MHz).[34,52,53] A escolha do tipo de transdutor dependerá da estrutura a ser avaliada, podendo ser utilizados tanto os transdutores lineares quanto os convexos.

Para realização das medidas de espessura, da área de secção transversa e da ecointensidade, de um modo geral, é escolhida a porção que corresponde à área de maior espessura daquele músculo.[34] A fim de evitar a compressão do transdutor sobre a região, uma quantidade generosa de gel deve ser aplicada. Para melhor aquisição da imagem, o transdutor precisa ser posicionado perpendicularmente à pele.[34,44]

Qualquer mudança no posicionamento do transdutor pode levar a mensurações erradas da arquitetura muscular. Para cada músculo, devem ser realizadas três imagens consecutivas, sendo o transdutor desacoplado e então reposicionado para realização das demais imagens, com o intuito de minimizar a variação das medidas.[34]

Os pacientes podem ser posicionados de diversas formas; o mais importante é que as avaliações sejam sempre na mesma postura. Comumente, eles são colocados em decúbito dorsal, com braços e pernas em extensão e completamente relaxados. Os estudos em doentes críticos têm utilizado principalmente o **plano transversal** para aquisição das imagens com objetivo de avaliar a espessura, a área de secção transversa e a ecointensidade muscular.[34]

Arts e colaboradores[34] descreveram um protocolo interessante que pode ser utilizado na UTI. Nesse estudo, os autores avaliaram diversos músculos, entre eles, tibial anterior, reto femoral e bíceps braquial. Para a medida do músculo bíceps braquial, o transdutor deve ser posicionado a dois terços craniocaudal da distância entre o acrômio e a fossa cubital (Figura 10A). Para o músculo reto femoral, a imagem é realizada a 50% da distância entre a espinha ilíaca anterossuperior e a borda superior da patela (Figura 10B) e, no músculo tibial anterior, o transdutor é alocado a 25% craniocaudal da distância entre a borda inferior da patela e o maléolo lateral (Figura 10C).[34]

A partir da aquisição dessas imagens, será possível a realização das medidas de espessura, da área de secção transversa e de ecointensidade.

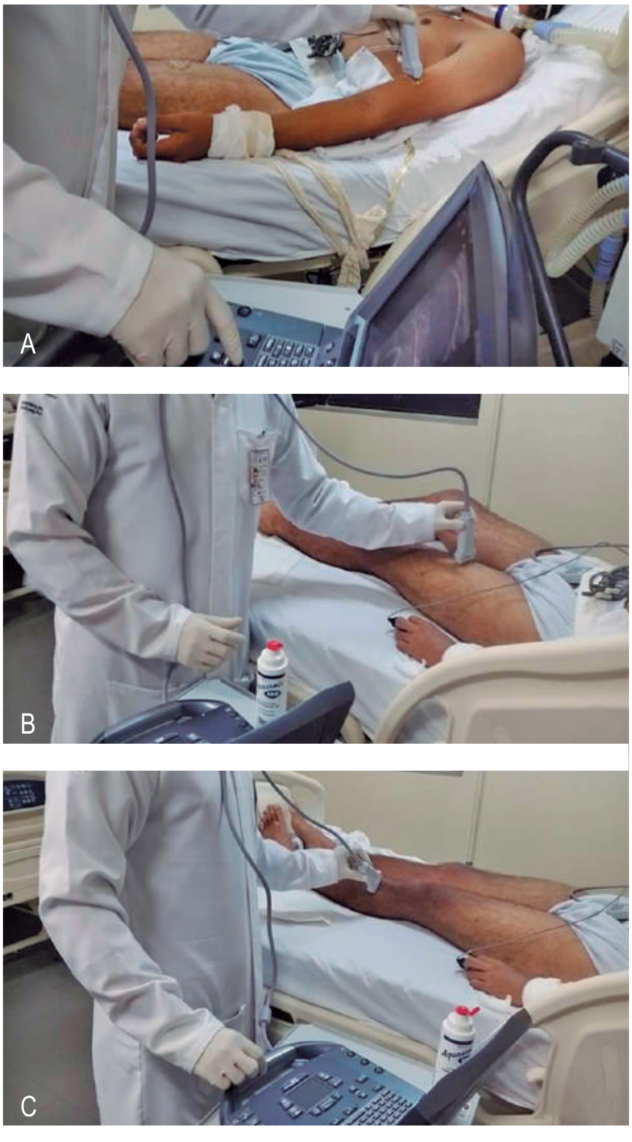


Figura 10 — *Avaliação ultrassonográfica à beira do leito. Posicionamento do transdutor para aquisição das imagens dos músculos bíceps braquial, reto femoral e tibial anterior, de acordo com o protocolo proposto por Arts e colaboradores.* ***A)*** *Bíceps braquial.* ***B)*** *Reto femoral.* ***C)*** *Tibial anterior.*

Fonte: *Arquivo de imagens dos autores.*

O ângulo do fascículo pode ser mensurado em diversos músculos, e, em pacientes críticos, o **vasto lateral** tem sido o mais utilizado.[9] Para realização das medidas do ângulo do fascículo no vasto lateral, o paciente deverá ser posicionado em decúbito dorsal. De acordo com Ando e colaboradores,[54] o ângulo do fascículo pode ser avaliado a **50% da distância entre o trocanter maior e o epicôndilo lateral do fêmur**. O transdutor deverá estar orientado no mesmo plano dos fascículos e perpendicular à pele.

LEMBRAR

O ângulo do transdutor é variável conforme o eixo longitudinal dos fascículos; portanto, varia entre os indivíduos. O alinhamento apropriado do transdutor permite a visualização sem interrupção de vários fascículos por meio da imagem.[52]

Após a aquisição das imagens, é iniciada uma nova etapa — a análise dessas imagens — que pode ser realizada no próprio *software* do equipamento de USG como também em *softwares* específicos para tratamento de imagens.[9,44,54]

Os *softwares* para tratamento de imagens apresentam mais recursos do que os dos equipamentos de USG, e, por isso, vêm sendo mais utilizados.[9,44,54] Uma boa opção é o *software* livre ImageJ, que permite todas as formas de avaliação da arquitetura muscular.

