Universidade Federal de Sergipe
Pró-Reitoria de Pós-graduação e Pesquisa
Centro de Ciências Biológicas e da Saúde
Programa de Pós-Graduação em Ciências Fisiológicas

DOR LOMBAR CRÔNICA E EXERCÍCIO FÍSICO: DA AVALIAÇÃO AO TRATAMENTO

POLIANA DE JESUS SANTOS

São Cristóvão
2025

POLIANA DE JESUS SANTOS

DOR LOMBAR CRÔNICA E EXERCÍCIO FÍSICO: DA AVALIAÇÃO AO TRATAMENTO

Tese apresentada ao Programa de Pós-Graduação em Ciências Fisiológicas da Universidade Federal de Sergipe como requisito parcial para obtenção do grau de Doutora em Ciências Fisiológicas.

Orientador: Marzo Edir Da Silva-Grigoletto

Coorientador: José Carlos Aragão-Santos

São Cristóvão
2025

FICHA CATALOGRÁFICA ELABORADA PELO SIBIUFS
UNIVERSIDADE FEDERAL DE SERGIPE

Santos, Poliana de Jesus
S237d Dor lombar crônica e exercício físico : da avaliação ao treinamento / Poliana de Jesus Santos ; orientador Marzo Edir da Silva-Grigoletto. – São Cristóvão, SE, 2025.
110 f. : il.

Tese (Doutorado em Ciências Fisiológicas) - Universidade Federal de Sergipe, 2025.

1. Dor crônica. 2. Dor lombar. 3. Exercícios físicos. 4. Envelhecimento – Aspectos fisiológicos. I. Grigoletto, Marzo Edir da Silva, orient. II. Título.

CDU 616.8-009.7:796

POLIANA DE JESUS SANTOS

DOR LOMBAR CRÔNICA E EXERCÍCIO FÍSICO: DA AVALIAÇÃO AO TRATAMENTO

Tese apresentada ao Programa de Pós-Graduação em Ciências Fisiológicas da Universidade Federal de Sergipe como requisito parcial para obtenção do grau de Doutora em Ciências Fisiológicas.

Orientador: Marzo Edir Da Silva-Grigoletto

Coorientador: José Carlos Aragão-Santos

Aprovada em ________/_____/______

Marzo Edir Da Silva-Grigoletto (presidente)

Jader Pereira de Farias Neto

Marcela Rodrigues Castro

Ana Silvia Moccellin

Héctor Julián Tejada Herrera

AGRADECIMENTOS

A Deus, fonte inesgotável de amor, força e sabedoria, meu primeiro e mais profundo agradecimento. Sem a Sua Graça, nada disso teria sido possível. Foi Ele quem me sustentou nos momentos mais difíceis, quem iluminou meu caminho e fortaleceu minha fé para seguir em frente, mesmo quando as adversidades pareciam insuperáveis.

Ao meu pai, Valdir, e à minha mãe, Ana, meu alicerce mais sólido. Mãe, você é minha inspiração, meu maior exemplo de força, determinação e amor incondicional. Obrigada por nunca medir esforços para que eu pudesse realizar meus sonhos. Cada conquista minha é, na verdade, um reflexo do seu amor e dedicação. Ao meu irmão, Valdenilson, obrigada por sempre acreditar em mim, por me apoiar em todos os momentos e por entender a minha ausência. Amo vocês imensamente e sou profundamente grata por tê-los ao meu lado.

Ao meu noivo, Elondark, obrigada por toda a paciência, especialmente nos momentos mais intensos da reta final, por entender meu silêncio e por nunca soltar a minha mão. Seu amor e apoio tornaram essa caminhada mais leve e possível. Que essa seja apenas mais uma das muitas conquistas que ainda compartilharemos juntos.

As minhas amigas, que foram meu porto seguro nos momentos mais turbulentos. Bia, minha querida, obrigada por cada palavra de conforto, por me ouvir sem pressa e por me acolher com tanto carinho nos momentos mais difíceis desse processo. Seu apoio foi um abraço para a minha alma. Mariele e Verônica, minhas grandes amigas, obrigada por compreenderem minha ausência em certos momentos, mas, acima de tudo, por nunca deixarem de estar comigo. Mesmo quando eu não conseguia estar tão presente, vocês permaneceram ao meu lado, firmes e cheias de carinho, provando que a amizade verdadeira não se mede pelo tempo, mas pela conexão do coração.

Ao grupo de pesquisa que faço parte, pois ninguém constrói nada grandioso sozinho. Essa conquista é também fruto da dedicação, do esforço coletivo e do espírito colaborativo do FTG. Foram seis anos intensos, repletos de aprendizado, crescimento e superação de desafios, mas também de trocas valiosas, risadas e momentos

inesquecíveis. Cada um de vocês deixou sua marca nesta trajetória, tornando-a mais rica e significativa. Meu agradecimento especial a Alan, Carlos e Carol, obrigada por tornarem essa caminhada muito mais leve.

Às meninas do Projeto Mais Viver, minha gratidão mais sincera e emocionada. Vocês foram a essência dessa pesquisa, trazendo consigo histórias, vivências e sorrisos que enriqueceram cada passo desse trabalho. Mais do que participantes, vocês foram professoras da vida, ensinando sobre resiliência, afeto e a beleza de continuar sempre em movimento. Obrigada por abrirem seus corações e por permitirem que eu fizesse parte da trajetória de vocês.

Por fim, mas com imensa gratidão, ao meu orientador Prof. Marzo, por toda dedicação, paciência e por compartilhar comigo um oceano de conhecimento. Sua orientação foi muito além da academia; foi uma verdadeira inspiração para mim. Obrigada por cada hora dedicada, por cada ensinamento e por acreditar no meu potencial. Seu exemplo e comprometimento foram fundamentais para que este sonho se concretizasse.

A todos que, de alguma forma, estiveram ao meu lado nessa caminhada, meu mais sincero e profundo obrigada. Essa vitória é nossa!

RESUMO

Dor lombar crônica e exercício físico: da avaliação ao tratamento. Poliana de Jesus Santos, São Cristóvão, 2025.

A dor lombar crônica inespecífica (DLCI), principal causa de incapacidade global, especialmente entre mulheres de 40 a 80 anos. Apesar da alta prevalência, não há uma compreensão sobre as melhores práticas desde prevenção ao tratamento. O exercício físico é a principal intervenção recomendada, com o treinamento funcional (TF) e o de dupla tarefa (TDT) eficazes na redução da dor, embora sem consenso sobre a superioridade entre eles. O objetivo dessa tese foi avaliar as alterações na dor lombar em função da prática de diferentes abordagens de treinamento físico. O Estudo 1 investigou métodos acessíveis de avaliação da dor, apresentando testes sensoriais quantitativos e questionários simples para uma abordagem multidimensional. O Estudo 2 revisou os mecanismos de ação do TF e do TDT na dor lombar, indicando que o TF melhora estabilidade do tronco e função, enquanto o TDT inibe circuitos da dor e ativa áreas cerebrais ligadas à analgesia. No estudo 3, trinta e oito mulheres entre 60 e 79 anos com DLCI divididas em dois grupos (TF e TDT), realizaram 16 semanas de treinamento. O TF foi realizado em circuito com exercícios simulando atividades cotidianas, enquanto o TDT envolveu a execução simultânea de tarefas motoras e cognitivas. Avaliamos o limiar de dor à pressão (LDP), somação temporal da dor (ST), modulação condicionada da dor (MCD), instabilidade do tronco, força isométrica e resistência dos músculos do tronco. No estudo 4, setenta voluntárias com e sem DLCI foram divididas em quatro grupos (TF com DLCI, TF sem DLCI, TDT com DLCI e TDT sem DLCI) e seguiram o mesmo protocolo do estudo 3. Além das variáveis anteriores, avaliamos a aptidão funcional. No estudo 3, o TF mostrou aumento superior ao TDT no LDP e MCD ($p < 0,05$), sem efeito sobre a ST. Ambos os treinamentos aumentaram a força isométrica máxima dos extensores do tronco ($p < 0,001$) sem diferença entre os grupos. A resistência dos extensores ($p = 0,01$) e flexores laterais do tronco ($p < 0,001$) aumentou somente no TDT, sem diferença significativa entre os grupos. Não houve alterações na estabilidade do tronco e na resistência dos flexores do tronco. No estudo 4, ambos os treinamentos aumentaram a estabilidade do tronco ($p < 0,05$) e a força isométrica dos flexores e extensores ($p < 0,001$), sem diferenças entre os treinamentos. As mulheres com DLCI apresentaram maior força de flexores em comparação às sem dor ($p = 0,03$), enquanto as sem DLCI mostraram maior força de extensores ($p = 0,02$). A resistência dos flexores e extensores do tronco também aumentou nos dois grupos ($p < 0,05$). Para os flexores laterais, houve aumento significativo apenas no TDT, especialmente entre mulheres com DLCI ($p < 0,05$). A aptidão funcional melhorou em todos os grupos ($p < 0,05$), independente da presença de dor. Concluímos que existem métodos avaliativos práticos e de baixo custo para a dor, que os mecanismos envolvidos na analgesia são diferentes entre os treinamentos investigados e que ambas as modalidades são eficazes para o tratamento da DLCI em mulheres idosas.

Palavras-chaves: dor crônica; estabilidade do tronco; exercício físico; envelhecimento.

ABSTRACT

Chronic Low Back Pain and Physical Exercise: From Assessment to Treatment
Poliana de Jesus Santos, São Cristóvão, 2025

Non-specific chronic low back pain (NSCLBP) is the leading cause of disability worldwide, particularly among women aged 40 to 80 years. Despite its high prevalence, there is a lack of understanding regarding best practices for prevention and treatment. Physical exercise is the primary recommended intervention, with functional training (FT) and dual-task training (DTT) both showing effectiveness in pain reduction, although no consensus exists on which modality is superior. This thesis aimed to evaluate the effects of different physical training approaches on low back pain outcomes. Study 1 investigated accessible methods for pain assessment, presenting quantitative sensory testing and simple questionnaires for a multidimensional approach. Study 2 reviewed the mechanisms of action of Functional Training (FT) and Dual-Task Training (DTT) in low back pain, suggesting that FT improves trunk stability and functional capacity, while DTT appears to inhibit pain-related circuits and activate brain regions associated with analgesia. In Study 3, thirty-eight women aged 60–79 years with NSCLBP were randomly assigned to FT or DTT groups and participated in 16 weeks of training. FT consisted of circuit exercises simulating daily activities, while DTT involved the simultaneous execution of motor and cognitive tasks. We assessed pressure pain threshold (PPT), temporal summation (TS), conditioned pain modulation (CPM), trunk instability, isometric strength, and trunk muscle endurance. In Study 4, seventy volunteers with and without NSCLBP were divided into four groups (FT with NSCLBP, FT without NSCLBP, DTT with NSCLBP, and DTT without NSCLBP) and followed the same training protocol as in Study 3. In addition to the previously mentioned variables, we also evaluated functional fitness. In Study 3, FT resulted in greater improvements than DTT in PPT and CPM ($p < 0.05$), with no effect on TS. Both interventions increased maximum isometric strength of trunk extensors ($p < 0.001$), with no between-group differences. Endurance of trunk extensors ($p = 0.01$) and lateral flexors ($p < 0.001$) increased only in the DTT group, without significant group differences. No changes were observed in trunk stability or endurance of trunk flexors. In Study 4, both training modalities improved trunk stability ($p < 0.05$) and isometric strength of flexors and extensors ($p < 0.001$), with no differences between groups. Women with NSCLBP showed greater flexor strength than those without pain ($p = 0.03$), while women without NSCLBP showed greater extensor strength ($p = 0.02$). Endurance of trunk flexors and extensors improved in both groups ($p < 0.05$). Lateral flexor endurance increased significantly only in the DTT group, especially among women with NSCLBP ($p < 0.05$). Functional fitness improved in all groups ($p < 0.05$), regardless of pain status. We conclude that there are practical and low-cost methods for pain assessment, that the analgesic mechanisms differ between the investigated training modalities, and that both FT and DTT are effective for managing NSCLBP in older women.

Keywords: *chronic pain; trunk stability; physical exercise; aging.*

RESUMO VOLTADO PARA A SOCIEDADE

A dor nas costas, bem na parte de baixo da coluna, é muito comum. Ela aparece com mais frequência em mulheres entre 40 e 80 anos. Muitas vezes, mesmo indo ao médico e fazendo exames, não se encontra um motivo certo para essa dor. Ela simplesmente aparece e vai ficando cada vez mais forte. Isso atrapalha muito o dia a dia. Atividades simples, como andar, subir escada, se abaixar ou carregar uma sacola, ficam difíceis de fazer. Algumas pessoas até deixam de sair de casa por causa da dor. Neste trabalho, comparamos dois tipos de treinamento físico que poderiam ajudar mulheres idosas a sentirem menos dor. Um dos treinamentos se chama treinamento funcional. Ele usa movimentos parecidos com os do dia a dia, como agachar para usar o vaso sanitário, empurrar um móvel, puxar um objeto para perto do corpo e carregar peso como as compras do mercado. Já o outro treinamento se chama dupla tarefa. Nele, a pessoa faz um movimento físico junto de um mental, como por exemplo caminhar ao mesmo tempo que fala ao telefone. Desta forma a dupla tarefa consiste na realização dos dois treinamentos (físico e mental) ao mesmo tempo. Trinta e oito mulheres, com idades entre 60 e 79 anos fizeram os dois treinamentos três vezes por semana, durante quatro meses. No final, vimos que as duas formas de treinamento ajudaram bastante. O grupo do treinamento funcional reduziu mais a dor, enquanto o grupo da dupla tarefa ficou com os músculos das costas mais fortes. Todos os grupos melhoraram a força dos músculos das costas, o equilíbrio e conseguiram fazer as tarefas do dia a dia de forma mais rápida. Por isso, os dois tipos de treinamento são boas escolhas para ajudar mulheres idosas a sentirem menos dor e a viver com mais saúde e liberdade.