Para saber mais:

O *software* ImageJ pode ser baixado em http://imagej.nih.gov/ij/.[55]

ANÁLISE DAS IMAGENS ULTRASSONOGRÁFICAS

A combinação do avanço tecnológico com o avanço da medicina tem possibilitado melhores métodos de aquisição de imagens e, consequentemente, facilitado o diagnóstico clínico e funcional. A importância de se determinar a relação entre estrutura e função vem aumentando, e com ela, a preocupação em se realizar análises acuradas.[55]

Os fabricantes de dispositivos de aquisição de imagem geralmente incluem um *software* de processamento de imagem, porém esses programas não costumam ser muito flexíveis, limitando ou mesmo impedindo a manipulação de imagens mais complexas.[55]

O ImageJ é um *software* de domínio público, ou seja, não há qualquer taxa ou licença necessária para adquiri-lo. Funciona em qualquer sistema operacional e é de fácil manuseio, além de possibilitar uma série de manipulações na imagem a ser analisada. Realiza desde medidas mais simples, como a de espessura, ecointensidade, área de secção transversa e ângulo de fascículo, até mais complexas.[55]

A seguir, serão descritas as técnicas para análises da espessura, da ecointensidade, da área de secção transversa e do ângulo de fascículo para cada músculo.

ESPESSURA

Para a medida de espessura do **músculo bíceps braquial**, é traçada uma linha entre o ponto mais alto do úmero até sua fáscia superficial. A medida de espessura irá incluir o músculo braquial (Figura 11).[34]

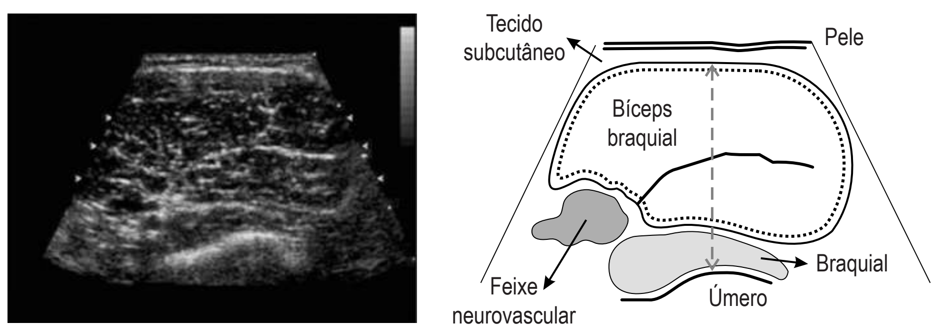


***Figura 11 —** Medida de espessura do músculo bíceps braquial.*
***Fonte:** Adaptada de Arts e colaboradores (2010).[34]*

Para a medida de espessura do **músculo reto femoral**, é traçada uma linha entre o ponto mais alto do fêmur até sua fáscia superficial. Essa linha, que inclui os músculos reto femoral e vasto intermédio, foi descrita por Arts e colaboradores como uma medida alternativa para mensuração global da espessura do **músculo quadríceps femoral** (Figura 12).[3]

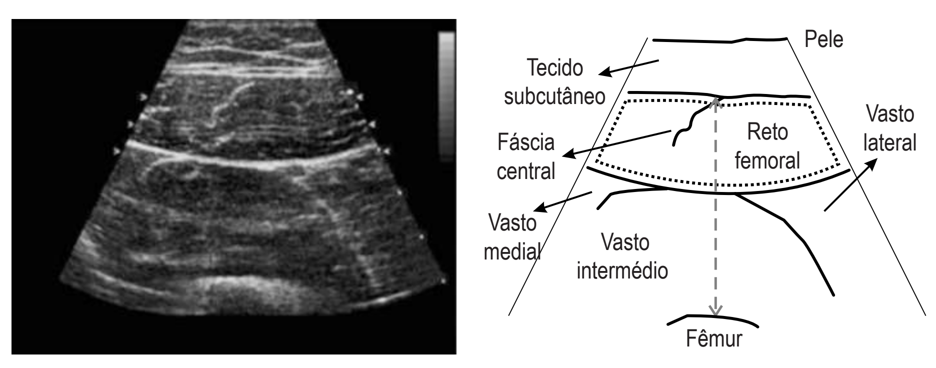


***Figura 12 —** Medida de espessura do músculo reto femoral.*
***Fonte:** Adaptada de Arts e colaboradores (2010).[34]*

Para a medida de espessura do **músculo tibial anterior**, é traçada uma linha a partir da membrana interóssea até a fáscia superficial desse músculo (Figura 13).[34]

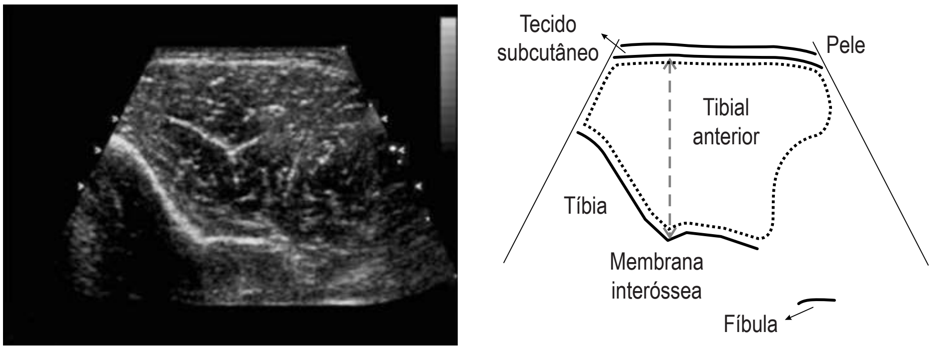


***Figura 13 —** Medida de espessura do músculo tibial anterior.*
***Fonte:** Adaptada de Arts e colaboradores (2010).[34]*

ECOINTENSIDADE

O cálculo da ecointensidade poderá ser determinado por meio da análise da escala de cinza. A ROI (Figuras 14A e B) é selecionada com o intuito de incluir o máximo de músculo, devendo ser evitados ossos e fáscias.[34,57]