LISTA DE FIGURAS

Estudo 1	*Figure 1. Quantitative sensory testing.*	14
	Figure 2. Pain scales.	15
Estudo 3	*Figure 1. Experimental design.*	57
	Figure 2. Effects of interventions on endogenous pain modulation.	62
Estudo 4	*Figure 1. Experimental design.*	79
	Figure 2. Experimental diagram.	80
	Figure 3. Effects of interventions on trunk function.	81
	Figure 4. Effects of interventions on functional fitness.	82

LISTA DE TABELAS

Estudo 1	*Table 1. Pain assessment instruments.*	17
Estudo 2	*Table 1. Characterization of the functional training used in the studies.*	30
	Table 2. Characterization of the dual-task training used in the studies.	39
Estudo 3	*Table 1. Participant characteristics.*	61
	Table 2. Effects of the training interventions on the investigated variables.	64
	Table S1. Detailed description of the training protocols.	74
Estudo 4	*Table 1. Participant characteristics.*	81

LISTA DE ABREVIATURAS E SIGLAS

ADL	*Activities of daily living*
BMI	*Body mass index*
BPI-SF	*Brief pain inventory - short form*
CI	*Confidence intervals*
CLBP	*Chronic low back pain*
CNLBP	*Chronic nonspecific low back pain*
CNS	*Central nervous system*
CoP	*Center of pressure*
CPM	*Conditioned pain modulation*
CS	*Central sensitization*
CSI	*Central sensitization inventory*
DLC	Dor lombar crônica
DLCI	Dor lombar crônica inespecífica
DRt	*Dorsal reticular subnucleus*
DT	*Dual-task*
DTT	*Dual-task training*
EQ-5D	*European quality of life-5 dimensions*
FT	*Functional training*
FTSS	*Five times sit-to-stand test*
GJST	*Gallon-jug shelf-transfer test*
GLMM	*Generalized linear mixed models*
IASP	*International association for the study of pain*
MPQ	*McGill pain questionnaire*
NPRS	*Numerical pain rating scale*

PAG *Periaqueductal gray*

PCS *Pain catastrophizing scale*

PPT *Pressure pain threshold*

PSEQ-10 *Pain self-efficacy questionnaire*

PTS *Put on and take off a t-shirt*

QST *Quantitative sensory testing*

RPE *Rate of perceived effort.*

RVM *Rostroventromedial medulla*

SD *Standard deviations*

SPP *Standing up from the prone position*

ST Somação temporal

TDT *Tactile detection threshold*

TDT Treinamento de dupla tarefa

TF Treinamento funcional

TS *Temporal summation*

TSP *Temporal summation of pain*

TUG *Timed up and go*

VAS *Visual analog scale*

W10m *10 m walk*

SUMÁRIO

1. INTRODUÇÃO..1

2. OBJETIVOS E HIPÓTESE..5

2.1. Objetivo geral...5

2.2. Objetivos específicos..5

2.3. Hipótese...5

3. DESENVOLVIMENTO...7

3.1. Estudo 1: *Pain and movement: practical assessment methods for healt and exercise professionals*……………………………………………………………………8

3.2. Estudo 2: *Functional training and dual-task as a treatment option for chronic low back pain*…………………………………………………………………….....22

3.3. Estudo 3. *Effects of 2 training protocols on aspects of pain in older women with chronic low back pain: a randomized clinical trial*………………..………………..52

3.4. Estudo 4. *Functional vs. dual-task training effects on trunk muscle function and functional fitness in older women with and without chronic low back pain: A randomized clinical trial*……………………..…………………………………………..77

4. CONCLUSÃO……………………………………………………………………......85

REFERÊNCIAS………………………………………………………………….…87

APÊNDICE………………………………………………………………………….90

ANEXO……………………………………………………………………………….93

1. INTRODUÇÃO

A dor lombar crônica (DLC) é atualmente o problema musculoesquelético mais prevalente no mundo, afetando principalmente a população com idade entre 40 e 80 anos (WU et al., 2020). No Brasil, a prevalência ao longo da vida foi de 62,6%, sendo as mulheres as mais afetadas (GONZALEZ et al., 2021). Estudos mostram que mulheres apresentam intensidades da dor maiores (FILLINGIM et al., 2003) e menor tolerância a dor em testes sensoriais quantitativos, quando comparado a homens (FILLINGIM et al., 1998). Essas diferenças entre os sexos podem ser justificadas devido os hormônios sexuais femininos apresentarem tanto efeitos pro-nociceptivos quanto anti nociceptivo na dor, enquanto a testosterona parece ser mais anti nociceptiva e protetora (CRAFT, 2007; SMITH et al., 2006). Além disso, as mulheres também apresentam maior ativação de áreas corticais relacionadas a processamento de estímulos dolorosos como córtex pré frontal, ínsula e tálamo quando comparado a homens (PAULSON et al., 1998). Assim, essas diferenças neurobiológicas e hormonais ajudam a explicar por que as mulheres são mais suscetíveis e apresentam maior prevalência de dor crônica em comparação aos homens.

Além das diferenças sexuais, as diferenças de idades também se fazem presentes entre a população acometida pela dor crônica. No Brasil, a prevalência de dor crônica entre pessoas idosas (60 anos ou mais) pode variar entre 29% a 76% dependo da região do país (SANTIAGO et al., 2023). Outro estudo realizado na Turquia, mostrou que 92% dos indivíduos com 65 anos ou mais apresentaram alguma dor crônica ao longo da vida, (KAPTAN et al., 2020). Essa maior prevalência na população idosa se dá em partes devido as alterações musculoesqueléticas que ocorrem com o envelhecimento, tornando-o esse público mais suscetível a desenvolver problemas crônicos (LEVEILLE, 2004). Além disso, essa população apresenta alterações nas estruturas e funções das vias nociceptivas, redução da eficiência dos sistemas analgésicos endógenos, consequentemente aumentando o limiar de percepção da dor em pessoas idosas. Dessa forma, estas alterações fisiológicas decorrentes do envelhecimento, tornam a população idosa especialmente vulnerável ao desenvolvimento e à manutenção da dor crônica, reforçando a necessidade de estratégias específicas e individualizadas para essa faixa etária.

Dentre as diversas condições de dor crônica, a dor lombar é a mais prevalente e incapacitante no mundo (WU et al., 2020). A dor lombar pode ser classificada de acordo com sua duração em aguda (menor que 6 semanas), subaguda (de 6 a 12 semanas) e crônica (acima de 12 semanas) (VIOLANTE; MATTIOLI; BONFIGLIOLI, 2015). E de acordo com sua origem em específica e inespecífica. A dor lombar de origem inespecífica é aquela que não pode ser atribuída a uma causa ou uma doença pré estabelecida (BALAGUÉ et al., 2012). A origem da dor lombar crônica inespecífica (DLCI) é multifatorial e envolve o surgimento de micro lesões favorecendo a degeneração articular e danos nos ligamentos, músculos, fáscias e discos intervertebrais, quando essas lesões não são resolvidas geram um aumento da responsividade dos neurônios, resultado no surgimento da sensibilização central e periférica (MOSABBIR, 2022).

As alterações ocorridas no sistema nervoso levam a modificações no controle motor, resultando em modificações na atividade muscular em pessoas com DLCI (VAN DIEËN et al., 2019). Estudos realizados em modelo animal indicaram que, na fase aguda, há uma redução na atividade elétrica dos músculos multifidos, na fase subaguda, ocorrem modificações fibróticas relacionadas à ativação de citocinas que promovem a fibrose, e na fase crônica, observam-se mudanças semelhantes às provocadas pelo desuso muscular (HODGES et al., 2009, 2014, 2015; ZHAO et al., 2000). Consequentemente, pacientes acometidos pela DLCI geralmente apresentam aumento da instabilidade e redução da força dos músculos do tronco (PRANATA et al., 2017; VAN DIEËN et al., 2019). Todas essas alterações musculares repercutem no desenvolvimento das atividades do dia a dia dessa população, gerando dificuldade na realização de tarefas como puxar/empurrar, agachar, realizar tarefas domésticas, caminhar, subir escadas e alcançar objetos (RUDY et al., 2007; WEINER et al., 2003).

Atualmente o exercício físico é indicado como primeira opção de tratamento para a DLCI (PEDERSEN; SALTIN, 2015) devido ativação de mecanismos como os sistemas endocanabinóide, serotoninérgico, opioide, imunológico, sistema nervoso autônomo e da modulação condicionada da dor, todos relacionados com o processo de analgesia (DA SILVA SANTOS; GALDINO, 2018; RICE et al., 2019). Além disso, uma revisão sistemática com meta-análise mostrou que o exercício físico promove aumento da força, resistência e da atividade elétrica dos músculos do tronco (CLAEL et al., 2021), e outra meta-analise de rede mostrou que o exercício é eficaz no aumento da aptidão funcional de populações com DLCI (HAYDEN et al., 2021). Esses achados reforçam a eficácia do exercício físico no manejo da DLCI, atuando tanto na modulação da dor quanto no aumento da aptidão física dos pacientes.

Entre as diferentes modalidades de exercício físico, o treinamento funcional (TF) destaca-se por envolver a ativação simultânea de diversas capacidades físicas em uma única sessão, por meio de exercícios multiarticulares e multiplanares (LA SCALA TEIXEIRA et al., 2017). Diferente dos métodos tradicionais, que geralmente utilizam máquinas com movimentos isolados, o TF é mais dinâmico e orientado para atividades cotidianas, o que favorece uma maior transferência funcional para a vida diária (LA SCALA TEIXEIRA et al., 2017). Evidências apontam que o TF é eficaz na melhora da força muscular (DA SILVA-GRIGOLETTO et al., 2019) e da aptidão funcional (ARAGÃO-SANTOS et al., 2021) em mulheres idosas. Esses benefícios são particularmente relevantes para pessoas idosas com DLCI, já que esses pacientes frequentemente apresentam perda de força, mobilidade reduzida e dificuldades na realização de tarefas diárias (LEVEILLE, 2004). Além disso, em um estudo agudo, observou-se que uma sessão de TF foi capaz de elevar os níveis circulantes de β-endorfina em mulheres na pós-menopausa com DLCI, sugerindo um efeito analgésico imediato, ainda que de curta duração (SANTOS et al., 2022). Esses achados indicam que o TF pode representar uma alternativa promissora para promover ganhos funcionais e efeitos analgésicos de forma crônica em mulheres com DLCI.

Outra modalidade de exercício que vem ganhando destaque na literatura é o treinamento de dupla tarefa (TDT), definido como a realização simultânea de duas atividades distintas, geralmente envolvendo a combinação de demandas cognitivas e motoras (dupla tarefa cognitivo-motora) ou duas tarefas motoras diferentes (dupla tarefa motora-motora) (ABOU et al., 2022). Essa abordagem busca reproduzir situações comuns do cotidiano, nas quais a execução concomitante de múltiplas tarefas é frequente, como caminhar enquanto conversa ou preparar alimentos enquanto fala ao telefone. Diversos estudos têm investigado os efeitos do TDT, especialmente o cognitivo-motor, em populações com DLCI. Os resultados demonstram melhorias no controle postural (VAN DAELE et al., 2010), aumento da estabilidade do tronco (GE et al., 2021), redução da intensidade da dor e melhora da função física e da qualidade de vida na população idosa (MERCHANT et al., 2021). O TDT tem se destacado por sua capacidade de integrar simultaneamente estímulos motores e cognitivos, o que se alinha às demandas funcionais da vida diária (ABOU et al., 2022). Esse aspecto é especialmente relevante para idosos com DLCI, que frequentemente apresentam prejuízos no equilíbrio, controle postural e estabilidade do tronco, fatores que comprometem significativamente sua autonomia (LEVEILLE, 2004; RUDY et al., 2007). Ao simular tais desafios cotidianos, o TDT mostra-se uma abordagem promissora para promover ganhos físicos e cognitivos, além de auxiliar na modulação da dor e na melhora da qualidade de vida, aspectos essenciais para essa população (MERCHANT et al., 2021).

Diante disso, investigar especificamente essas duas modalidades se justifica pela forma como elas se alinham às demandas reais da população idosa com DLCI. Essas modalidades oferecem uma abordagem mais completa, que pode gerar benefícios motores, funcionais, cognitivos e analgésicos, sendo, portanto, estratégias promissoras para essa população.

2. OBJETIVOS E HIPÓTESE

2.1. Objetivo geral

Avaliar as alterações na dor lombar em função da prática de diferentes abordagens de treinamento físico.

2.2. Objetivos específicos

- Apresentar e discutir métodos práticos e de baixo custo para uma avaliação multidimensional da dor voltada para profissionais do movimento (Estudo 1).

- Compreender as possíveis vias pelos quais TF e TDT atuam direta ou indiretamente na redução da dor em pessoas com DLCI (Estudo 2).

- Comparar os efeitos de dezesseis semanas de TF e TDT sobre a dor e função do tronco de mulheres idosas com DLCI (Estudo 3).

- Comparar os efeitos do TF e TDT na função do tronco e aptidão funcional de mulheres idosas com DLCI (Estudo 4).

2.3. Hipótese

O TF promove maior eficácia na redução da dor, no aumento da estabilidade do tronco e na melhora da aptidão funcional de mulheres idosas com DLCI em comparação ao TDT, em virtude de sua capacidade de induzir adaptações biomecânicas, neuromusculares e neuroendócrinas integradas às demandas funcionais da vida diária. Especificamente, o TF proporciona estímulos multicomponentes que envolvem instabilidade, variação de bases de suporte e padrões motores complexos, promovendo o recrutamento eficiente dos músculos estabilizadores profundos da coluna e a melhoria do controle postural. Além disso, sua execução em formatos de circuitos e com maior intensidade promove aumento da liberação de β-endorfinas e maior ativação de vias descendentes inibitórias da dor, favorecendo uma redução da sensibilidade dolorosa. Embora o TDT também atue positivamente sobre aspectos de estabilidade do tronco e redução da dor por meio da automatização do controle postural e da ativação de regiões corticais envolvidas na modulação da dor, sua eficácia pode ser limitada pela menor especificidade dos estímulos motores e pela dependência da atividade cognitiva aplicada. Assim, o TF apresenta-se como uma intervenção mais abrangente para promover alterações nos componentes neuromusculares e neurofisiológicos da DLCI em mulheres idosas.

3. DESENVOLVIMENTO

A presente tese de doutorado foi escrita no modelo alternativo e para responder os objetivos propostos, foram realizados quatro estudos. O estudo 1 foi publicado na revista Brasileira de Fisiologia do Exercício. O estudo 2 será submetido como artigo de opinião na revista *Frontiers in Physiology.* O estudo 3 foi aceito no *Journal of Manipulative and Physiological Therapeutics*, como artigo original. E o estudo 4 foi publicado na *Gait & Posture*, também como artigo original.

3.1. ESTUDO 1: *Pain and movement: practical assessment methods for health and exercise professionals*

How to cite: Santos PJ, Barbosa LFV, Aragão-Santos JC, Pereira-Monteiro MR, Da Silva-Grigoletto ME. Pain and movement: practical assessment methods for health and exercise professionals. Rev Bras Fisiol Exerc. 2024;23(3):e235618. doi: 10.33233/rbfex.v23i3.5618

RBFEx
ISSN Online: 2675-1372

Revista Brasileira de Fisiologia do Exercício

Literature review

Pain and movement: practical assessment methods for health and exercise professionals

Dor e movimento: métodos práticos de avaliação para profissionais da saúde e do exercício

Poliana de Jesus Santos, Lara Fabian Vieira Barbosa, José Carlos Aragão-Santos, Marcos Raphael Pereira-Monteiro, Marzo Edir Da Silva-Grigoletto

Universidade Federal de Sergipe, São Cristovão, SE, Brazil

ABSTRACT

Pain is an unpleasant experience that affects almost the entire world population at some point in life. While acute pain serves as a protective mechanism, chronic pain nega-tively impacts individuals' physical fitness, social and psychological aspects, leading to high levels of absenteeism and reduced productivity, thus becoming a global health issue. There are several treatment options for chronic pain, with physical exercise being the most recom-mended. However, to obtain the benefits of physical exercise in pain reduction, it is neces-sary to understand the factors that may be related to or interfere with the pain phenomenon. Likewise, it is essential to recognize that each individual responds differently to this phenom-enon. In this context, a detailed pain assessment is required. Proper evaluation will allow movement professionals, such as physical education instructors, physiotherapists, and other health professionals, to act more efficiently in managing pain through physical exercise. Nevertheless, pain assessment can sometimes be complex or costly, limiting its use in professional practice. Therefore, the present study seeks to present and discuss practical, low-cost methods for multidimensional pain assessment and highlight important concepts in pain management. Hence, this article will serve as a starting point for movement profession--als in managing pain through practical and cost-effective methods.

Keywords: assessment, pain; quality of life; professional competence; physical exercise

RESUMO

A dor é uma experiência desagradável que aflige quase toda a população mundial em algum momento da vida. Apesar da dor aguda servir como mecanismo de proteção, a dor crônica afeta negativamente a aptidão física, os aspectos sociais e psicológicos dos indivíduos, resultando em altos níveis de absentismo no trabalho e diminuição da produtividade, tornando-se um problema de saúde mundial. Existem várias opções de tratamento para a dor crônica e o exercício físico é a opção mais recomendada. No entanto, para a obtenção dos benefícios do exercício físico na redução da dor é preciso compreender os fatores que podem estar relacionados e/ou interferindo no fenômeno da dor. De igual forma, é essencial entender que cada indivíduo responde de uma maneira diferente a esse fenômeno. Nesse contexto, é preciso realizar uma avaliação detalhada da dor. Uma avaliação adequada permitirá aos profissionais do movimento, tais como profissionais de educação física, fisioterapeutas e outros profissionais da saúde, atuarem de forma mais eficiente no manejo da dor por meio do exercício físico. Contudo, por vezes a avaliação da dor pode ser muito complexa ou de alto custo dificultando sua utilização na prática profissional. Portanto, o presente estudo busca apresentar e discutir métodos práticos e de baixo custo para a avaliação da dor de modo multidimensional, bem como destacar conceitos importantes no tratamento da dor. Desta forma, esse artigo será um ponto de partida para a atuação dos profissionais do movimento no manejo da dor por meio de métodos práticos e de baixo custo.

Palavras-chave: avaliação, dor; qualidade de vida; competência profissional; exercício físico

Received 2024 november 8th; accepted 2024 10th December

Correspondence: Poliana de Jesus Santos, polianadejsantos@gmail.com

Introduction

The International Association for the Study of Pain (IASP) defines pain as "an unpleasant sensory and emotional experience associated with, or resembling that associated with, actual or potential tissue damage" [1]. Pain can be temporally classified as either acute or chronic. Chronic pain is defined as pain persisting for more than three months beyond the typical healing time for an injury or associated with chronic pathological processes that result in continuous or recurrent pain. Studies indicate that the global prevalence of chronic pain is 53% [2], and in Brazil, this prevalence stands at 45.59%, with the lower back being the most affected area [3].

Chronic pain impacts not only physical fitness but also social and psychological aspects of an individual's life. Among people reporting chronic pain, high levels of work absenteeism and decreased productivity have been observed [4]. Given the high prevalence of chronic pain, it is reasonable to expect significant economic repercussions. Furthermore, individuals with chronic pain have been found to be twice as likely to report suicidal behaviors or to die by suicide [5], underscoring the impact of chronic pain on mental health. Despite these consequences, pain is often overlooked in the context of assessing an individual's health status. Nevertheless, certain interventions can provide a better experience for those suffering from pain-related distress, facilitating decision-making and leading to improved outcomes [6].

However, some movement professionals still seem to underestimate the impact of pain when interacting with clients and patients. This may be due to factors such as a lack of knowledge about pain assessment methods [7] and the normalization of pain during physical exercise. This tendency to normalize pain, along with the lack of professional conduct adjustments in response to this condition, results in decreased engagement with these professionals among individuals suffering from chronic pain [8]. Consequently, this leads to a lack of awareness of the beneficial effects of physical exercise on pain management among some of these professionals. Interestingly, the same professionals who sometimes normalize pain are also responsible for one of the most scientifically supported non-pharmacological interventions for pain reduction: physical exercise [9-11].

For movement professionals to effectively promote health and reduce pain through exercise, it is essential to conduct a holistic assessment of the condition of the client or patient, including pain assessment to guide professional conduct and provide indicators for medium- and long-term follow-up [12]. Immediately, pain assessment can help to identify movement patterns that the client or patient may alter or even avoid due to pain. Additionally, baseline assessment values enable the professional to monitor whether pain increases or decreases in response to the adopted approach. In cases where pain worsens, a "fear-avoidance" cycle often occurs, leading to the cessation of exercise due to past painful experiences, which may foster limiting beliefs [13].

Despite the challenges discussed, exercise remains the primary approach for treating chronic pain [14] and is also the main tool used by movement professionals. Mechanisms such as exercise-induced hypoalgesia reduce pain intensity and enhance the quality of life for individuals with chronic pain [15]. However, studies show that participants in various exercise modalities — such as Pilates, weight training, martial arts, CrossFit, body jump, and others — who are guided by movement professionals exhibit high rates of pain incidence, regardless of regular exercise practice [16-19]. This may stem from underlying biomechanical or social factors that are inadequately assessed. Thus, it becomes necessary for these professionals to incorporate pain assessment in their approach. This ensures that regular physical exercise promotes pain reduction and encourages individuals to see exercise as an effective approach to pain management, alongside its numerous health benefits.

Considering the impact of chronic pain, the potential of physical exercise in its treatment, and the limited use of pain assessment methods among movement professionals, this study aims to present and discuss practical, low-cost methods for multidimensional pain assessment tailored to movement professionals. Additionally, it highlights pain-related concepts and mechanisms, consolidating existing literature into an accessible, reader-friendly narrative review

Pain mechanisms

Pain is a response to noxious stimuli that threaten tissues or the organism's survival, alerting the body to protect the tissue from damage. These noxious stimuli typically stem from extreme pressure and/or temperatures, potentially resulting in tissue damage. Pain pathways form a complex and dynamic system encompassing sensory, cognitive, and behavioral aspects [20].

The noxious stimulus is initially detected by peripheral neurons called nociceptors, which transmit the nociceptive stimulus to the central nervous system (CNS) [21]. Pain-related nerve fibers are classified into two types: Aδ and C fibers. Aδ fibers are larger in diameter and myelinated, resulting in faster conduction speeds and typically associated with acute or sharp pain. Conversely, C fibers have slower conduction speeds, smaller diameters, and are unmyelinated associating them more with prolonged nociceptive stimuli, as in cases of chronic pain [21, 22].

Among the ascending pain pathways, the spinothalamic pathway stands out for its role in the sensory-discriminative aspects of the pain experience, including the identification of location, intensity, and type of pain stimulus. Meanwhile, the spinoreticular pathway, connected to the amygdala, is associated with more diffuse pain and the affective properties of pain [23]. These pathways are vertically located along the ventrolateral portion of the spinal cord and transmit pain, temperature, and deep pressure stimuli to the thalamus [24]. Once reaching the thalamus, the nociceptive stimulus is directed to other brain areas, such as the cortex, for processing, which results in pain perception [25].

After processing a painful stimulus, the brain can modulate pain through descending mechanisms, producing an analgesic effect during the pain process. In the gray matter region of the brain, a pain inhibition system is activated via its connection with the ventromedial nucleus of the spinal cord, a process mediated by opioids. This structure is involved in both pain inhibition and facilitation [26]. Literature suggests that an imbalance between the ascending and descending pain pathways may lead to a pathological and continuous pain process, initiating chronic pain [27].

Another mechanism related to the pain experience is temporal summation (TS), which mainly affects C fibers. TS increases the activity of second-order neuron receptors, resulting in increased pain, particularly present in cases of chronic pain [28]. TS is thought to be part of a phenomenon known as central sensitization (CS), leading to hyperalgesia (increased pain intensity in response to a noxious stimulus) and allodynia (pain in response to a non-painful stimulus), which exacerbate pain perception [29].

Pain not only induces changes in neurons communicating with the thalamus but also in neurons projecting from the amygdala to the medial prefrontal cortex, related to cognitive and emotional processes [30]. Thus, the pain experience impacts not only the sensory-discriminative dimension but also the affective-motivational dimension. Within this context, chronic pain patients often exhibit pain catastrophizing, reduced self-efficacy, and depression. Pain catastrophizing is defined as an exaggerated negative orientation towards current or anticipated painful experiences, encompassing feelings of helplessness related to pain, and is a risk factor for the development of chronic pain [31].

Furthermore, a factor that can either positively or negatively influence the pain experience is self-efficacy — the belief that one can successfully perform a task or achieve a favorable outcome. Self-efficacy is one of the main determinants of how a person with chronic pain will manage their pain, potentially affecting their adherence to different forms of treatment depending on its level [31]. Additionally, it is worth noting that participant experience plays a crucial role in adherence to regular exercise; thus, enjoyment is linked to greater participation and the effectiveness of physical exercise, while unpleasant experiences negatively impact exercise adherence and participation [32].

Moreover, studies indicate that 40-50% of individuals with chronic pain also suffer from depression [33], as chronic pain can be a stress factor that induces depression or exacerbates the processes involved in the progression of the disease. Individuals who develop both conditions simultaneously often face a poor prognosis [33].

Pain assessment

Conducting a detailed pain assessment is essential for guiding professional conduct during pain treatment and for prescribing physical exercise effectively, aiming to prevent the onset of pain during intervention. To achieve this, it is crucial to select appropriate tools for assessing pain based on the specific situation, as well as the specificity and information each instrument provides [33]. Quantitative sensory testing (QST) can be employed, which assigns numerical values to the observed phenomenon — in this case, pain — using simple tools such as an algometer, a sphygmomanometer, and a stopwatch. Among the tests highlighted in the literature are pressure pain threshold (PPT), temporal summation (TS), conditioned pain modulation (CPM), and tactile detection threshold (TDT). Together, these tests form a method for assessing CS, which is commonly present in chronic pain patients [34].

Additionally, pain can be assessed using scales such as the Numerical Pain Rating Scale (NPRS), the Visual Analog Scale (VAS), and the Pain Catastrophizing Scale (PCS), which are practical and quick to administer. Questionnaires like the McGill Pain Questionnaire (MPQ), the Brief Pain Inventory - Short Form (BPI-SF), and the Pain Self-Efficacy Questionnaire (PSEQ-10) can also be used to gather more detailed insights about the pain experience.

The PPT assesses the minimum pressure applied to a body area necessary to elicit a painful or uncomfortable sensation. This test evaluates the nociceptive threshold of free nerve endings in the sensory neurons located in the dorsal horn of the spinal cord [35]. Studies indicate that individuals with chronic pain generally have a lower pain threshold compared to healthy individuals, which can be considered a factor related to CS [36] (Figure 1A). The PPT can be evaluated near the affected area or in a distant region from the pain focus. For assessing PPT in the lumbar region, a digital pressure algometer with a 1 cm^2 area is used, bilaterally 5 cm laterally from the spinous processes of the third (L3) and fifth (L5) lumbar vertebrae [37].

Another measure of quantitative sensory testing is the TS which assesses the excitability of type C fibers in the dorsal horn of the spinal cord when painful stimulation is applied [38]. The main characteristic of TS is the increase in pain perception with repeated painful stimulation [39]. For this test, a persistent painful stimulus is applied using a pressure algometer at a constant pressure of 4 kg/cm^2 on an area of the body, usually the forearm or thenar region, for 30 seconds. During this period, pain intensity is assessed at four different time points (1st, 10th, 20th, and 30th seconds) using a numerical pain scale (0-10). Significant discrepancies in values are an indicator that pain is summing in this individual rather than habituating to the stimulus, a feature often present in populations with chronic pain due to CS [40] (Figure 1B).

CPM is described as the phenomenon where "one pain inhibits another pain". The CPM assesses the nervous system's ability to reduce pain sensation when another painful stimulus is applied at a distant site. When the pain control system functions correctly, the second painful stimulus, known as the conditioning stimulus, reduces the pain of the first painful stimulus [41]. It is worth noting that CPM and TS are complementary, as they assess, respectively, the descending and ascending pain pathways.

To assess CPM, the PPT is first evaluated in a specific area, possibly the same area where TS was assessed. A second painful stimulus (conditioning) is applied at another location, which may involve pressure (e.g., using a sphygmomanometer) or a thermal stimulus (e.g., cold water), until the stimulus is perceived with an intensity greater than 4 on the NPRS. During the application of the conditioning stimulus, the PPT is reassessed at the same site evaluated earlier. Five minutes after the removal of the conditioning stimulus, the PPT is reassessed [34]. An increase in PPT during the second and third measurements indicates pain modulation reduction, suggesting that descending pain pathways are activated and capable of decreasing pain intensity (Figure 1C). For further guidance on performing these tests, access the video.

Click or scan to watch

Figure 1 - 1A: Assessment of PPT, performed bilaterally 5 cm from the spinous processes of L3 and L5. 1B: Assessment of TS of pain in the dominant arm of the volunteer, 7.5 cm above the wrist line. 1C: Evaluation of CPM, using ischemic compression as the conditioned stimulus via a sphygmomanometer. The PPT was assessed at the same location as the temporal summation, 7.5 cm above the wrist line

The TDT is used to identify signs of hyperalgesia and allodynia, conditions commonly found in individuals with CS [42]. To perform this test, a set of six monofilaments, all made of nylon and each with a different diameter and weight, is used. The filaments progressively increase in pressure applied to the skin. If a filament that does not normally induce pain elicits a painful response in the individual, it is likely that the person has allodynia. Furthermore, if one of the filaments used as a mild painful stimulus induces a pain intensity greater than what is expected, this may be a sign of hyperalgesia [43].

It is important to note that the performance of quantitative sensory tests is done using devices such as a pressure algometer, Semmes-Weinstein monofilaments, and a sphygmomanometer. These devices are widely available for purchase by professionals, and they are generally more affordable compared to other research equipment. An example of a device that requires greater financial investment is the computerized pressure algometry. The choice of equipment depends on the professional's available budget and desired investment, as both digital and computerized algometers provide reliable evaluation results.

In addition to quantitative sensory testing, pain can be assessed using the NPRS and the VAS, both of which evaluate an individual's subjective pain perception [44]. For the NPRS, a ruler divided into eleven equal parts (ranging from zero to ten) is used, where the patient matches their pain intensity to a corresponding number, with zero representing no pain and ten representing the maximum pain [45]. The VAS is similar but does not involve specific numbers; instead, the patient is asked to mark a point on a 10 cm line, where 0 represents no pain and 10 represents the worst possible pain. A ruler is then used to measure the exact point marked by the patient [46]. Both scales are easy to understand and require minimal resources for use. These tools allow for an understanding of pain intensity in an individual and can be used to assess pain tolerance during exercise, as well as monitor progress over time for those being evaluated [46].

Pain scales and their variations have been validated in Brazil for use in various populations [46]. For example, the VAS gave rise to the Faces Pain Scale, which is used to improve understanding for specific populations, such as children, adolescents, older people, people with hearing impairments, and aphasic individuals. When used with children, the scale includes drawings of characters from well-known programs [47]. For older people, adaptations are also made using concepts that are easier to understand in cases of cognitive impairment related to aging [48]. Figure 2 shows the variations of pain scales.

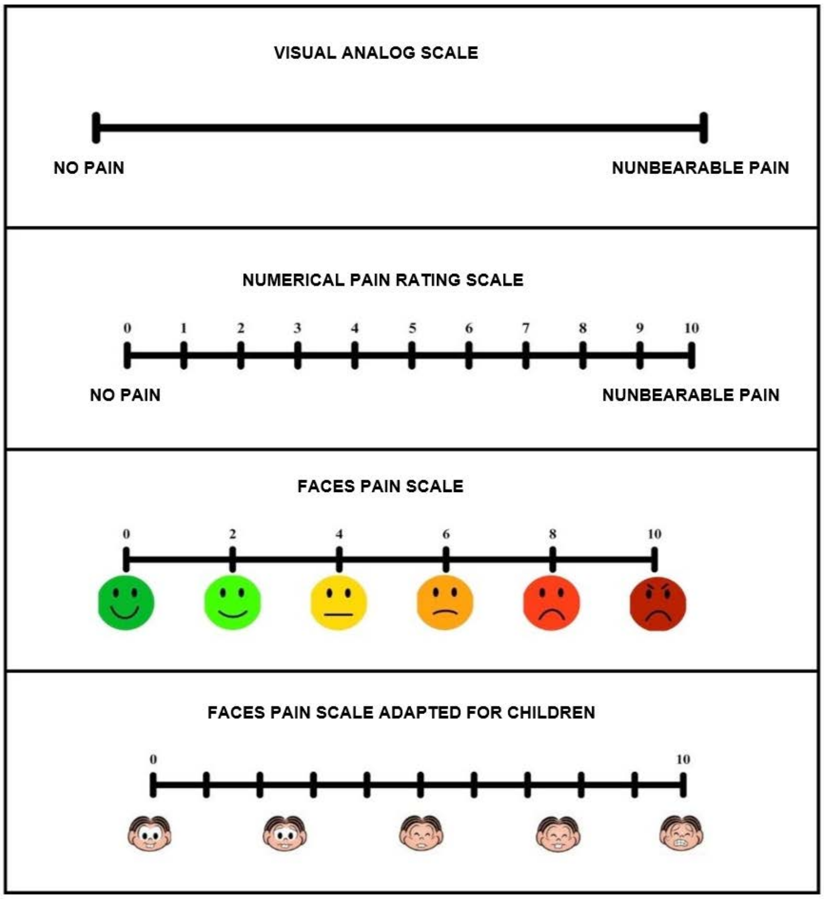

Figure 2 - Pain Scales

Another way to assess individuals suffering from pain is through questionnaires, which can be directly related to pain or psychosocial problems associated with the chronicity of pain. A well-known questionnaire for pain assessment is the MPQ, which focuses on the context and characterization of pain, addressing sensory and affective aspects. This questionnaire has a broad range of application and can be used for both chronic and acute pain in various conditions where pain is a symptom [49]. The MPQ is subdivided into four subscales that assess the sensory, affective/evaluative, and miscellaneous aspects of pain. Responses are given on a scale from: (0) none, (1) mild, (2) discomforting, (3) distressing, (4) horrible, and (5) excruciating [50].

Similar to the MPQ, the pain severity subscale of the BPI-SF directly assesses the interference and intensity of pain and can also be used in various situations. It consists of four 11-point numeric pain scales: two assess the worst and least pain experienced in the last 24 hours, and the other two assess the average and current pain at the time of the evaluation [51].

Another questionnaire that can be used is the Central Sensitization Inventory (CSI), which indicates the presence of symptoms associated with CS through a self-perception scale. In this context, other factors related to CS, such as catastrophizing and self-efficacy, can also be assessed through the Pain Catastrophizing Scale (PCS) and the PSEQ-10, respectively. It is important to note that these latter measures enable a psychosocial evaluation of this population [52].