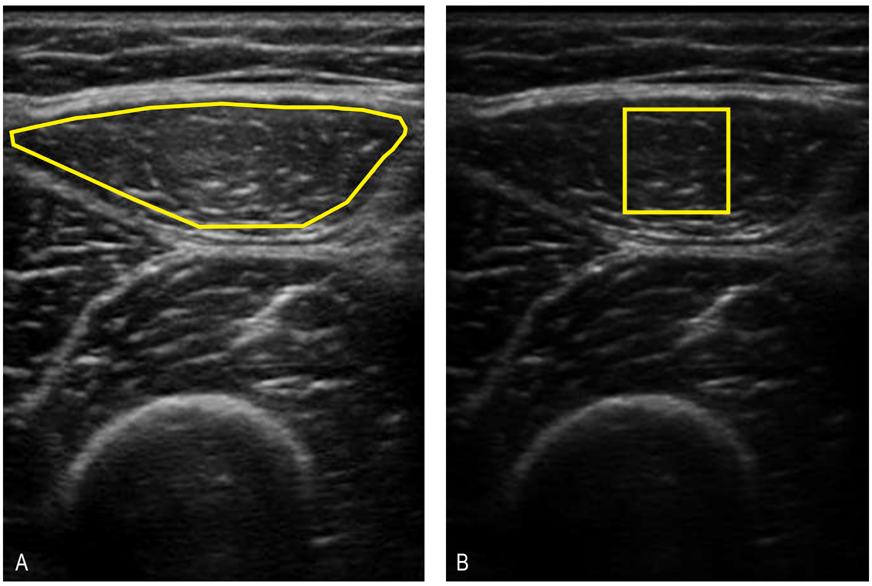


***Figura 14 —** Contorno do músculo reto femoral. A partir dessa análise, pode-se calcular a ecointensidade e a área de secção transversa. Nessa imagem, foi utilizada a técnica do traçado para determinação na ROI. **A)** ROI com técnica do traçado. **B)** ROI com técnica do quadrado.*
***Fonte:** Arquivo de imagens dos autores.*

A ecointensidade correspondente de cada músculo será a média das três imagens. O resultado será um **valor entre 0 e 255**, onde 0 corresponde a cor preta e 255 a cor branca.[34,47] No **músculo bíceps braquial**, a ROI corresponde somente a esse músculo, não sendo incluído o músculo braquial para a medida. No exame do **quadríceps femoral**, os músculos devem ser verificados separadamente para que as fáscias não sejam incluídas na avaliação. Os valores de ecointensidade variam entre os equipamentos de USG; nesse sentido, é necessário utilizar sempre o mesmo equipamento, além de manter os mesmos ajustes de ganho de sinal para medidas comparativas.[34]

A determinação da ROI por ser realizada também pela técnica do quadrado, porém, em indivíduos com doenças neuromusculares, a técnica do traçado parece ser mais apropriada.[56]

ÁREA DE SECÇÃO TRANSVERSA

Assim como para a medida de ecointensidade, a medida da área de secção transversa é feita a partir do delineamento do músculo a ser avaliado e cada músculo deve ser traçado em sua totalidade, evitando fáscias e ossos circundantes (ver Figura 14A). Essa medida corresponde ao volume muscular e é mais sensível do que a espessura para detectar a perda de massa muscular.[56]

ÂNGULO DE FASCÍCULO

O ângulo de fascículo corresponde à média dos ângulos encontrados nas imagens, mensurados a partir da angulação entre o fascículo do músculo avaliado e sua aponeurose profunda.[54] Seu aumento resulta em menor transmissão da força muscular para o tendão.[57]

Em virtude da desorganização e diminuição da qualidade das fibras musculares, em muitos pacientes, não é possível realizar a mensuração do ângulo de fascículo (Figura 15) e, por conta dessas dificuldades técnicas, poucos estudos realizaram a mensuração desse ângulo em pacientes críticos.[9]

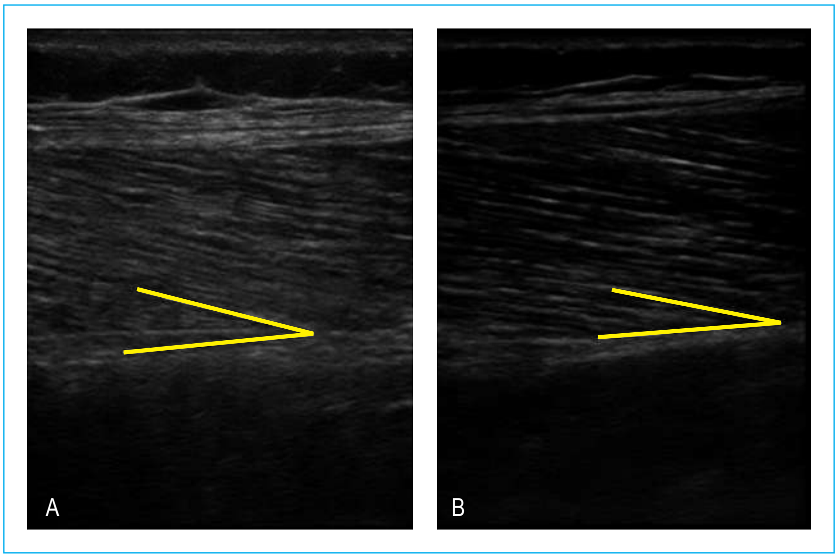


Figura 15 — *Avaliação do ângulo do fascículo do músculo vasto lateral. É possível ver a diferença na escala de cinza e nos contornos dos fascículos (imagem mais branca e com menor definição dos contornos dos fascículos em A).* ***A)*** *Imagem ultrassonográfica do vasto lateral de um paciente com 29 anos de idade, do sexo masculino, no 9° dia de pós-operatório de ressecção de tumor cerebral e em ventilação mecânica. Ângulo = 19°.* ***B)*** *Imagem ultrassonográfica do vasto lateral de um indivíduo saudável, 27 anos de idade, do sexo masculino. Ângulo = 18°.*
Fonte: *Arquivo de imagens dos autores.*

COMPRIMENTO DO FASCÍCULO

O comprimento do fascículo e seu ângulo funcionam como **preditores das propriedades contráteis da musculatura esquelética**.[58] Em casos de comprimento do fascículo, há correlação direta com a velocidade de contração.[59]

Há vários modelos que se baseiam em algoritmos para realização da medida do comprimento do fascículo, tendo em vista que, normalmente, o transdutor é incapaz de captar todo o fascículo de um grande músculo (como é o caso do vasto lateral), necessitando de fórmulas para estimá-lo.[52,54]

O comprimento do fascículo pode ser estimado pela seguinte fórmula:[52]

Comprimento do fascículo = seno(γ + 90°) x EM / seno(180° - (γ + 180° - θ)

O **γ** representa o ângulo entre a aponeurose superficial e profunda (tendo em vista que a imagem pode não estar com as aponeuroses paralelas entre si, funcionando como um fator de correção), o **θ**, representa o ângulo do fascículo e o **EM** a espessura muscular. Para a medida de espessura muscular no plano longitudinal, serão traçadas duas linhas na imagem — uma no início e outra no fim, a partir da aponeurose profunda até a aponeurose superficial do vasto lateral. A espessura do músculo vasto lateral é a média das duas linhas (Figura 16).[52]