Furthermore, when discussing pain, another important factor that is highly affected in this population is quality of life. Quality of life can be assessed using the European Quality of Life-5 Dimensions (EQ-5D) questionnaire, which evaluates the quality of life across five dimensions: mobility, self-care, usual activities, anxiety/depression, and pain/discomfort. The last dimension specifically evaluates the impact of pain on quality of life. EQ-5D results can be classified according to the severity level [53]. Additionally, there are specific questionnaires for evaluating the quality of life in individuals with chronic pain, such as the Short Form Health Survey 36 (SF-36), which assesses the multidimensional aspects of pain's impact on this population [53].

Thus, we believe that the use of these tests, scales, and questionnaires provides a comprehensive view of the health status of the individual being assessed, helping to guide the treatment plan and track the progress of the patient/client beyond commonly known aspects such as strength, hypertrophy, and range of motion. The evolution of pain and how it affects other socioemotional domains is an important aspect to monitor, as it significantly contributes to the well-being and quality of life of individuals. Table I summarizes the main instruments used for pain assessment by movement professionals.

Rev Bras Fisiol Exerc 2024;23(3);e235618

Table I - Pain Assessment instruments

Assessment methods		Brief summary of what it assesses	Required materials	Average time needed	Advantages	Disadvantages
Physical test	PPT	Nociceptive threshold of free nerve endings	Algometer	Less than 1 minute	Quick and easy to perform	Requires a pressure algometer
	TS	Excitability level of C-fibers	Algometer stopwatch	Less than 1 minute	Quick and easy to perform	Requires a pressure algometer and stopwatch
	CPM	Nercous system's ability to reduce pain sensation when another painful stimulus is aplied at a distant area	Algometer, sphygmomanometer, or ice bucket and stopwatch	Around 8 minutes	Quick and easy to perform	Requires a pressure algometer, sphygmomanometer, and stopwatch
	TDT	Presence of signs of hyperalgesia or allodynia	Semmes-Weinstein monofilaments	Around 8 minutes	Quick and easy to perform	Requires Semmes-Weinstein monofilaments
Scales	NPRS	Subjective pain perception	Paper, ruler, pen	Less than 1 minute	Very quick to perform and does not require expensive equipment	Subjective assessment
	VAS	Subjective pain perception	Paper, ruler, pen	Less than 1 minute	Very quick to perform and does not require expensive equipment	Subjective assessment
	PCS	Pain catastrophizing	Printed questionnaire and pen	Around 10 minutes	Easy and quick to perform	Understanding how to interpret the questionnaire results
Questionnaires	MQP	Characterization of pain addressing sensory and affective aspects	Printed questionnaire and pen	Around 15 minutes	Identifies more aspects related to pain	Depending on educational level, the respondent may have difficulty understanding the questions
	BPI- SF	Pain interference and intensity	Printed questionnaire and pen	Around 5 minutes	Easy and quick to perform	Subjective assessment
	PSEQ-10	Self-efficacy	Printed questionnaire and pen	Around 10 minutes	Easy and quick to perform	Depending on educational level, the respondent may have difficulty understanding the questions

PPT = pressure pain threshold; TS = temporal summation; CPM = conditioned pain modulation; TDT = tactile detection threshold; NPRS = Numerical Pain Rating Scale; VAS = visual analog scale; PCS = pain catastrophizing scale; MPQ = McGill pain questionnaire; BPI-SF = brief pain inventory – short form. PSEQ-10 = pain self-efficacy questionnaire

Final considerations

Pain assessment by movement professionals is highly valuable in clinical and practical contexts, including gyms, studios, and clinics, as individuals in these settings are often afflicted by pain, whether chronic or acute. Understanding the importance of pain assessment, the tools available, and their proper application enables professionals to conduct thorough evaluations and prevent pain from hindering clients' performance when pain is not the treatment focus. This can help shift the perspective, viewing exercise not as something that causes pain, but as something that reduces it.

Conflict of interest
No potential conflict of interest relevant to this article was reported

Funding
This work was partially supported by the Coordination for the Improvement of Higher Education Personnel, Brazil-CAPES. The funding source had no involvement in the conduct of the study or in the preparation of the article for publication

Author contributions
Conception and design of the research: Da Silva-Grigoletto ME, Santos PJ; Acquisition of data: Barbosa LFV; Writing of the manuscript: Barbosa LFV, Santos PJ, Aragão-Santos JC, Pereira-Monteiro MR; Critical revision of the manuscript for important intellectual content: Da Silva-Grigoletto ME

Glossary

Hypoalgesia - Reduction in sensitivity to pain.
Hyperalgesia - Increased sensitivity to pain.
Noxious stimuli - Stimuli that have the potential to cause tissue damage or evoke the sensation of pain.
Nociceptors - Sensory receptors located in the skin that are specialized in detecting noxious stimuli and transmitting pain signals to the central nervous system.
Myelinated - Refers to nerve fibers that are surrounded by a myelin sheath, which increases the speed of nerve signal transmission.
Unmyelinated - Nerve fibers that lack a myelin sheath, resulting in slower transmission of nerve signals.
Temporal summation - A process in which repetitive and continuous stimuli gradually increase the perception of pain, even if the stimulus itself does not intensify.
Central sensitization - Increased responsiveness of neurons in the central nervous system following repetitive or intense stimulation, leading to an exaggerated perception of pain.
Allodynia - Pain caused by stimuli that do not normally provoke pain, such as light touch on the skin.
Sensory-discriminative dimension- The aspect of pain experience that allows for identification of the location, intensity, and type of the painful stimulus.
Affective-motivational dimension- The aspect of pain experience related to the emotional and motivational responses it triggers, such as distress or the desire to avoid pain.

References

1. DeSantana JM, Perissinotti DM, Oliveira Junior JO, Correia LM, Oliveira CM e Fonseca PR. Definition of pain revised after four decades. BrJP. 2020;3(3):197-8. doi: 10.5935/2595-0118.20200191

2. Latina R, Sansoni J, D'Angelo D, Di Biagio E, De Marinis MG e Tarsitani, G. Etiology and prevalence of chronic pain in adults: a narrative review. Professioni Infermieristiche. 2013;66(3):151–58. doi: 10.7429/pi.2013.663151

3. Aguiar DP, Souza CPQ, Barbosa WJM, Santos Júnior FFU, Oliveira AS. Prevalence of chronic pain in Brazil: systematic review. BrJP. 2021;4(3):257-67. doi: 10.5935/2595-0118.20210041

4. Patel AS, Farquharson R, Carroll D, Moore A, Phillips CJ, Taylor RS, *et al*. The impact and burden of chronic pain in the workplace: a qualitative systematic review. Pain Practice, 2012;12(7):578–89. doi: 10.1111/j.1533-2500.2012.00547.x

5. Racine M. Chronic pain and suicide risk: a comprehensive review. Prog Neuropsychopharmacol Biol Psychiatry. 2018;87;269–80. doi: 10.1016/j.pnpbp.2017.08.020

6. Liang Z, Tian S, Wang C, Zhang M, Guo H, Yu Y, *et al*. The best exercise modality and dose for reducing pain in adults with low back pain: a systematic review with model based Bayesian Network Meta-analysis. J Orthop Sports Phys Ther. 2024;54(5):315-27. doi: 10.2519/jospt.2024.12153

7. Alves RC, Tavares JP, Funes RAC, Gasparetto GAR, Silva KCC, Ueda TK. Análise do conhecimento sobre dor pelos acadêmicos do curso de fisioterapia em centro universitário. Revista Dor. 2013;14(4):272–79. doi: 10.1590/S1806-00132013000400008

8. Silva AC e Ferreira J. Corpos no 'limite' e risco à saúde na musculação: etnografia sobre dores agudas e crônicas". Interface - Comunicação, Saúde, Educação. 2017;21(60):141–51. doi: 10.1590/1807-57622015.0522

9. Meeus M, Hermans L, Ickmans K, *et al*. Endogenous pain modulation in response to exercise in patients with rheumatoid arthritis, patients with chronic fatigue syndrome and comorbid fibromyalgia, and healthy controls: a double-blind randomized controlled trial. Pain Pract. 2015;15(2):98-106. doi: 10.1111/papr.12181

10. Naugle KM, Fillingim RB, Riley JL. A meta-analytic review of the hypoalgesic effects of exercise. J Pain. 2012;13(12):1139-1150. doi: 10.1016/j.jpain.2012.09.006

11. Oliveira MAS, Fernandes RSC, Daher SS. Impact of exercise on chronic pain. Rev Bras Med Sport. 2014;20(3):200-203. doi: 10.1590/1517-86922014200301415

12. Bottega FH e Fontana RT. A dor como quinto sinal vital: utilização da escala de avaliação por enfermeiros de um hospital geral. Texto & Contexto Enfermagem. 2010;19(2):283–90. https://www.redalyc.org/articulo.oa?id=71416097009

13. Borges PA, Koerich MHAL, Wengerkievicz KC, Knabben RJ. Barreiras e facilitadores para adesão à prática de exercícios por pessoas com dor crônica na Atenção Primária à Saúde: estudo qualitativo. Physis: Revista de Saúde Coletiva. 2023;33:e33019. doi: 10.1590/s0103-7331202333019

14. Medeiros JD e Pinto APS. Impacto social e econômico na qualidade de vida dos indivíduos com lombalgia: revisão sistemática. Caderno de Graduação - Ciências Biológicas e da Saúde. 2014;2(1):73–78. https://periodicos.set.edu.br/fitsbiosaude/article/view/1037

15. Borisovskaya A, Chmelik E e Karnik A. Exercise and chronic pain. Advances in Experimental Medicine and Biology. 2020;1228:233–53. doi: 10.1007/978-981-15-1792-1_16

16. Polaski AM, Phelps AL, Kostek MC, Szucs KA, Kolber BJ. Exercise-induced hypoalgesia: a meta-analysis of exercise dosing for the treatment of chronic pain. Plos One. 2019;14(1):e0210418. doi: 10.1371/journal.pone.0210418

17. Souza RFC e Pereira Júnior AA. Prevalência de dor lombar em praticantes de musculação. Revista da UNIFEBE. 2010;1(8):190–98. https://periodicos.unifebe.edu.br/index.php/RevistaUnifebe/article/view/549

18. Cardoso M. e Rosas RF. Presença de dor em praticantes de exercício físico em academia nas diferentes modalidades. Repositorio Unesc.net. 2012. http://repositorio.unesc.net/handle/1/956

19. Freire VHJ, Almeida BR, Barros RC, Soares ACN, Ribas IGC, Sá FAF. Caracterização da dor em praticantes profissionais e amadores de jiu-jitsu. Revista Eletrônica Acervo Saúde. 2023;23(10):e13888. doi: 10.25248/reas.e13888.2023

20. Buzetti LC, Silva VF, Ferreira GLA, Lima JÁ, Batista SO, Moretti VB *et al*. Prevalência e local de dor em praticantes de crossfit em uma cidade do sul de minas gerais. Rev Bras Med Esporte. 2023;29:e2021_0328. doi: 10.1590/1517-8692202329022021_0328p

21. Boron, W. F. Fisiologia médica. 2 ed. Rio de Janeiro: 2015.

22. Aires MM. Fisiologia. 4 ed. Rio de Janeiro: 2012.

23. Basbaum AI, Bautista DM, Scherrer G, Julius D. Cellular and molecular mechanisms of pain. Cell. 2009;139:267–84. doi: 10.1016/j.cell.2009.09.028

24. Lee GI, Neumeister MW. Pain. Clin Plast Surg. 2020;47:173–80. doi: 10.1016/j.cps.2019.11.001

25. Martin E. Pathophysiology of pain. Pain Management in Older Adults, Cham: Springer International Publishing; 2018: p.7–29. doi: 10.1007/978-3-319-71694-7_2

26. Ossipov MH, Morimura K, Porreca F. Descending pain modulation and chronification of pain. Curr Opin Support Palliat Care. 2014;8:143–51. doi: 10.1097/SPC.0000000000000055

27. Nir R-R, Yarnitsky D. Conditioned pain modulation. Current Opinion in Supportive & Palliative Care 2015;9:131–7. doi: 10.1097/SPC.0000000000000126

28. Meeus M, Nijs J. Central sensitization: a biopsychosocial explanation for chronic widespread pain in patients with fibromyalgia and chronic fatigue syndrome. Clin Rheumatol. 2007;26:465–73. doi: 10.1007/s10067-006-0433-9

29. Lumley MA, Cohen JL, Borszcz GS, Cano A, Radcliffe AM, Porter LS, *et al*. Pain and Emotion: A Biopsychosocial Review of Recent Research. J Clin Psychol. 2011;67:942–68. doi: 10.1002/jclp.20816

30. Edwards RR, Dworkin RH, Sullivan MD, Turk D, Wasan AD. The role of psychosocial processes in the development and maintenance of chronic pain disorders. J Pain. 2016;17:T70–92. doi: 10.1016/j.jpain.2016.01.001

31. Sheng J, Liu S, Wang Y, Cui R, Zhang X. The Link between depression and chronic pain: neural mechanisms in the brain. Neural Plast. 2017;2017:1–10. doi: 10.1155/2017/9724371

32. Collado-Mateo D, Lavín-Perez AM, Penacoba C, Del Coso J, Leyton-Román M, Luque-Casado A, *et al*. Key Factors associated with adherence to physical exercise in patients with chronic diseases and older adults: an umbrella review. Int J Environ Res Public Health. 2021;18(4);2023. doi: 10.3390/ijerph18042023

33. Dansie EJ, Turk DC. Assessment of patients with chronic pain. Br J Anaesth 2013;111:19–25. doi: 10.1093/bja/aet124

34. Leite PMS, Mendonça ARC, Maciel LYS, Poderoso-Neto ML, Araujo CCA, Góis HCJ, *et al*. Does electroacupuncture treatment reduce pain and change quantitative sensory testing responses in patients with chronic nonspecific low back pain? a randomized controlled clinical trial. Evid Based Complement Alternat Med. 2018;2018:e8586746. doi: 10.1155/2018/8586746

35. Stein C. Opioid receptors. Annu Rev Med. 2016;67:433-51. https://doi:10.1146/annurev--med-062613-093100

36. Amiri M. Alavinia M, Singh M e Kumbhare D. Pressure pain threshold in patients with chronic pain: a systematic review and meta-analysis. Am J Phys Med Rehabil. 202:100(7):656. doi: 10.1097/PHM.0000000000001603

37. Corrêa JB, Costa LO, Oliveira NT, Sluka KA e Liebano RE. Central sensitization and changes in conditioned pain modulation in people with chronic nonspecific low back pain: A case-control study. Exp Brain Res. 2015;233(8):2391–99. doi: 10.1007/s00221-015-4309-6

38. Staud R, Crass JG, Robinson ME, Peristen WM, Price DD. Atividade cerebral relacionada à soma temporal da dor evocada pela fibra C. Dor. 2007;129:130–42. doi: 10.1016/j.pain.2006.10.010

39. Koltyn KF, Knauf MT e Brellenthin AG. Temporal summation of heat pain modulated by isometric exercise. Eur J Pain. 2013;17(7): 1005–1011. doi: 10.1002/j.1532-2149.2012.00264.x

40. Woolf CJ. Central sensitization: implications for the diagnosis and treatment of pain. Pain 2011;152:S2–15. doi: 10.1016/j.pain.2010.09.030

41. Kennedy DL, Kemp HI, Wu C, Ridout DA e Rice ASC.Determining real change in conditioned pain modulation: A repeated measures study in healthy volunteers. J Pain. 2020;21(5-6):708–721. doi: 10.1016/j.jpain.2019.09.010

42. Ji R-R, Nackley A, Huh Y, Terrando N, Maixner W. Neuroinflammation and central sensitization in chronic and widespread pain. Anesthesiology. 2018;129:343–66. doi: 10.1097/ALN.0000000000002130

43. Sydney PBH, Conti PCR. Diretrizes para avaliação somatossensorial em pacientes portadores de disfunção temporomandibular e dor orofacial. Rev Dor. 2011;12:349–53. doi: 10.1590/S1806-00132011000400012

44. Pimenta CAM. Escalas de avaliação de dor. In: Teixeira MD (ed.) Dor conceitos gerais. São Paulo: Limay. 1994;46-56. https://repositorio.usp.br/item/000882788

45. Chiarotto A, Maxwell LJ, Ostelo RW, Boers M, Tugwell P, Terwee CB. Measurement properties of visual analogue scale, numeric rating scale, and pain severity subscale of the brief pain inventory in patients with low back pain: a systematic review. J Pain. 2019;20:245–63. doi: 10.1016/j.jpain.2018.07.009

46. Shafshak TS, Elnemr R. The visual analogue scale versus numerical rating scale in measuring pain severity and predicting disability in low back pain. J Clin Rheumatol. 2021;27:282–5. doi: 10.1097/RHU.0000000000001320

47. Tsze DS, von Baeyer CL, Bulloch B, Dayan PS. Validation of self-report pain scales in children. Pediatrics. 2013;132:e971–9. doi: 10.1542/peds.2013-1509

48. Pereira LV, Pereira GDA, Moura LAD, Fernandes RR. Pain intensity among institutionalized elderly: a comparison between numerical scales and verbal descriptors. Rev Esc Enferm USP. 2015;49:804–10. doi: 10.1590/S0080-623420150000500014

49. Hawker GA, Mian S, Kendzerska T, French M. Measures of adult pain: Visual Analog Scale for Pain (VAS Pain), Numeric Rating Scale for Pain (NRS Pain), McGill Pain Questionnaire (MPQ), Short-Form McGill Pain Questionnaire (SF-MPQ), Chronic Pain Grade Scale (CPGS), Short Form-36 Bodily Pain Scale (SF-36 BPS), and Measure of Intermittent and Constant Osteoarthritis Pain (ICOAP). Arthritis Care Res (Hoboken). 2011;63Suppl 11:240-252. doi: 10.1002/acr.20543

50. Escalante A, Lichtenstein MJ, White K, Rios N, Hazuda HP. A method for scoring the pain map of the McGill pain questionnaire for use in epidemiologic studies. Aging Clin Exp Res. 1995;7(5):358–66. doi: 10.1007/BF03324346

51. Chiarotto A, Maxwell LJ, Ostelo RW, Boers M, Tugwell P, Terwee CB. Measurement properties of visual analogue scale, numeric rating scale, and pain severity subscale of the brief pain inventory in patients with low back pain: a systematic review. J Pain. 2019;20:245–63. doi: 10.1016/j.jpain.2018.07.009.

52. Bonafé FSS, Marôco J, Campos JADB. Questionário de autoeficácia relacionado à dor e seu uso em amostra com diferentes durações de ocorrência de dor. BrJP. 2018;1(1):33–9. doi: 10.5935/2595-0118.20180008

53. Robinson CL, Phung A, Dominguez M, Remotti E, Ricciardelli R, Momah DU, *et al*. Pain scales: what are they and what do they mean. Curr Pain Headache Rep. 2024;28(1):11–25. doi: 10.1007/s11916-023-01195-2

3.2. ESTUDO 2: *Functional training and dual-task as a treatment option for chronic low back pain*

FUNCTIONAL TRAINING AND DUAL TASK AS A TREATMENT OPTION FOR CHRONIC LOW BACK PAIN

Abstract: Low back pain is the leading cause of disability worldwide, affecting individuals from young to old. Currently, physical exercise is the most recommended option for the treatment of patients with chronic low back pain (CLBP) as it promotes a reduction in pain intensity and an increase in physical function in this population. In this way, functional training (FT), defined as a set of exercises performed to improve performance in daily and/or sports activities, emerges as a safe and effective option by promoting an increase in the release of endogenous substances related to analgesia, through its direct effects on improving trunk stability and increasing functional capacity. Another modality that seems to be effective in improving these variables is dual-task training (DTT), which involves performing two activities simultaneously (motor and cognitive), reducing the activation of pain-related circuits while increasing activation in other brain areas related to attention and cognition, resulting in improved pain intensity. Despite the benefits presented by the mentioned training modalities, the pathways through which FT and DTT can promote pain reduction and increased functional capacity in the CLBP population are not clear. Therefore, the objective of this manuscript is to discuss the possible pathways through which FT and DTT can promote pain reduction, increased trunk stability, and functional capacity in people with CLBP.

Keywords: Chronic pain, Exercise, Analgesia, Functional capacity.

INTRODUCTION

Low back pain is the most common and disabling musculoskeletal problem in the world (1), with estimates suggesting that 80% of the global population will experience low back pain at least once in their lifetime, and about 40% will develop chronic low back pain (CLBP). The origin of low back pain is multifactorial and complex, potentially associated with micro-injuries that promote joint degeneration in the spine and damage to associated structures such as ligaments, muscles, fascia, and intervertebral discs. When these injuries are unresolved, the pain can progress to a chronic state, resulting in greater degeneration and damage, which, in turn, promote changes in the nervous system and cause central and peripheral sensitization (2), leading to increased pain sensitivity in these patients (3). Additionally, studies show that this population exhibits decreased stability and strength of the trunk muscles(4,5) and reduced physical function (6)

Various treatment options are proposed for CLBP (7). Physical exercise is currently recommended as the first treatment option (8) due to its ability to activate the opioid, serotonergic, immune, endocannabinoid systems, the autonomic nervous system, and conditioned pain modulation, all involved in the analgesia process (9). Moreover, physical exercise has also been proven effective in promoting increased physical function (10) in patients with CLBP. However, there is no consensus on the most effective modality; nonetheless, multicomponent modalities and those exploring dual-task situations are promising options (11,12).

Functional training (FT) is a set of exercises aimed at improving performance in daily activities through the execution of multiplanar and multi-joint exercises (13). This modality has proven to be safe and effective for people with CLBP by promoting increased strength and endurance of trunk muscles, as well as functional capacity (14,15).

Another modality is dual-task training (DTT), which consists of performing two tasks simultaneously, either motor and cognitive or motor and motor. This modality has shown to reduce the activation of pain-related circuits while increasing activation in other brain areas related to attention and cognition (16), resulting in reduced pain intensity (12).

Despite the beneficial effects of these training modalities, the pathways through which they exert their effects in this population are not clear. Therefore, this review investigates the possibles pathways through which FT and DTT act directly or indirectly in reducing pain, increasing trunk stability, and enhancing functional capacity in people with CLBP. Since pain is a major cause of disability in this population and affects various aspects of social and work life, understanding the pathways through which physical exercise can impact this outcome is essential for more efficient prescription.

DEVELOPMENT

Chronic Low Back Pain

CLBP can originate from degenerative, non-degenerative, or indeterminate causes. The first is related to changes in intervertebral discs, joints, and/or ligaments. The second arises from trauma, tumors, infections, and/or spondylolysis. Finally, when the pain is not associated with any abnormality detected by imaging exams, it is defined as indeterminate in origin (17).

Indeterminate CLBP is believed to result from changes in the processing of nociception and pain throughout the central nervous system, as well as structural and sensorimotor function alterations in the cortex (18). Animal model studies suggest that glial cells (microglia, astrocytes, and oligodendrocytes) are involved in the onset of chronic pain through the production of cytokines and other inflammatory mediators (13,19–22). Specifically, in the initial phase, glial activation generates temporary hypersensitivity as a way to protect the injured site. However, when there is excessive activation or a failure to reduce this activation after the resolution of the initial problem, antagonistic effects may occur, promoting peripheral and central sensitization and, consequently, a greater perception of pain (23).

This sensitization can be defined as an increased responsiveness of nociceptive neurons in the central and peripheral nervous systems to normal or sub-threshold afferent input (24). In clinical practice, this sensitization is commonly assessed through temporal summation (TS) (25). TS evaluates the state of hyperactivity in the dorsal horn pain facilitation pathways by applying a repetitive nociceptive stimulus with constant intensity

(26). Staud et al. (27) demonstrated that TS was higher in patients with chronic pain compared to healthy controls, confirming the hypothesis that central and peripheral pain sensitization is associated with the development and maintenance of chronic pain (28).

Another important factor present in these patients is the alteration in endogenous pain modulation circuits, which involve the periaqueductal gray (PAG), rostroventromedial medulla (RVM), and the dorsal reticular subnucleus (DRt) (29). These descending pain modulation circuits can increase or decrease the perceived magnitude of afferent nociceptive stimuli (30). Experimentally, the functionality of endogenous pain inhibition in the CNS is usually assessed through a quantitative sensory test called conditioned pain modulation (CPM) (31). For the test, a painful stimulus is applied before and after applying another conditioning painful stimulus. When a pain modulatory system performs its physiological inhibitory role, the conditioning stimulus inhibits the pain felt during the test stimulus (30). Lewis et al. (32), through a meta-analysis, showed that most patients with chronic pain exhibited a significant reduction in CPM compared to healthy controls. Another meta-analysis reinforced those patients with CLBP not only had impaired CPM but also significantly increased TS (3).

This central and peripheral sensitization in patients with CLBP can consequently affect neuromuscular control, ligaments, tendons, and spinal muscles, which under normal conditions must work together and in a coordinated manner to maintain spinal stability. Alterations in these structures due to CLBP result in increased spinal load, potentially causing undesirable effects such as nociceptor activation and inflammatory responses, leading to even more pain (33,34). All these changes contribute to reduced autonomy and quality of life due to decreased strength, endurance, and trunk stability (35,36), which are necessary for performing daily activities such as walking, sitting and standing from a chair, climbing stairs, shopping, carrying, or pulling items.

The main muscles involved in lumbar stability are the erector spinae, multifidus, internal oblique, external oblique, and transversus abdominis (37). Several studies (4,5,38–40) show that individuals with CLBP exhibit decreased coordination, muscle strength, and endurance in these muscles, leading to reduced stability and motor control.

These changes are possibly due to atrophy, fat infiltration, and accumulation of connective tissue in these muscles (41). Supporting these findings, Hodges et al. (2015) (42), in an animal model study, showed a decrease in electrical impulse in the multifidus muscle during the acute phase of pain, fibrotic changes in the subacute phase, and changes similar to disuse in the chronic phase. All these changes together contribute to the worsening of pain and reduced function, making it necessary to propose treatments that simultaneously reduce pain and increase function. Below, two alternatives are presented along with the respective mechanisms by which each may act in the context of CLBP.

Functional Training

Functional training (FT) can be defined as a set of exercises aimed at improving performance in daily activities, whether work-related or sports, through the execution of multiplanar, multi-joint exercises that are transferable to daily life activities. Additionally, FT protocols encompass different physical capacities in an integrated manner within the same session, as more than one capacity is used simultaneously in daily actions (13). According to Da Silva-Grigoletto et al. (43), the main physical capacities stimulated include strength, power, flexibility, agility, coordination, muscular endurance, speed, and balance, all of which are necessary for performing daily activities in an integrated manner. Based on these characteristics, FT, through its emphasis on functional capacity, is a promising option for the treatment of CLBP as it specifically and integratively targets trunk musculature in contexts resembling real-life situations (11,13).

Da Silva-Grigoletto et al. (14) demonstrated positive effects of FT on the strength and muscular endurance of the trunk in elderly women after 12 weeks of training, with a frequency of three times per week, conducted in a circuit format. On the other hand, traditional resistance training performed over the same period did not promote benefits in these outcomes. The authors suggest that the characteristics of FT, such as greater degrees of freedom, a range of movement speeds, and exercise instability, likely activate more spinal stabilizer muscles, improving postural control. Supporting this hypothesis, La Scala Teixeira and colleagues (13) assert that a key feature of FT is the application of exercises exploring different levels of instability and variations in the base of support. This feature results in a controlled stressor stimulus that chronically promotes positive adaptations at the joint, muscular, and motor control levels, resulting in greater stabilization and increased function (44).

From a physiological perspective, Santos et al. (11) investigated the release of β-endorphin into the bloodstream after an acute session of FT compared to a session with isolated trunk muscle exercises. It was observed that FT, acutely, promotes an increase in β-endorphin release into the bloodstream of women with CLBP. This increase in β-endorphin concentration favors a reduction in pain sensitivity (9). Therefore, even acutely, FT can induce immediate pain reduction, allowing the inference that systematically performed FT can induce chronic pain reduction by increasing the response to sensory information resulting from muscular activity and reducing neuronal sensitization (45). Supporting this hypothesis, a study demonstrated that a 12-week multicomponent training program, performed once per week, was sufficient to reduce pain among a team of nurses (46).

Reinforcing the use of FT, Hayden et al. (47), in a network meta-analysis, showed that exercises aimed at increasing function are more effective in reducing functional limitations in people with CLBP compared to conservative training, such as global strengthening and aerobic exercises. The emphasis of FT on increasing function becomes evident when considering the use of basic movement patterns, such as pushing, pulling, squatting, and carrying (13). Additionally, this training employs coordinated patterns associated with acceleration and deceleration actions that require greater activation of the trunk muscles, resulting in positive adaptations in this region and promoting increased function (14).

Supporting the use of FT, Aragão-Santos et al. (15) identified an increase in the functional fitness of elderly women after 12 FT sessions over four weeks, while concurrent training (strength + endurance) showed positive effects only after 24 sessions. Corroborating these findings, other studies have shown improvements in functional capacity, better body alignment and joint angles (48), as well as enhancements in posture and movement quality (49). Weiner et al. (6) showed a strong association between pain duration and low physical function, endorsing the use of FT in the context of CLBP, as this training emphasizes increased physical function. Therefore, FT presents itself as a viable alternative for people with CLBP, both for its direct effect on trunk muscle function, suggesting increased stabilization and motor control, and for improving pain intensity, suggesting increased release of endogenous substances related to analgesia. Table 1 lists the main studies involving FT, the protocols executed, and the intervention duration.

Table 1. Characterization of functional training used in the studies.

Author and year	**Age**	**Sex**	**Exercises/tasks**	**Duration of intervention**	**Training protocol specifications**	**Outcome**
Da Silva-Grigoletto et al. 2019	between 60 and 79 years	Women (n 45)	ascending and descending steps; step jump; deadlift; alternating waves (rope); rowing; squat; medicine ball throws on the ground; push-ups; farmer's walk; run and jump between cones; pelvic elevation; run and jump between cones; movement between cones; lateral agility ladder; front plank.	12 weeks	Frequency: 3 x week session time: 50 min each 1º block: Total time 5 min., 3-5 exercises per joint, 1 set of 8 seconds 2º block: Total time 15 min, 5 exercises, 3 sets of 30 s, 1 min by exercise, density 1/1 intensity 6-7 3º block: Total time:	Increased strength and endurance of trunk muscles

					20 min., 8 exercises, 2 sets of 8-12 repetitions, 1 min per station, density 1/1. intensity 7-9 4º block: total time: 5 min., 5-8 efforts, density of 1/1 intensity 8-9	
Aragão-Santos et al. 2021	between 60 and 79 years	Women (n 108)	Lateral jump; frontal jump; deadlift; single leg deadlift; rope side to side waves; rope double waves; lateral skips in agility ladder; front jumps in agility ladder; front squat; medicine ball push press throw overhead; elastic chest press; incline push up; lateral shuffle	44 sessions	Frequency: 3 x week Session time: 1 hour each 1º block: Total time: 5 min; 1 set of 12 s per exercise; 10 squats and 10	Increased functional fitness

			cutting; farmer's walk; pelvic lift; standing elastic row;		jumping jacks; intensity 4–5 2º block: Total time: 15 min; 5 exercises; 2 rounds; 30 s of exertion/60 s of rest per exercise - Density 1/2; intensity 6–7 3º block: Total time: 32 min; 8 exercises; 2 rounds; 40 s of exertion/80 s of rest - Density 1/2; intensity 7–9 4º block: total time: 3 min; density 1/2; intensity: 8–9	

Otto e Wollesen, 2022	mean age of 42.5	Men (n 3) and women (n 39)	Warm-up and mobilization - Exercises for the mobilization of upper ankle joint, hip joint, thoracic spine, shoulder joint, and wrist joint Coordination - Feet (e.g., rotation of the tibia around the foot first in sitting, then in standing position) Hip (e.g., cat-cow) Spine (e.g., round and straighten up the back vertebra by vertebra) Shoulder blades (e.g., breathing into the shoulder blades) Head (e.g., push the head back and forth)	12 weeks	Frequency: 1 x week Session time: 45-60 min each 5–10 min warm-up and mobilization 10–15 min coordination 30–40 min strength exercises 5–10 min relaxation Week 1–4 2 × 5 repetitions (deadlift) hold 2 × for 60 s (hip thrust and sit ups) 2 × for 30 s on each side (lunges) Week 5–8	Reduced pain and increased muscle strength

			Strength exercises - Deadlift, deadlift with a partner, hip thrust, one-legged hip thrust, standing scale, sit ups, sitting rotation, lying leg rotation, lunges, split squad Relaxation - Static stretching, self-massage (myofascial release).		2 × 5 repetitions (deadlift) hold 2 × for 30 s on each side (one-legged hip thrust) 2 × for 60 s (sitting rotation) 2 × for 30 s on each side (step up) Week 9–12 2 × 5 repetitions (deadlift with a partner) hold 2 × for 30 s on each side (standing scale) 2 × for 60 s (lying leg rotation) 2 × for 30 s on each side (split squad)	

Sobrinho et al. 2023	between 60 and 70 years	Women (n 141)	warm-up, balance, motor coordination, and games muscle strength training- which strengthens the regions mentioned above—such as squats, different formats of displacement (lateral, side, front, back, with high and low knees), pelvic elevation, sinks, curved row, and reverse crucifix aerobic activities relaxation	14 weeks	Frequency: 1 x week Session time: 90 min each 15 min of warm-up 35 min of muscle strength 35 min of aerobic activities 5 minutes of relaxation In each training session, ten exercises were used, with 2 min of execution and 1 min of rest. The circuit was performed twice with a 7-min water break between sets Intensity:	Improvement in body alignment and joint angles.

					weeks 1 to 2 = 3 to 4 weeks 3–5 = 4–6 weeks 6–8 = 6 to 7 weeks 9–11 = 7 to 8 weeks 11–14 = 8–10	

Dual Task Training

Dual Task Training (DTT) involves performing two simultaneous tasks, typically including cognitive and motor tasks or motor-motor tasks (50). In daily life, it is common to engage in such tasks, such as cooking while talking on the phone or talking while walking. Van Daele et al. (51) demonstrated that adding a cognitive task reduced postural sway and trunk stiffness in patients with nonspecific low back pain and improved their postural control. Additionally, DTT is capable of increasing trunk stability, which is significantly affected by CLBP (52). Therefore, DTT emerges as a promising modality for treating CLBP.