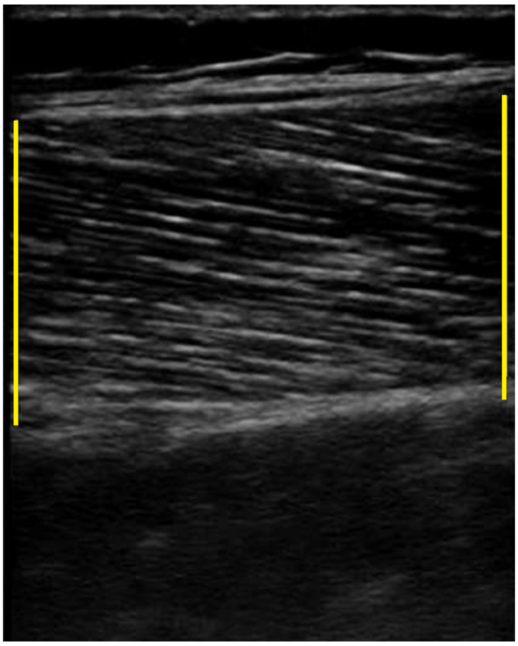


Figura 16 *— Avaliação da espessura no plano longitudinal. As linhas amarelas correspondem à distância entre as aponeuroses profunda e superficial do músculo vasto lateral. A média das duas linhas corresponde à espessura muscular.*
Fonte: *Arquivo de imagens dos autores.*

ATIVIDADES

10. A escolha adequada do transdutor, bem como os ajustes realizados no equipamento de USG, são fundamentais para aquisição adequada das imagens. Qual transdutor pode ser utilizado para avaliação de músculos estriados esqueléticos?

A) Linear, com frequência de 1–5kHz.
B) Convexo, com frequência de 10–25MHz.
C) Linear, com frequência de 5–10MHz.
D) Linear ou convexo, com frequência de 5–10kHz.

Resposta no final do artigo

11. Assinale a alternativa correta a respeito das técnicas utilizadas para definição da ROI.

A) A técnica do quadrado vem sendo abandonada, por não demonstrar boa reprodutibilidade.
B) A técnica do traçado possui a vantagem de mensurar a maior quantidade de músculo disponível nas imagens, sendo capaz de avaliar com mais precisão músculos heterogêneos.
C) Na técnica do traçado, é possível utilizar uma ROI sem excluir regiões ósseas e de fáscias.
D) A técnica do quadrado apresenta ótima reprodutibilidade e validade, pois é precisa mesmo em pacientes com doenças neuromusculares, os quais podem apresentar heterogeneidades focais nas imagens de USG.

Resposta no final do artigo

12. Assinale a alternativa correta sobre a ecointensidade muscular.

A) O aumento da ecointensidade muscular está correlacionado com a diminuição da força muscular apenas se acompanhado de redução na espessura.
B) A diminuição da ecointensidade muscular é um forte indicador de perda de força muscular.
C) Em idosos, a ecointensidade muscular está diminuída, em razão da substituição muscular por tecido fibroso e adiposo.
D) Foi demonstrado, por meio de biópsia, que mudanças na ecointensidade refletem a ruptura da arquitetura muscular em nível celular em doentes críticos, estando, portanto, o aumento da ecointensidade relacionado à perda de força muscular e da capacidade funcional.

Resposta no final do artigo

13. Assinale a alternativa correta a respeito da realização das medidas de espessura, da área de secção transversa e de ecointensidade.

A) Em geral, é escolhida a parte que corresponde a maior espessura do músculo a ser analisado.
B) Para que a mensuração realizada não sofra interferências, deve ser aplicada apenas uma fina camada de gel.
C) Para cada músculo, devem ser realizadas duas imagens consecutivas, sendo que o transdutor não deverá ser movimentado.
D) O paciente deve ser posicionado preferencialmente em decúbito ventral, com braços e pernas em extensão.

Resposta no final do artigo

14. Para a avaliação do ângulo do fascículo no vasto lateral, é correto afirmar que

A) essas medições devem ser feitas com o paciente em decúbito ventral.
B) o ângulo do fascículo pode ser avaliado a 50% da distância entre o trocanter maior e o epicôndilo lateral do fêmur.
C) deverá estar posicionado perpendicularmente ao plano dos fascículos.
D) as medições devem ser realizadas com o paciente em posição lateral, e o transdutor deverá estar posicionado no mesmo plano dos fascículos.

Resposta no final do artigo

15. Quanto aos *softwares* de análise de imagens de USG, é correto afirmar que

A) até as análises mais complexas podem ser realizadas com os *softwares* de processamento de imagem inclusos pelos fabricantes dos dispositivos de aquisição de imagem.
B) o ImageJ é um *software* de fácil manuseio e de grande flexibilidade na análise de imagens, mas que tem pouca utilização, em função do alto custo de aquisição.
C) apesar de o ImageJ ser um *software* livre, há a desvantagem de não possibilitar a medida de espessura e de ecointensidade dos músculos.
D) o ImageJ é um *software* livre, que funciona em qualquer sistema operacional e permite a realização de medidas mais simples até as mais complexas, que não podem ser realizadas com os *softwares* disponibilizados pelos fabricantes dos dispositivos de aquisição de imagem.

Resposta no final do artigo

16. Quanto à análise das imagens de USG para cálculo da ecointensidade, é correto afirmar que

A) a ROI deve ser selecionada de modo que se inclua o máximo de músculos, ossos e fáscias.
B) a ROI, no músculo bíceps braquial, deve incluir o músculo braquial para a medida.
C) a ecointensidade correspondente de cada músculo será a média de três imagens analisadas, sendo o resultado um valor entre 0 e 255, onde 0 corresponde a cor preta e 255 a branca.
D) a determinação da ROI, em pacientes com doenças neuromusculares, deve ser feita apenas pela técnica do quadrado.

Resposta no final do artigo

17. Assinale a alternativa correta a respeito da análise de imagens para a medida da área de secção transversa.

A) Essa medida corresponde ao volume muscular e é mais sensível do que a da espessura para detectar a perda de massa muscular.
B) Para a medida da área de secção transversa, deve ser traçada a circunferência da parte mais espessa do músculo.
C) Na medida da área de secção transversa, deve-se traçar a totalidade do músculo, incluindo as fáscias.
D) A medida da área de secção transversa pode dar indicações quanto a alterações musculares, mas é menos precisa do que a medição da espessura para detectar a perda de massa muscular.

Resposta no final do artigo

18. O ângulo do fascículo é um parâmetro da arquitetura muscular utilizado para inferir a capacidade de contração muscular. Em relação à medida de ângulo do fascículo, marque **V** (verdadeiro) ou **F** (falso).