Supporting the use of DTT in CLBP, Rowley et al. (53) showed that the introduction of low-intensity cognitive exercises combined with a dynamic balance task (performed using a device called the balance-dexterity device, which utilized a custom device with a spring mounted between two plates) prevented conscious processing of postural memory, resulting in better trunk coupling compared to a single-task condition in people with CLBP. These results are consistent with other studies (54,55), which demonstrated that postural sway was reduced, and posture was more stable when low-intensity cognitive tasks were applied along with motor tasks. According to Xião et al. (56), adding a low-intensity cognitive task to a motor task diverts attention from postural control and increases the automation of postural processing, thus improving trunk stability.

On the other hand, some studies (53,57) have shown that postural stability decreases as the difficulty of the cognitive task increases. This phenomenon can be explained by the U-shaped nonlinear model proposed by Lacour et al. (58), which states that improvements or reductions in postural control performance depend on the cognitive task demand level. Thus, when cognitive tasks require greater attention resources, postural control performance decreases, whereas when cognitive tasks require less attention, postural control increases. Consequently, it is evident that DTT can be a safe and effective option for improving trunk stability in patients with CLBP, but the complexity and demands of the cognitive task must be considered for a positive effect.

DTT has also proven effective in reducing pain intensity in individuals with CLBP. Merchant et al. (12) applied DTT twice a week over three months in elderly individuals and found reductions in pain, as well as improvements in quality of life and function. According to the authors, dual-task exercises incorporating cognitive and physical tasks activate cortical areas including the frontal, temporal, parietal, and prefrontal cortices, where opioid receptors are located, thereby reducing pain intensity.

Similarly, in an acute study with healthy individuals, Banticki et al. (16) examined attention-induced changes in pain perception using functional magnetic resonance imaging in healthy adults. Their results showed that individuals reported significantly lower pain intensities when engaged in demanding cognitive tasks compared to the condition without cognitive task addition. Additionally, the study found that reduced perception of painful stimuli applied during the cognitive task was accompanied by reduced activation in some key components of the pain matrix, including the insula, mid-cingulate cortex, and thalamus. Concurrently, it was found that the anterior cingulate and orbitofrontal regions involved in cognitive tasks and attention showed greater activation during cognitive interference associated with pain (16).

Metzger et al. (59) investigated brain activation during dual-task activities using functional near-infrared spectroscopy in healthy young adults. They observed that dual-task exercise (motor and cognitive) increased generalized cortical activation in the frontal, temporal, parietal, and prefrontal cortices. According to Maarrawi et al. (60), these regions have a high concentration of opioid receptors. Additionally, stimulation of the motor cortex can induce the release of endogenous opioids, providing pain relief. Therefore, DTT, through the stimulation of these areas, has potential beneficial effects for treating CLBP.

In addition to benefits in pain management and postural control, DTT has shown effectiveness in improving physical function. Jardim et al.(61) reported positive effects of 24 DTT sessions on the functional capacity of healthy elderly individuals compared to a control group that received educational health materials. Another study found positive effects of eight weeks of DTT on cognitive performance and gait in an older population compared to a control group receiving educational health materials (62). Similar results were reported by Eggenberger et al. (2015) (63), who demonstrated that six months of cognitive–physical multicomponent training were effective in improving gait performance in an older adult population. Similarly, another study showed increased gait performance in older adults after twelve weeks of physical-cognitive dual task training (64). Therefore, DTT also appears to be effective in enhancing the functional capacity of individuals with CLBP. However, DTT programs should be multi-component, similar to functional training, or at least include blocks of exercises focusing on strength, endurance, and balance. Thus, DTT is a viable and effective modality for treating CLBP, owing to its apparent effects on improving postural control, reducing pain intensity, and enhancing physical function.

This research offers practical applications, such as encouraging regular physical exercise to reduce pain intensity. Exercises that mimic daily activities can enhance physical function and reduce disability caused by CLBP. Furthermore, the study shows that adding cognitive tasks can further stimulate pain reduction by activating specific areas of the central nervous system. Consequently, movement professionals have the opportunity to implement FT and/or DTT based on the specific goals for each patient. Table 2 summarizes the main studies on DTT exploring motor and cognitive stimuli.

Table 2. Characterization of dual-task training used in the studies.

Author and year	Age	Sex	Motor task	Cognitive task	Duration of intervention	Training protocol specifications	Outcome
Kitazawa et al. 2015	Between 70 to 89 years	Men (n 27) and women (n 33)	Walk	To memorize each step design on the basis of the instructor's demonstration.	8 weeks	Frequency: 1 x week Session time: 60 min The total time for actual walking by each participant was approximately 30 minutes in each session Participants walked 216 steps per session during the first 4 weeks of the program and 240 steps per session from the fifth to eighth weeks.	Increased cognitive performance and gait

Eggenberger et al. 2015	over 70 years	Men (n 16) and women (n 30)	DANCE: virtual reality video game dancing. continuous flat or inclined treadmill walking (or running) Muscular strength (complement to each intervention): Examples of lower body exercises: seated leg extensions with 2 kg ankle weights, chair rises, split leg squats, calf raises (all with or without 5–10 kg weight vest), standing toe raises; two exercises per session Examples of upper-body exercises:	To memorize the correct sequence of 3–20 words lighting up one after the other for 3 seconds on the computer screen.	26 weeks	Frequency: 2 x week Session time: 60 min DANCE 2–3 min/game/song, 1–2 min rest periods only if required MUSCULAR STRENGTH 1 to 3 sets with 8 to 12 repetitions, progressing from slow to fast movement speed, ~1 min rest between sets BALANCE 2 to 4 sets of four to five different exercises per session, 20–60 s per exercise, 30–60 s rest Intensity: 5–7	Increased walking performance

			standing arm row, biceps curls (both with resistive rubber bands), standing wall push-ups. knee push-ups; Examples of trunk stabilization exercises: incline seated single-leg raises, crunches, front plank; One to three sets with eight to 12 repetitions, progressing from slow to fast movement speed Balance (complement to each intervention): Examples: tandem stand, two-leg stand on				

			foam pad, walking over a skipping rope on the floor, single-leg stand on air pad, single-leg stand with eyes closed				
Falbo et al. 2016	Between 65–80 years	Men (n 4) and women (n 32)	Each training session comprised a 10-minute warm-up made of walking at different speeds, light running, and moving different body segments: arms, wrists, fingers, shoulders, legs, and ankles. This part leads to a 30-minute period of coordination training (e.g., walking with arms circles), balance (e.g., maintaining a monopodalic stance with and	During the performance of physical tasks, several features of equipment (i.e., colour and/or size of obstacles) were associated with different motor requirements and participants were required to switch randomly between stimulus-response sets.	12 weeks	Frequency: 2 x week Session time: 1 hour not informed by the authors	Increased gait performance

			without swinging the free leg), strengthening (e.g., squatting while extending an elastic band with arms), agility (e.g., walking through an agility ladder at different speed), followed by 20 minutes of stretching, strengthening and relaxation with exercises alternating contraction and decontraction of muscles coupled with breathing, and slow rotations of hands, head, and ankles performed lying on the floor.				
Jardim et al. 2021	>59 years	Men (n 11) and women (n 61)	Functional Circuit + Walking	To speak out loudly the days of the week, months of the year, and the	12 weeks	Frequency: 2 x week Session time: 75 min	Increased physical fitness and quality of life

			Resistance training Dance	alphabet in direct and reverse order To remember pre-selected words and sing songs with the vocabulary included At functional physical exercise circuit beginning, researcher reads a word sequence (places, animals, and objects), which were requested to be reproduced by the participant at the circuit endpoint Simple calculations (arithmetic) The group was encouraged to remember and to speak out loud words from a certain category or phoneme.		warm-up (10 min), aerobic exercise (30 min), resistance exercise (30 min), and stretching (5 min). Intensity 60–70% of the maximum heart rate estimated using the Karvonen formula	

Discussion

Both approaches are characterized by the inclusion of elements that simulate daily life demands, thereby facilitating the transfer of functional gains to everyday activities. However, while FT is predominantly structured around multiplanar and multicomponent exercises emphasizing fundamental motor patterns such as squatting, pushing, and pulling (13), DTT is based on the simultaneous performance of motor and cognitive tasks (or two motor tasks), simulating situations of attentional overload and multitasking demands (50).

From a physiological perspective, FT acts primarily through muscle strengthening, increasing trunk stability and generating neuromuscular and structural adaptations that enhance postural control (14). In this context, a systematic review demonstrated that exercises simulating daily activities, such as those proposed by this modality, require the activation of larger muscle groups (65), including the trunk muscles (13). Furthermore, the use of unstable exercises and variations in the base of support, which are typical of functional training, appears to more effectively activate the deep spinal stabilizing muscles, thereby reducing vertebral overload and improving functional capacity (44). There is also evidence that FT induces the release of β-endorphin, an endogenous opioid with analgesic effects, contributing to pain modulation (11).

Conversely, DTT appears to act mainly on central pain modulation circuits and automated postural control. Studies show that performing cognitive tasks concurrently with motor execution shifts attention away from pain and stimulates cortical areas involved in attention, cognition, and pain modulation, such as the prefrontal cortex, anterior cingulate cortex, and insula (12). This activation is associated with the release of endogenous opioids and a reduction in activity in brain regions traditionally linked to pain processing, such as the thalamus and the midcingulate cortex. These central effects contribute not only to analgesia but also to improvements in postural stability (56).

The reduction in pain intensity with TF seems to occur due to the release of endogenous substances related to analgesia in the bloodstream. DT, in contrast, appears to induce activation of specific areas in the central nervous system involved in reducing pain intensity. Furthermore, TF has been shown to improve functional capacity due to its emphasis on exercises with movement patterns similar to those used in daily life activities, such as squatting, pulling, pushing, and carrying. Despite the differing mechanisms, both protocols prove beneficial for individuals with chronic pain, allowing professionals the freedom to choose between options based on patient preference and their expertise.

Regarding clinical application, FT requires a greater focus on the controlled and progressive execution of functional movements in unstable environments, often structured as circuit training (13). In contrast, DTT requires careful planning of the complexity of cognitive tasks, as excessive cognitive demands may compromise postural stability and attenuate the expected benefits (58).

In summary, FT and DTT share the ability to reduce pain and improve function in individuals with CLBP, although they act through distinct mechanisms FT with a peripheral and neuromuscular focus, and DTT with a central and cognitive emphasis. This complementarity can be explored in clinical practice to foster more effective and personalized interventions.

Final Considerations

The TF and DTT are effective in reducing pain intensity, improving trunk muscle function, and enhancing the functional capacity of this population. However, it is worth noting that the pathways through which these training methods benefit this population are different. TF appears to enhance motor control due to its direct action on improving trunk strength, endurance, and stability, given its focus on multi-joint and multi-planar exercises that require constant activation of the trunk muscles. On the other hand, DT diverts attention from postural control and increases the automation of postural processing, resulting in a lower perception of pain. We suggest that future studies investigate the physiological and biochemical mechanisms involved in pain reduction, such as the chronic effects of exercise on β-endorphins and other markers. Additionally, research emphasizing biomechanical aspects could contribute to scientific literature on the effects of specific exercises on increasing stability and motor control of the spine and their impact on the functional fitness of individuals with chronic pain.

References

1. Wu A, March L, Zheng X, Huang J, Wang X, Zhao J, et al. Global low back pain prevalence and years lived with disability from 1990 to 2017: estimates from the global burden of disease study 2017. Ann Transl Med. 2020;8(6):299.

2. Mosabbir A. Mechanisms behind the development of chronic low back pain and its neurodegenerative features. Life (Basel). 2022;13(1):84.

3. McPhee ME, Vaegter HB, Graven-Nielsen T. Alterations in pro-nociceptive and anti-nociceptive mechanisms in patients with low back pain: a systematic review with meta-analysis. Pain. 2019;161(3):464-475.

4. Della Volpe R, Popa T, Ginanneschi F, Spidalieri R, Mazzocchio R, Rossi A. Changes in coordination of postural control during dynamic stance in chronic low back pain patients. Gait Posture. 2006;24(3):349–55.

5. Pranata A, Perraton L, El-Ansary D, Clark R, Fortin K, Dettmann T, et al. Lumbar extensor muscle force control is associated with disability in people with chronic low back pain. Clin Biomech (Bristol, Avon). 2017;46:46–51.

6. Weiner DK, Haggerty CL, Kritchevsky SB, Harris T, Simonsick EM, Nevitt M, et al. How does low back pain impact physical function in independent, well-functioning older adults? Evidence from the health ABC cohort and implications for the future. Pain Med. 2003;4(4):311–20.

7. Owen PJ, Miller CT, Mundell NL, Verswijveren SJ, Tagliaferri SD, Brisby H, et al. Which specific modes of exercise training are most effective for treating low back pain? Network meta-analysis. Br J Sports Med. 2019; 54(21):1279-1287.

8. Pedersen BK, Saltin B. Exercise as medicine - evidence for prescribing exercise as therapy in 26 different chronic diseases. Scand J Med Sci Sports. 2015;25 Suppl 3:1–72.

9. Da Silva Santos R, Galdino G. Endogenous systems involved in exercise-induced analgesia. J Physiol Pharmacol. 2018;69(1):3–13.

10. Niederer D, Mueller J. Sustainability effects of motor control stabilisation exercises on pain and function in chronic nonspecific low back pain patients: A systematic review with meta-analysis and meta-regression. PLoS One. 2020;15(1):e0227423.

11. Santos MS, Santos P de J, Vasconcelos ABS, Gomes ACA, de Oliveira LM, Souza PRM, et al. Neuroendocrine effects of a single bout of functional and core stabilization training in women with chronic nonspecific low back pain: A crossover study. Physiol Rep. 2022;10(17):e15365.

12. Merchant RA, Au L, Seetharaman S, Ng SE, Nathania J, Lim JY, et al. Association of pain and impact of dual-task exercise on function, cognition and quality of life. J Nutr Health Aging. 2021;25(9):1053–63.

13. La Scala Teixeira CV, Evangelista AL, Novaes JS, Da Silva Grigoletto ME, Behm DG. “You’re only as strong as your weakest link”: a current opinion about the concepts and characteristics of functional training. Front Physiol. 2017;8:643.

14. Da Silva-Grigoletto ME, Mesquita MMA, Aragão-Santos JC, Santos MS, Resende-Neto AG, de Santana JM, et al. Functional training induces greater variety and magnitude of training improvements than traditional resistance training in elderly women. J Sports Sci Med. 2019;18(4):789–97.