( ) O aumento desse ângulo resulta em menor transmissão da força muscular para o tendão.
( ) Poucos estudos realizaram a mensuração do ângulo do fascículo em pacientes críticos.
( ) O transdutor deverá ser posicionado paralelamente à pele, em corte transversal.
( ) O ângulo do transdutor varia conforme o eixo longitudinal dos fascículos; portanto, varia entre os indivíduos.

Assinale a alternativa que apresenta a sequência correta.

A) V — V — F — F
B) F — V — F — V
C) V — V — F — V
D) F — F — V — V

Resposta no final do artigo

ULTRASSONOGRAFIA DO MÚSCULO DIAFRAGMA

A USG é uma ferramenta de diagnóstico cada vez mais comum na UTI, em função de sua facilidade de aplicabilidade, seu baixo custo, pela rápida curva de aprendizado, pela variedade de informações que pode oferecer sobre diferentes órgãos e tecidos e por não ser invasiva. À medida que o entusiasmo em torno desse tópico cresce, aumentam também seus campos de aplicação clínica e de pesquisa.[60]

Entre esses novos campos de aplicação, o uso da USG para avaliação do músculo diafragma vem se expandindo exponencialmente.[60] Ao longo dos últimos anos, um número crescente de artigos tem sido publicado sobre o assunto e, até 2016, mais de 1.800 publicações em língua inglesa foram encontradas.[61]

Estudos mostram que parâmetros, como a excursão do diafragmática, a espessura e a fração de espessura, podem ser usados para quantificação da disfunção e atrofia do diafragma e para a mensuração do esforço respiratório em pacientes sob ventilação mecânica (VM). Clinicamente, esses marcadores são importantes para **predizer o sucesso de extubação e avaliar o efeito do treinamento muscular inspiratório**.

ESTRUTURA DO DIAFRAGMA E PARÂMETROS AVALIADOS

Do ponto de vista funcional e anatômico, o diafragma é caracterizado por duas principais áreas — a **área de aposição** (Figura 17A), que tem contato direito com o gradil costal interior, e a **cúpula**, composta pelo centro do tendão diafragmático. Ambas as estruturas estão cercadas pela pleura parietal.

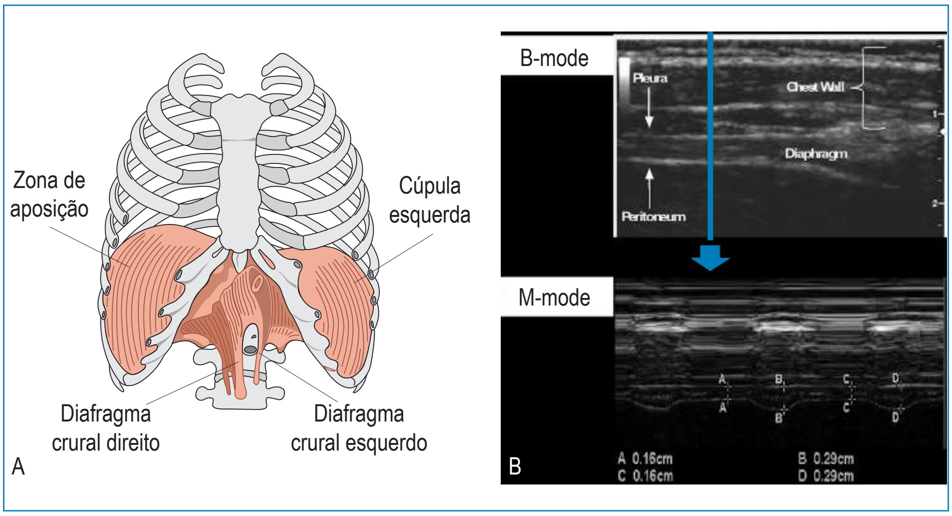


***Figura 17 —** Anatomia diafragmática e medida da espessura diafragmática. **A)** Zona de aposição diafragmática para medida de espessura. **B)** Espessura do diafragma em modo M, com a espessura inspiratória (B–B, D–D) e a expiratória (A–A, C–C).*
***Fonte:** A: Adaptada de TeachMeAnatomy (2017);[62] B: Goligher e colaboradores (2015).[63]*

Na prática clínica, em geral, são analisados dois parâmetros para avaliação do diafragma, que são as **medidas da excursão e da espessura**.

A avaliação da **excursão diafragmática** permite analisar a velocidade e a mobilidade da cúpula diafragmática, além do tempo inspiratório e da duração total do ciclo.[35,64] A avaliação da **espessura diafragmática** é realizada durante o momento da contração desse músculo, em que ocorre o encurtamento e, portanto, o aumento de sua espessura. A medida de espessura diafragmática está relacionada diretamente com a geração de força.[65]

PETIÇÃO EM PDF

Excelentíssimo Senhor Desembargador Relator

Dr. Roberto Wanderley

Ref. Agravo de Instrumento de nº 0815869-85.2023.4.05.0000

CREFITO-1, já qualificado nos autos, vem, pelo presente, promover emenda à petição de id. 4050000.42016810, o que faz nos seguintes termos:

No tópico **5. DOS PEDIDOS**, onde se lê:

b. Sejam consideradas as contribuições trazidas pelo CREFITO-1 para revogar a liminar concedida por meio da decisão agravada e **negar provimento** ao presente agravo de instrumento.

Leia-se

b. Sejam consideradas as contribuições trazidas pelo CREFITO-1 para revogar a liminar concedida por meio da decisão agravada e **dar provimento** ao presente agravo de instrumento.

Pede e Espera Deferimento,

Recife/PE, 18 de Dezembro de 2023.

Carlos Francisco da Silva

Advogado – OAB/PE: 46.301

PROCESSO Nº: 0815869-85.2023.4.05.0000 **- AGRAVO DE INSTRUMENTO**
AGRAVANTE: ANAJARA NERES DA SILVA
ADVOGADO: Erickson Lourenco Dantas
AGRAVADO: CONSELHO REGIONAL DE MEDICINA DO ESTADO DE ALAGOAS
ADVOGADO: Yves Maia De Albuquerque
RELATOR(A): Desembargador(a) Federal Roberto Wanderley Nogueira - 1ª Turma
MAGISTRADO CONVOCADO: Desembargador(a) Federal Marco Bruno Miranda Clementino
JUIZ PROLATOR DA SENTENÇA (1° GRAU): Juiz(a) Federal

DECISÃO

O Desembargador Federal ROBERTO WANDERLEY NOGUEIRA (Relator): Trata-se de agravo de instrumento interposto por ANAJARA NERES DA SILVA, em face de decisão prolatada pelo Juízo da 13ª Vara Federal da Seção Judiciária de Alagoas, que deferiu tutela de urgência para suspender liminarmente do curso intitulado "CURSO DE ULTRASSONOGRAFIA MUSCOESQUELÉTICA", marcado para ocorrer nos dias 15, 16 e 17 de dezembro de 2023, a ser ministrado por Wagner Cruz Haun, fisioterapeuta.

Em suas razões, a agravante sustenta a necessidade de reforma da decisão, por considerar não haver proibição na realização do curso, pois a matéria não se trata de atribuição exclusiva de profissional médico. Apresentou Acórdão do STJ, bem como jurisprudência da 20ª Vara Federal Cível da SJDF.

Requer tutela recursal, para que seja atribuído efeito suspensivo ao recurso. No mérito, requer a revogação da decisão recorrida, para que seja dado prosseguimento ao referido curso.

Cumpre ressaltar que o referido agravo de instrumento fora distribuído inicialmente ao plantão, porém, após análise do Exmo. Desembargador Plantonista, este entendeu não haver "demonstração de perecimento do direito que justifique a apreciação da medida no plantão judiciário. Destaque-se que o expediente forense se inicia hoje, às 9h, e, por sua vez, a parte interpôs o recurso, às 8h12, objetivando que seja proferida tutela a fim de assegurar o início do curso descrito nas razões recursais às 8h30. Ocorre que, diante da iminência do início do expediente, não estaria caracterizada a urgência a justificar a manifestação do juízo plantonista. Ademais, se reconhecido pelo juiz natural o direito à realização do curso em questão, este poderá ser ministrado hoje ou nos dias seguintes, inexistindo, assim, prejuízo para a parte recorrente diante da livre distribuição do recurso". (4050000.41971623).

O Conselho Regional de Fisioterapia e terapia ocupacional da 1ª Região - CREFITO-1 apresentou petição, requerendo que o mesmo seja admitido nos autos na condição de *Amicus Curiae* .

Decido.

Inicialmente, **admito** o CREFITO-1 aos presentes autos, na condição de *Amicus Curiae,* na forma do art. 138 do CPC.

É possível a tutela recursal (art. 1.019, I, do CPC) quando evidenciada a probabilidade do recurso e o risco de dano grave ou de difícil reparação (art. 995, parágrafo único, do CPC).

Compulsando aos autos, verifico que a decisão recorrida deferiu a liminar do CREMAL, suspendendo o curso em epígrafe, por considerar que a matéria é de exclusividade da área médica, verbis:

> *8. O Enunciado 143 do Fórum Permanente de Processualistas Civis assim dispôs acerca da*

redação do art. 300 do Código de Processo Civil:

> *143. (art. 300, caput) A redação do art. 300, caput, superou a distinção entre os requisitos da concessão para a tutela cautelar e para a tutela satisfativa de urgência, erigindo a probabilidade e o perigo na demora a requisitos comuns para a prestação de ambas as tutelas de forma antecipada. 59 (Grupo: Tutela Antecipada).*

9. Logo, a concessão da tutela de urgência depende, em primeiro lugar, da preponderância dos fatores convergentes à aceitação do direito alegado na exordial. Em seguida, também se faz necessária a presença de fundado receio de sofrer dano irreparável ou de difícil reparação.

10. É necessário, ainda, que a providência adotada antes do pronunciamento definitivo não esgote o objeto da ação. A reversibilidade, como visto, é nota marcante a influenciar o magistrado quando esse aprecia medidas de cunho liminar, sob pena de converter o pleito em julgamento antecipado e, pior, sem observância do contraditório e da ampla defesa.

11. No caso dos autos, pretende o Conselho autor impedir a realização do ""CURSO DE ULTRASSONOGRAFIA MUSCOESQUELÉTICA", a ser ministrado pelo réu WAGNER CRUZ HAUN em parceria com a Clínica TM Fisioterapia, marcado para ocorrer nos dias 15, 16 e 17 de dezembro de 2023.

12. Pois bem. Considerando o teor do art. 1º da Resolução CFM n. 1.361/1992: "É da exclusiva competência do médico a execução e a interpretação do exame ultra-sonográfico em seres humanos, assim como a emissão do respectivo laudo". Ademais, o art. 4º da Lei n. 12.842/2013 (Lei do Ato Médico) confere privativamente aos profissionais da Medicina, dentre outras atribuições: a emissão de laudo dos exames de imagem e a determinação do prognóstico relativo ao diagnóstico nosológico (art. 4º, alíneas "f" e "g").

13. Afora isso, pontuou o demandante que a "ultrassonografia" é uma especialidade médica, tanto que "para o médico obter registro e poder se anunciar como especialista em radiologia e diagnóstico por imagem, é necessária a realização de residência médica, em período não inferior a 03 (três anos) ou por meio de concurso realizado pela Associação Medica Brasileira/Colégio Brasileiro de Radiologia e Diagnóstico por Imagem", ao passo que o curso em questão, destinado a não-médicos, tem duração de apenas 03 (três) dias.

14. Sendo assim, a partir de uma análise perfunctória do caso, própria do atual estágio processual, e considerando os fundamentos apresentados, entendo que o pleito liminar atende satisfatoriamente ao requisito da probabilidade do direito (fumus boni iuris).

15. Quanto ao requisito do periculum in mora, entendo-o manifesto, já que o multicitado curso está marcado para se iniciar no dia de amanhã (15.12.2023), não havendo sequer tempo hábil para o exercício do contraditório. **(Decisão agravada, id. 4058000.14116385).**

Apesar da exposição da parte agravante, entendo não se ter desincumbido do ônus de demonstrar a ocorrência do risco de dano grave ou de difícil reparação (art. 995, parágrafo único, do CPC), pois, na hipótese de ser reconhecida a possibilidade da realização do curso objeto desta lide, este poderá ser realizado em data futura, visto que a data marcada para o evento já fora transcorrida.

Com estas considerações, **INDEFIRO A TUTELA RECURSAL, recebendo o recurso apenas em seu efeito devolutivo** . Intimem-se as partes desta decisão. Comunique-se ao Juízo da 13ª Vara Federal da Seção Judiciária de Alagoas.

Intime-se a parte agravada para contrarrazoar o recurso no prazo de 15 (quinze) dias (art. 1.019, II, do CPC).

À Subsecretaria da Turma para providências de estilo.