15. Aragão-Santos JC, Vasconcelos ABS, Resende-Neto AGD, Rodrigues LS, Silva NDL, Da Silva DN, et al. Functional and concurrent training do not impair immune function and improve functional fitness in postmenopausal women: A randomized controlled trial. Experimental Gerontology. 2021;153:111504.

16. Bantick SJ, Wise RG, Ploghaus A, Clare S, Smith SM, Tracey I. Imaging how attention modulates pain in humans using functional MRI. Brain. 2002;125(2):310–9.

17. Barrey CY, Le Huec JC. Chronic low back pain: Relevance of a new classification based on the injury pattern. Orthopaedics & Traumatology: Surgery & Research. 2019;105(2):339–46.

18. Brumagne S, Diers M, Danneels L, Moseley GL, Hodges PW. Neuroplasticity of sensorimotor control in low back pain. J Orthop Sports Phys Ther. 2019;49(6):402–14.

19. Chacur M, Lambertz D, Hoheisel U, Mense S. Role of spinal microglia in myositis-induced central sensitisation: an immunohistochemical and behavioural study in rats. Eur J Pain. 2009;13(9):915–23.

20. Gao YJ, Zhang L, Samad OA, Suter MR, Yasuhiko K, Xu ZZ, et al. JNK-induced MCP-1 production in spinal cord astrocytes contributes to central sensitization and neuropathic pain. J Neurosci. 2009;29(13):4096–108.

21. Gritsch S, Lu J, Thilemann S, Wörtge S, Möbius W, Bruttger J, et al. Oligodendrocyte ablation triggers central pain independently of innate or adaptive immune responses in mice. Nat Commun. 2014;5:5472.

22. Ji RR, Berta T, Nedergaard M. Glia and pain: is chronic pain a gliopathy? Pain. 2013;154 Suppl 1(0 1):S10-28.

23. Hodges PW, Barbe MF, Loggia ML, Nijs J, Stone LS. Diverse role of biological plasticity in low back pain and its impact on sensorimotor control of the spine. J Orthop Sports Phys Ther. 2019;49(6):389–401.

24. Fernández-Carnero J, Fernández-de-Las-Peñas C, de la Llave-Rincón AI, Ge HY, Arendt-Nielsen L. Widespread mechanical pain hypersensitivity as sign of central sensitization in unilateral epicondylalgia: a blinded, controlled study. Clin J Pain. 2009;25(7):555–61.

25. Arribas-Romano A, Fernández-Carnero J, Molina-Rueda F, Angulo-Diaz-Parreño S, Navarro-Santana MJ. Efficacy of physical therapy on nociceptive pain processing alterations in patients with chronic musculoskeletal pain: A systematic review and meta-analysis. Pain Med. 2020;21(10):2502-2517.

26. Hackett J, Naugle KE, Naugle KM. The decline of endogenous pain modulation with aging: a meta-analysis of temporal summation and conditioned pain modulation. J Pain. 2019;21(5-6):514-528

27. Staud R, Bovee CE, Robinson ME, Price DD. Cutaneous C-fiber pain abnormalities of fibromyalgia patients are specifically related to temporal summation. Pain. 2008;139(2):315–23.

28. Nijs J, Lahousse A, Kapreli E, Bilika P, Saraçoğlu İ, Malfliet A, et al. Nociplastic pain criteria or recognition of central sensitization? pain phenotyping in the past, present and future. J Clin Med. 2021;10(15) 3203.

29. Millan MJ. Descending control of pain. Prog Neurobiol. 2002;66(6):355–474.

30. Nir RR, Yarnitsky D. Conditioned pain modulation. Curr Opin Support Palliat Care. 2015;9(2):131–7.

31. Fernandes C, Pidal-Miranda M, Samartin-Veiga N, Carrillo-de-la-Peña MT. Conditioned pain modulation as a biomarker of chronic pain: a systematic review of its concurrent validity. Pain. 2019;160(12):2679–90.

32. Lewis GN, Rice DA, McNair PJ. Conditioned pain modulation in populations with chronic pain: a systematic review and meta-analysis. J Pain. 2012;13(10):936–44.

33. Abboud J, Nougarou F, Descarreaux M. Muscle activity adaptations to spinal tissue creep in the presence of muscle fatigue. PLoS One.2016;11(2):e0149076.

34. Van Dieën JH, Reeves NP, Kawchuk G, Van Dillen IR, Hodges PW. Analysis of motor control in patients with low back pain: A key to personalized care? J Orthop Sports Phys Ther. 2019;49(6):380–8.

35. Leveille SG. Musculoskeletal aging. Curr Opin Rheumatol. 2004;16(2):114–8.

36. Rudy TE, Weiner DK, Lieber SJ, Slaboda J, Boston JR. The impact of chronic low back pain on older adults. Pain. 2007;131(3):293–301.

37. Panjabi MM. The stabilizing system of the spine. Part I. Function, dysfunction, adaptation, and enhancement. J Spinal Disord. 1992;5(4):383–9.

38. Gill KP, Callaghan MJ. The measurement of lumbar proprioception in individuals with and without low back pain. Spine (Phila Pa 1976).1998;23(3):371–7.

39. Hodges PW, Richardson CA. Altered trunk muscle recruitment in people with low back pain with upper limb movement at different speeds. Arch Phys Med Rehabil. 1999/09/17 ed setembro de 1999;80(9):1005–12.

40. Lam SS, Jull G, Treleaven J. Lumbar spine kinesthesia in patients with low back pain. J Orthop Sports Phys Ther. 1999;29(5):294–9.

41. Li Y, Liu J, Liu ZZ, Duan DP. Inflammation in low back pain may be detected from the peripheral blood: suggestions for biomarker. Biosci Rep. 2016;36(4):e00361.

42. Hodges PW, James G, Blomster L, Hall L, Schmid A, Shu C, et al. Multifidus muscle changes after back injury are characterized by structural remodeling of muscle, adipose and connective tissue, but not muscle atrophy: molecular and morphological evidence. Spine (Phila Pa 1976). 2015;40(14):1057–71.

43. Da Silva-Grigoletto ME, Brito CJ, Heredia JR. Treinamento funcional: funcional para que e para quem? Rev Bras Cineantropom Desempenho Hum. 2014;16(6):714.

44. Behm D, Colado JC. The effectiveness of resistance training using unstable surfaces and devices for rehabilitation. Int J Sports Phys Ther. 2012;7(2):226–41.

45. Paungmali A, Joseph LH, Sitilertpisan P, Pirunsan U, Uthaikhup S. Lumbopelvic core stabilization exercise and pain modulation among individuals with chronic nonspecific low back pain. Pain Pract. 2017;17(8):1008–14.

46. Otto AK, Wollesen B. Multicomponent exercises to prevent and reduce back pain in elderly care nurses: a randomized controlled trial. BMC Sports Sci Med Rehabil. 2022;14:114.

47. Hayden JA, Ellis J, Ogilvie R, Stewart SA, Bagg MK, Stanojevic S, et al. Some types of exercise are more effective than others in people with chronic low back pain: a network meta-analysis. Journal of Physiotherapy. 2021;67(4):252–62.

48. Sobrinho AC da S, de Almeida ML, Rodrigues G da S, Bertani RF, Lima JGR, Bueno Junior CR. Stretching and multicomponent training to functional capacities of older women: a randomized study. Int J Environ Res Public Health. 2021;19(1):27.

49. Sobrinho ACS, Benjamim CJR, Luciano de Almeida M, Rodrigues G da S, Feitosa Lopes LG, Ribeiro de Lima JG, et al. Fourteen weeks of multicomponent training associated with flexibility training modifies postural alignment, joint range of motion and modulates blood pressure in physically inactive older women: a randomized clinical trial. Front Physiol. 2023;14:1172780.

50. Abou L, Peters J, Fritz NE, Sosnoff JJ, Kratz AL. Motor cognitive dual-task testing to predict future falls in multiple sclerosis: a systematic review. Neurorehabilitation and Neural Repair. 2022;36(12):757–69.

51. Van Daele U, Hagman F, Truijen S, Vorlat P, Van Gheluwe B, Vaes P. Decrease in postural sway and trunk stiffness during cognitive dual-task in nonspecific chronic low back pain patients, performance compared to healthy control subjects. Spine. 2010;35(5):583.

52. Ge L, Yu Q, Wang C, Huang H, Li X, Zhang S, et al. How cognitive loads modulate the postural control of older women with low back pain? BMC Geriatrics. 2021;21(1):82.

53. Rowley KM, Winstein CJ, Kulig K. Persons in remission from recurrent low back pain alter trunk coupling under dual-task interference during a dynamic balance task. Exp Brain Res. 2020;238(4):957–68.

54. Vuillerme N, Nougier V, Teasdale N. Effects of a reaction time task on postural control in humans. Neuroscience Letters. 2000;291(2):77–80.

55. Huxhold O, Li SC, Schmiedek F, Lindenberger U. Dual-tasking postural control: Aging and the effects of cognitive demand in conjunction with focus of attention. Brain Research Bulletin. 2006;69(3):294–305.

56. Xiao W, Yang H, Wang Z, Mao H, Wang H, Hao Z, et al. Postural control of patients with low back pain under dual-task conditions. J Pain Res. 2023;16:71–82.

57. Legrand A, Bui-Quoc E, Doré-Mazars K, Lemoine C, Gérard CL, Bucci MP. Effect of a dual task on postural control in dyslexic children. PLoS One. 2012;7(4):e35301.

58. Lacour M, Bernard-Demanze L, Dumitrescu M. Posture control, aging, and attention resources: Models and posture-analysis methods. Neurophysiologie Clinique/Clinical Neurophysiology. 2008;38(6):411–21.

59. Metzger FG, Ehlis AC, Haeussinger FB, Schneeweiss P, Hudak J, Fallgatter AJ, et al. Functional brain imaging of walking while talking – An fNIRS study. Neuroscience. 2017;343:85–93.

60. Maarrawi J, Peyron R, Mertens P, Costes N, Magnin M, Sindou M, et al. Motor cortex stimulation for pain control induces changes in the endogenous opioid system. Neurology. 2007;69(9):827–34.

61. Jardim NYV, Bento-Torres NVO, Costa VO, Carvalho JPR, Pontes HTS, Tomás AM, et al. Dual-task exercise to improve cognition and functional capacity of healthy older adults. Front Aging Neurosci. 2021;13:589299.

62. Kitazawa K, Showa S, Hiraoka A, Fushiki Y, Sakauchi H, Mori M. Effect of a dual-task net-step exercise on cognitive and gait function in older adults. J Geriatr Phys Ther. 2015;38(3):133–40.

63. Eggenberger P, Theill N, Holenstein S, Schumacher V, de Bruin ED. Multicomponent physical exercise with simultaneous cognitive training to enhance dual-task walking of older adults: a secondary analysis of a 6-month randomized controlled trial with 1-year follow-up. Clin Interv Aging. 2015;10:1711–32.

64. Falbo S, Condello G, Capranica L, Forte R, Pesce C. Effects of physical-cognitive dual task training on executive function and gait performance in older adults: A randomized controlled trial. Biomed Res Int. 2016;2016:5812092.

65. Kraemer WJ, Fleck SJ, Callister R, Shealy M, Dudley GA, Maresh CM, et al. Training responses of plasma beta-endorphin, adrenocorticotropin, and cortisol. Med Sci Sports Exerc.1989;21(2):146–53.

3.3. ESTUDO 3: *Effects of 2 training protocols on aspects of pain in older women with chronic low back pain: a randomized clinical trial*

Artigo aceito no *Journal of Manipulative and Physiological Therapeutics* em 18 de setembro de 2024.

View Letter

Close

Date:	Sep 18, 2024
To:	"Poliana de Jesus Santos" polianasantos.28@hotmail.com
From:	"Claire Johnson, DC, MSEd, PhD" cjohnson@nuhs.edu
Subject:	Accept submission to Journal of Manipulative and Physiological Therapeutics and Invitation to Peer Review

Manuscript Number: JMPT-D-24-00015R3

Effects of 2 training protocols on aspects of pain in older women with chronic low back pain: a randomized clinical trial

Dear MSc Santos,

Thank you for submitting your manuscript to Journal of Manipulative and Physiological Therapeutics. I am pleased to inform you that your manuscript has been ACCEPTED for publication. In several weeks we will send you a proof which you will be asked to check and complete a number of online forms required for publication.

In addition, you are being invited to join as a peer reviewer for this journal. To keep the review process timely, excellent peer reviewers are needed. Most authors do not realize that for each paper they submit, at least 3 to 5 reviewers provide peer review for their paper. Therefore, to make this a fair process, each author who publishes in this journal should peer review for least 3 to 5 papers to balance out this service. Journals must rely on the benevolence and expertise of the peer reviewers, and it is unfair to ask only a few reviewers to shoulder the burden for all others. If there are only a few reviewers, the process becomes quite delayed, thus slowing down the process for all authors.
If everyone contributes to peer review, the process goes faster for everyone.

Therefore, we request that authors and coauthors who have accepted papers published in the journal sign up to be a peer reviewer for this journal. Your participation will assist everyone in making the process run more smoothly. Here is the link to sign up as a peer reviewer for the Journal of Manipulative and Physiological Therapeutics

https://www.surveymonkey.com/r/PeerReview_JMPT

Thank you so much for publishing in the journal and your kind consideration for you and your coauthors to sign up as a peer reviewer for the journal. Thank you.

We appreciate you publishing your manuscript to Journal of Manipulative and Physiological Therapeutics and hope you will consider this journal again for your future submissions.

Kind regards,
Claire Johnson, DC, MSEd, PhD
Editor-in-Chief
cjohnson@nuhs.edu

Journal of Manipulative and Physiological Therapeutics

Editor and Reviewer comments:

Fator de impacto da revista: 1.2

Effects of 2 training protocols on aspects of pain in older women with chronic low back pain: a randomized clinical trial

Abstract

Objective: The purpose of this study was to compare the effects of 16-weeks of functional versus dual-task training on aspects of pain in older women with chronic nonspecific low back pain (CNLBP). **Methods:** This is a randomized clinical trial. Thirty-eight participants aged 60 to 79 were divided into 2 groups: functional training (FT) and dual-task training (DT). We assessed pressure pain threshold (PPT), temporal summation of pain (TSP), conditioned pain modulation (CPM), trunk instability, isometric strength, and endurance of trunk muscles before and after 16 weeks of training. Generalized mixed models were used to compare the groups over time, adopting $p \leq 0.05$. Additionally, the effect size (Cohen's d) was calculated. **Results:** FT and DT promoted statistically significant increases in PPT, d = 1.82 - 1.10, and CPM, d = 1.60 - 1.13, respectively. Only FT promoted a statistically significant increase in PPT (d = 1.23). FT was superior to DT in PPT and CPM ($p < .05$). FT and DT increased the maximum isometric strength of trunk extensors, d = 2.14 - 2.12 ($p < .05$), respectively, without statistically significant differences between groups. Only DT showed a statistically significant improvement in the endurance of extensors and lateral flexors of the trunk (d = 0.77; d = 0.69). **Conclusion:** Both functional training and dual-task training were effective in promoting increased pain pressure threshold, improvement of conditioned pain modulation, and trunk function in older women with CNLBP, however, without effects on temporal summation of pain and trunk stability. These indicators show that the proposed training may promote pain attenuation and increased trunk function.

Keywords: Chronic Pain; Physical Exercise; Analgesia; Back Muscles; Core Stability; Aging.

Introduction

Chronic nonspecific low back pain (CNLBP) is defined as pain that has no relationship with any abnormal findings detected by imaging exams [1] It has a high prevalence[2,3] and is the leading cause of disability worldwide, representing 90% of cases of pain[4] affecting mainly individuals between 40 and 80 years of age.[5] Furthermore, women are more susceptible to developing CNLBP due to their higher perception and response to nociceptive stimuli.[6,7]

Patients with CNLBP present alterations in nociception processing and pain throughout the CNS with structural and functional alterations in the prefrontal cortex.[8] Consequently, there is an increase in pain sensitivity.[9,10] Moreover, those patients show a decrease in trunk muscle stability and strength, which is intensified by the aging process.[11-16] Additionally, postmenopausal women show a decrease in circulating estrogen levels, reducing the number of receptors involved in analgesia that are localized in specific areas of pain processing, increasing pain susceptibility in this population.[17]

The literature points to physical exercise as a treatment option due to endogenous analgesic pathways activation[18-20] and reduced pain sensitivity.[21] However, there is no consensus regarding the most appropriate modality. Functional training (FT), due to its multi-component nature and emphasis on activities of daily living, seems to be a safe and effective option for reducing CNLBP symptoms due to increased physical conditioning.[22] Additionally, dual-task training (DT, motor + cognitive tasks) appears to promote pain reduction through analgesic stimuli in regions involved in pain processing, such as the insula, pre-motor cortex, thalamus, and cerebellum.[23,24] Thus, these are 2 promising alternatives that can promote benefits for patients with CNLBP in clinical practice.