Recife, data da validação.

ROBERTO WANDERLEY NOGUEIRA

Desembargador Relator

RWN/phba

PROCESSO Nº: 0815869-85.2023.4.05.0000 **- AGRAVO DE INSTRUMENTO**
AGRAVANTE: ANAJARA NERES DA SILVA
ADVOGADO: Erickson Lourenco Dantas
AGRAVADO: CONSELHO REGIONAL DE MEDICINA DO ESTADO DE ALAGOAS
ADVOGADO: Yves Maia De Albuquerque
RELATOR(A): Desembargador(a) Federal Roberto Wanderley Nogueira - 1ª Turma
MAGISTRADO CONVOCADO: Desembargador(a) Federal Marco Bruno Miranda Clementino
JUIZ PROLATOR DA SENTENÇA (1° GRAU): Juiz(a) Federal

DECISÃO

O Desembargador Federal ROBERTO WANDERLEY NOGUEIRA (Relator): Trata-se de agravo de instrumento interposto por ANAJARA NERES DA SILVA, em face de decisão prolatada pelo Juízo da 13ª Vara Federal da Seção Judiciária de Alagoas, que deferiu tutela de urgência para suspender liminarmente do curso intitulado "CURSO DE ULTRASSONOGRAFIA MUSCOESQUELÉTICA", marcado para ocorrer nos dias 15, 16 e 17 de dezembro de 2023, a ser ministrado por Wagner Cruz Haun, fisioterapeuta.

Em suas razões, a agravante sustenta a necessidade de reforma da decisão, por considerar não haver proibição na realização do curso, pois a matéria não se trata de atribuição exclusiva de profissional médico. Apresentou Acórdão do STJ, bem como jurisprudência da 20ª Vara Federal Cível da SJDF.

Requer tutela recursal, para que seja atribuído efeito suspensivo ao recurso. No mérito, requer a revogação da decisão recorrida, para que seja dado prosseguimento ao referido curso.

Cumpre ressaltar que o referido agravo de instrumento fora distribuído inicialmente ao plantão, porém, após análise do Exmo. Desembargador Plantonista, este entendeu não haver "demonstração de perecimento do direito que justifique a apreciação da medida no plantão judiciário. Destaque-se que o expediente forense se inicia hoje, às 9h, e, por sua vez, a parte interpôs o recurso, às 8h12, objetivando que seja proferida tutela a fim de assegurar o início do curso descrito nas razões recursais às 8h30. Ocorre que, diante da iminência do início do expediente, não estaria caracterizada a urgência a justificar a manifestação do juízo plantonista. Ademais, se reconhecido pelo juiz natural o direito à realização do curso em questão, este poderá ser ministrado hoje ou nos dias seguintes, inexistindo, assim, prejuízo para a parte recorrente diante da livre distribuição do recurso". (4050000.41971623).

O Conselho Regional de Fisioterapia e terapia ocupacional da 1ª Região - CREFITO-1 apresentou petição, requerendo que o mesmo seja admitido nos autos na condição de *Amicus Curiae* .

Decido.

Inicialmente, **admito** o CREFITO-1 aos presentes autos, na condição de *Amicus Curiae,* na forma do art. 138 do CPC.

É possível a tutela recursal (art. 1.019, I, do CPC) quando evidenciada a probabilidade do recurso e o risco de dano grave ou de difícil reparação (art. 995, parágrafo único, do CPC).

Compulsando aos autos, verifico que a decisão recorrida deferiu a liminar do CREMAL, suspendendo o curso em epígrafe, por considerar que a matéria é de exclusividade da área médica, verbis:

> *8. O Enunciado 143 do Fórum Permanente de Processualistas Civis assim dispôs acerca da*

redação do art. 300 do Código de Processo Civil:

> *143. (art. 300, caput) A redação do art. 300, caput, superou a distinção entre os requisitos da concessão para a tutela cautelar e para a tutela satisfativa de urgência, erigindo a probabilidade e o perigo na demora a requisitos comuns para a prestação de ambas as tutelas de forma antecipada. 59 (Grupo: Tutela Antecipada).*

9. Logo, a concessão da tutela de urgência depende, em primeiro lugar, da preponderância dos fatores convergentes à aceitação do direito alegado na exordial. Em seguida, também se faz necessária a presença de fundado receio de sofrer dano irreparável ou de difícil reparação.

10. É necessário, ainda, que a providência adotada antes do pronunciamento definitivo não esgote o objeto da ação. A reversibilidade, como visto, é nota marcante a influenciar o magistrado quando esse aprecia medidas de cunho liminar, sob pena de converter o pleito em julgamento antecipado e, pior, sem observância do contraditório e da ampla defesa.

11. No caso dos autos, pretende o Conselho autor impedir a realização do ""CURSO DE ULTRASSONOGRAFIA MUSCOESQUELÉTICA", a ser ministrado pelo réu WAGNER CRUZ HAUN em parceria com a Clínica TM Fisioterapia, marcado para ocorrer nos dias 15, 16 e 17 de dezembro de 2023.

12. Pois bem. Considerando o teor do art. 1º da Resolução CFM n. 1.361/1992: "É da exclusiva competência do médico a execução e a interpretação do exame ultra-sonográfico em seres humanos, assim como a emissão do respectivo laudo". Ademais, o art. 4º da Lei n. 12.842/2013 (Lei do Ato Médico) confere privativamente aos profissionais da Medicina, dentre outras atribuições: a emissão de laudo dos exames de imagem e a determinação do prognóstico relativo ao diagnóstico nosológico (art. 4º, alíneas "f" e "g").

13. Afora isso, pontuou o demandante que a "ultrassonografia" é uma especialidade médica, tanto que "para o médico obter registro e poder se anunciar como especialista em radiologia e diagnóstico por imagem, é necessária a realização de residência médica, em período não inferior a 03 (três anos) ou por meio de concurso realizado pela Associação Medica Brasileira/Colégio Brasileiro de Radiologia e Diagnóstico por Imagem", ao passo que o curso em questão, destinado a não-médicos, tem duração de apenas 03 (três) dias.

14. Sendo assim, a partir de uma análise perfunctória do caso, própria do atual estágio processual, e considerando os fundamentos apresentados, entendo que o pleito liminar atende satisfatoriamente ao requisito da probabilidade do direito (fumus boni iuris).

15. Quanto ao requisito do periculum in mora, entendo-o manifesto, já que o multicitado curso está marcado para se iniciar no dia de amanhã (15.12.2023), não havendo sequer tempo hábil para o exercício do contraditório. **(Decisão agravada, id. 4058000.14116385).**

Apesar da exposição da parte agravante, entendo não se ter desincumbido do ônus de demonstrar a ocorrência do risco de dano grave ou de difícil reparação (art. 995, parágrafo único, do CPC), pois, na hipótese de ser reconhecida a possibilidade da realização do curso objeto desta lide, este poderá ser realizado em data futura, visto que a data marcada para o evento já fora transcorrida.

Com estas considerações, **INDEFIRO A TUTELA RECURSAL, recebendo o recurso apenas em seu efeito devolutivo** . Intimem-se as partes desta decisão. Comunique-se ao Juízo da 13ª Vara Federal da Seção Judiciária de Alagoas.

Intime-se a parte agravada para contrarrazoar o recurso no prazo de 15 (quinze) dias (art. 1.019, II, do CPC).

À Subsecretaria da Turma para providências de estilo.

Recife, data da validação.

ROBERTO WANDERLEY NOGUEIRA

Desembargador Relator

RWN/phba

TRIBUNAL REGIONAL FEDERAL DA 5ª REGIÃO
PROCESSO: **0815869-85.2023.4.05.0000 - AGRAVO DE INSTRUMENTO**
Gab 1 - Des. ROBERTO WANDERLEY - 1ª Turma
RELATOR(A): DESEMBARGADOR(A) FEDERAL ROBERTO WANDERLEY NOGUEIRA

Polo ativo	
ANAJARA NERES DA SILVA	AGRAVANTE
ERICKSON LOURENCO DANTAS	ADVOGADO

Polo passivo	
CONSELHO REGIONAL DE MEDICINA DO ESTADO DE ALAGOAS	AGRAVADO
YVES MAIA DE ALBUQUERQUE	ADVOGADO

Outros participantes	
MINISTÉRIO PÚBLICO FEDERAL	CUSTOS LEGIS

CERTIDÃO

CERTIFICO que, em 18/12/2023 16:04, o(a) ANAJARA NERES DA SILVA foi intimado(a) acerca de Decisão registrado em 18/12/2023 15:05 nos autos judiciais eletrônicos especificados na epígrafe.

1 - Esta Certidão é válida para todos os efeitos legais, havendo sido expedida através do Sistema Processo Judicial Eletrônico - PJe.

2 - A autenticidade desta Certidão poderá ser confirmada no endereço https://pje.trf5.jus.br/pje/Processo/ConsultaDocumento/listView.seam , através do código de autenticação nº 23121815154653400000042091924 .

3 - Esta Certidão foi emitida gratuitamente em 18/12/2023 16:04 - Tribunal Regional Federal 5ª Região.

TRIBUNAL REGIONAL FEDERAL DA 5ª REGIÃO
PROCESSO: **0815869-85.2023.4.05.0000** - **AGRAVO DE INSTRUMENTO**
Gab 1 - Des. ROBERTO WANDERLEY - 1ª Turma
RELATOR(A): DESEMBARGADOR(A) FEDERAL ROBERTO WANDERLEY NOGUEIRA

Polo ativo	
ANAJARA NERES DA SILVA	AGRAVANTE
ERICKSON LOURENCO DANTAS	ADVOGADO

Polo passivo	
CONSELHO REGIONAL DE MEDICINA DO ESTADO DE ALAGOAS	AGRAVADO
YVES MAIA DE ALBUQUERQUE	ADVOGADO

Outros participantes	
MINISTÉRIO PÚBLICO FEDERAL	CUSTOS LEGIS

CERTIDÃO

CERTIFICO que, em 19/12/2023 08:52, o(a) CONSELHO REGIONAL DE MEDICINA DO ESTADO DE ALAGOAS foi intimado(a) acerca de Decisão registrado em 18/12/2023 15:05 nos autos judiciais eletrônicos especificados na epígrafe.

1 - Esta Certidão é válida para todos os efeitos legais, havendo sido expedida através do Sistema Processo Judicial Eletrônico - PJe.

2 - A autenticidade desta Certidão poderá ser confirmada no endereço https://pje.trf5.jus.br/pje/Processo/ConsultaDocumento/listView.seam , através do código de autenticação nº 23121815154653400000042091924 .

3 - Esta Certidão foi emitida gratuitamente em 19/12/2023 08:52 - Tribunal Regional Federal 5ª Região.

TRIBUNAL REGIONAL FEDERAL DA 5ª REGIÃO
PROCESSO: **0815869-85.2023.4.05.0000 - AGRAVO DE INSTRUMENTO**
Gab 1 - Des. ROBERTO WANDERLEY - 1ª Turma
RELATOR(A): DESEMBARGADOR(A) FEDERAL ROBERTO WANDERLEY NOGUEIRA

Polo ativo	
ANAJARA NERES DA SILVA	AGRAVANTE
ERICKSON LOURENCO DANTAS	ADVOGADO

Polo passivo	
CONSELHO REGIONAL DE MEDICINA DO ESTADO DE ALAGOAS	AGRAVADO
YVES MAIA DE ALBUQUERQUE	ADVOGADO

Outros participantes	
MINISTÉRIO PÚBLICO FEDERAL	CUSTOS LEGIS

CERTIDÃO

CERTIFICO que, em 28/12/2023 23:59, o(a) MINISTÉRIO PÚBLICO FEDERAL foi intimado(a) acerca de Decisão registrado em 18/12/2023 15:05 nos autos judiciais eletrônicos especificados na epígrafe.

1 - Esta Certidão é válida para todos os efeitos legais, havendo sido expedida através do Sistema Processo Judicial Eletrônico - PJe.

2 - A autenticidade desta Certidão poderá ser confirmada no endereço https://pje.trf5.jus.br/pje/Processo/ConsultaDocumento/listView.seam , através do código de autenticação nº 23121815154653400000042091924 .

3 - Esta Certidão foi emitida gratuitamente em 29/12/2023 00:12 - Tribunal Regional Federal 5ª Região.

EXMO. SR. DESEMBARGADOR FEDERAL RELATOR E DEMAIS MEMBROS DO EGRÉGIO TRIBUNAL REGIONAL FEDERAL DA 5ª REGIÃO.

REF.: 0815869-85.2023.4.05.0000

Ciência nº 4 4 6 95 / 202 3

Pelo M inistério P úblico F ederal, ciente d a Decisão (i d. 4050000.42021683) .

Recife, d ata da assinatura eletrônica.

SÔNIA MARIA DE ASSUNÇÃO MACIEIRA

PROCURADORA REGIONAL DA REPÚBLICA