However, to our best knowledge, no studies compare these 2 approaches in older women with CNLBP, complicating professional decision-making. Considering the prevalence of CNLBP,[2,3] it is crucial to search for additional alternatives that can reduce symptoms and enhance the function of individuals with CNLBP. Thus, comparing 2 different methods, which are still underexplored but possess useful characteristics in pain management[20] becomes relevant given the pursuit of more alternatives. Besides, the exercise effectiveness depends on the patient’s adherence, so it is mandatory to show different exercise options to increase patient engagement. Therefore, the purpose of this study was to compare the effects of 16 weeks of FT and DT on aspects of pain and trunk function in older women with CNLBP. We hypothesize that both training protocols will promote pain reduction, while FT will also improve trunk function.

Methodology

Design

We conducted a randomized clinical trial with 2 arms lasting 22 weeks (April to October 2022). Specifically, 3 weeks were used for the pre-intervention assessments, 16 weeks for the training, and the last 3 weeks for the post-intervention evaluations. The entire study was conducted at the Physical Education Department of the institution and is registered in the Brazilian Clinical Trials Registry (REBEC) under the number RBR-5328h8g (https://ensaiosclinicos.gov.br/rg/RBR-5328h8g). Primary outcomes were pain modulation and trunk muscle function. This study followed the recommendations of the Consolidated Standards of Reporting Trials (CONSORT) statement.[25]

Participants

Participants were recruited by disseminating posters and flyers in the university surroundings. To participate in the study, participants were required to be women aged 60 to 79 with a clinical diagnosis of CNLBP, confirmed by an orthopedic physician after anamnesis and analysis of imaging studies that revealed no abnormalities. Additionally, the volunteers needed to report low back pain lasting more than 3 months, with a pain intensity greater than 3 on an 11-point numeric pain rating scale, and a body mass index (BMI) of less than 30 kg/m^2. Participants were excluded if they had undergone spinal surgery, were regular physical exercise practitioners, were undergoing treatment for pain or using an analgesic, anti-inflammatory, opioid, or immunosuppressive medication, as well as those with motor, psychiatric or cognitive disability, auditory, visual, or communication disorders that would prevent the completion of the protocol. To participate in the study, participants must be women aged 60 to 79 years with a clinical diagnosis of CNLBP, issued by an orthopedic doctor after analysis of imaging exams revealing no abnormalities and confirmed through anamnesis.

Ethics

The Institutional Human Research Ethics Committee approved the study under Opinion No. 5,291,267, and we followed the principles of the Helsinki Declaration. All participants were informed about the study's objectives and methodology through oral and written exposure. Those who voluntarily agreed to participate in the study signed the Informed Consent Form before starting the procedures.

Randomization

Three different researchers were involved in randomizing the participants. The first researcher conducted the registration of the participants, the second one carried out the randomization, and the last one informed which group each participant was assigned to. These researchers were not involved in the evaluation and implementation of the training.

The researcher responsible for statistical analysis ordered the participants in ascending order according to the Timed Up and Go (TUG) test values. We used a computerized random number generator (Microsoft Corp, Redmond, WA) to generate random values for each participant. Using blocks of 2 participants, we allocated the participant with the highest random value of the block to one group and the other with the lowest value to the other group. In case of discrepancies between the groups at the initial moment, we reallocated the participants to ensure equalization (Figure 1).

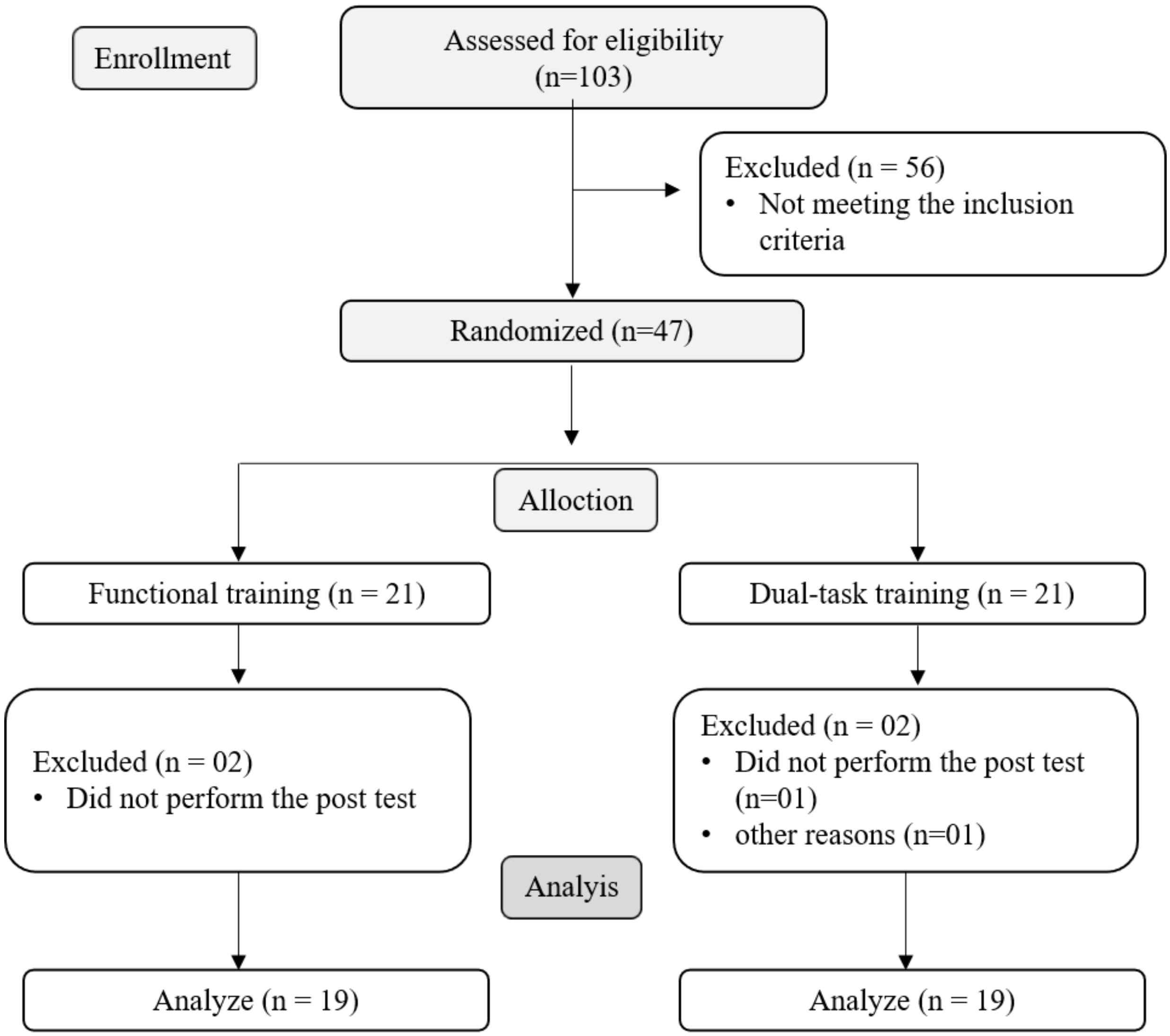

Figure 1. Flow diagram.

Intervention

Forty-eight training sessions were conducted in the morning by physical education professionals and physiotherapists, on non-consecutive days, 3 times a week, lasting approximately 1hour each. Professionals applied the circuit-based exercise protocols.[26] There was 1 professional for every 6 participants to ensure proper execution of the training, participant safety, and protocol progressions during the intervention (every 4 weeks).[27] Exercise intensity was assessed using the rate of perceived effort,[28] ranging from moderate to high.

Each training session for the FT group consisted of 4 parts: (1) movement preparation; (2) application of intermittent exercises with emphasis on power, coordination, and agility; (3) performance of multi-joint exercises for lower and upper limbs stimulating stabilizers spine muscles; and (4) intermittent activities.[27] DT group training sessions consisted of 5 parts: (1) mobility exercises, aiming to prepare for the following activities; (2) balance exercises in bi-pedal and uni-pedal support; (3) coordination exercises with and without displacement; (4) coordinative activity handling an implement concomitantly; and (5) stretching/relaxation. The training protocols description is shown in the supplemental file.

Outcomes

Primary outcomes were: (1) Pain Pressure Threshold (PPT), (2) Temporal Summation of Pain (TSP), and (3) Conditioned Pain Modulation (CPM). Secondary outcomes were: (1) Trunk Muscle Stability, (2) Trunk Muscle Strength, and (3) Trunk Muscle Endurance. The same evaluators applied all tests and were unaware of each participant's group allocation.

The evaluator evaluated the PPT using a digital pressure algometer with an area of 1 cm2 (Impac System®, São José dos Campos, SP, Brazil). The measurement was performed on the paravertebral and tibialis anterior muscles. In the lumbar region, PPT was bilaterally evaluated 5 cm from the spinous processes of L3 and L5.[29,30] In the tibialis anterior, the measurement was taken on the right leg, 5 cm below the tibial tuberosity.[31,32] The evaluator positioned the algometer perpendicularly to the patient's tissue and applied increasing pressure. The patient informed us when the pressure became painful. The average from 3 measurements was recorded.

TSP was assessed with the algometer positioned 7.5 cm above the wrist line, applying a constant pressure of 4 kg/cm^2. The participant verbally reported pain intensity using an 11-point numerical rating scale ranging from 0 to 10, with 0 representing no pain and 10 representing the worst pain imaginable, [33] during the 1st, 10th, 20th, and 30th seconds of stimulation. [34]

The researcher measured CPM on the right forearm to evaluate TSP, 7.5 cm from the wrist line. Next, a conditioned stimulus was applied by performing an ischemic compression of 270 mmHg on the contralateral arm using a sphygmomanometer (Mikatos®, Embu, SP, Brazil), positioned 3 cm proximal to the cubital fossa. The participant informed the pain intensity based on a numerical pain rating scale, and when the pain was 4 or higher, PPT was measured again.[34]

The participant sat on a stable and an unstable assent to measure trunk stability in a stable and unstable setup, respectively. Both seats allowed adjustments for each participant to maintain legs and feet at 90º knee and 110º hip flexion. Additionally, the evaluator fixed the participant's legs on the seat to prevent lower limb movements, and the participants crossed their arms over the chest. [35] One force plate (9286AA, Aracaju, SE, Brazil) was under the seat to record the center of pressure (CoP) displacement at 1000 Hz providing real-time feedback to the participants through a MatLab program (IMCM, Aracaju, SE, Brazil) displayed on a monitor (Samsung, LN32C530F1M, Manaus, AM, Brazil) positioned 2 meters in front of the seat.[36]

The researchers evaluated the maximum isometric strength of the trunk flexors and extensors with the participant sitting on an adjustable wooden seat with a slight trunk inclination. The lower limbs were fixed to the seat using a Velcro strap to isolate the trunk muscles, and the participant crossed their arms over the chest.[37] From this position, the maximum isometric strength for trunk extensors and flexors was verified using a load cell (Kyoto, 333 A, Hown Dong, South Korea) connected to the Chronojump software (Chronojump Boscosystem, Barcelona, Spain). The participant performed 1repetition for familiarization, followed by 3 maximum contractions of 5 seconds each, with a 30-second rest interval between each repetition, first for extensors and then for trunk flexors. The evaluator recorded the highest force values for analysis.[38]

The evaluator measured the trunk muscles' endurance, recording the maximum time the participant could hold each position using a stopwatch (iPhone Xr®, MH7M3, Zhengzhou, China). In all patterns, the participant rested for 1 minute between each attempt. The participant sat on a wooden wedge to evaluate the trunk flexors, aiming to maintain 60º of trunk flexion. Also, the participant kept their knees and hips at 90º of flexion and arms crossed over the chest. So, after the evaluator removed the wedge, the participant had to maintain the position as long as possible. For trunk extensors, the participant positioned themself in a prone position up to the height of the anterosuperior iliac crest on the edge of a stretcher. The evaluator attached the participant's lower limbs to the stretcher using 4 velcro straps. Then the participant should cross the upper limbs over their chest and hold this position as long as possible. Finally, to evaluate the trunk lateral flexors, the participant lying down in a lateral decubitus position on a mat with legs extended, the upper foot in front of the support foot, and the non-involved arm over the opposite shoulder. Then the evaluator asked them to raise the hip from the mat and maintain support on the elbow and foot with the whole body aligned as long as possible. The evaluator stopped the tests when the initial position was not maintained and recorded the longest time in each position.[39]

Statistical analysis

We estimated the sample size using G*Power[40] (version 3.1.9.4, University of Trier, Trier, Germany) based on the outcome variables of pain from the results obtained by Paungmali et al.[41] We adopted a test power of 80%, an alpha of 0.05, and an effect size of 0.4, which yielded a minimum of 32 volunteers (16 participants per group). Data were analyzed using the statistical software Jamovi (version 2.3.21). We presented all descriptive data as estimated marginal means, standard deviations (SD), and 95% confidence intervals (CI). Since all outcomes were continuous variables, we built 2 models to analyze them based on Generalized Linear Mixed Models (GLMM). We used a Gamma distribution model due to the data's asymmetry, based on the Akaike information criterion (AIC) and the visual inspection of the residuals by Q-Q plot graphs. We used the group (FT and DT), time (i.e., PRE and POST16), and the interaction effect (group × time) as fixed effects, and the participants' intercepts were used as a random effect to address individual variations in the repeated measures model. If 1 or more fixed effects were statistically significant, we performed post hoc pairwise comparisons (with Bonferroni adjustment) to identify the differences between pairs. We set the significance level at $p < 0.05$ for all analyses. Additionally, we calculated Cohen's d effect size[42] for main comparisons, interpreting the effect size value as small (0.2), moderate (0.5), and large (0.8).

Results

After randomization, 21 participants participated in each group. In the FT group, 2 older women missed the post-test measurements. In the DT group, 1 woman missed the post-test, and another dropped out due to health reasons. The final sample consisted of 19 participants in each group. There were no differences between the groups at baseline for the anthropometric and pain intensity variables (Table 1).

Table 1. Characterization of participants.

Variable	FT (19) Mean ± SD	DT (19) Mean ± SD	TOTAL (38) Mean ± SD	p
Age (years)	65.16 ± 5.15	68.26 ± 6.31	66.71 ± 5.90	.10
Body mass (kg)	66.90 ± 14.74	63.88 ±10.11	65.39 ±12.56	.46
Height (m)	1.53 ±0.06	1.52 ± 0.05	1.52 ± 0.05	.49
BMI (kg/m^2)	28.39 ± 5.90	27.60 ±4.07	28.00 ± 5.01	.63
Pain intensity on the day (0-10)	3.89 ± 1.62	3.84 ± 1.01	3.87 ± 1.33	.90
Pain intensity in the last week (0-10)	6.21 ±2.84	6.79 ± 2.65	6.50 ± 2.72	.52

Between-group comparisons based on independent t-tests (i.e., FT and DT). FT, functional training; DT, dual-task training; BMI, body mass index.

FT showed a superior effect to the DT (d = 0.94; p = .004) in lumbar pain pressure threshold, tibial anterior pain pressure threshold (d = 1.04; p = .003) and conditioned pain modulation (d = 0.84; p = .01). Specifically, both groups showed a large increase in lumbar pain pressure threshold (FT: d = 1.82; p < .001; DT: d = 1.10; p = .003) (Figure 2a). In contrast, FT showed a large increase in tibial anterior pain pressure threshold (d = 1.23; p < .001), while the DT showed a moderate and not significant increase (d = 0.60; p = .27) (Figure 2b). No group caused changes in the temporal summation of pain (p = .65) (Figure

2c). Finally, both groups showed large increases in conditioned pain modulation (FT: d = 1.60; p < .001; DT: d = 1.13 p = .009) (Figure 2d).

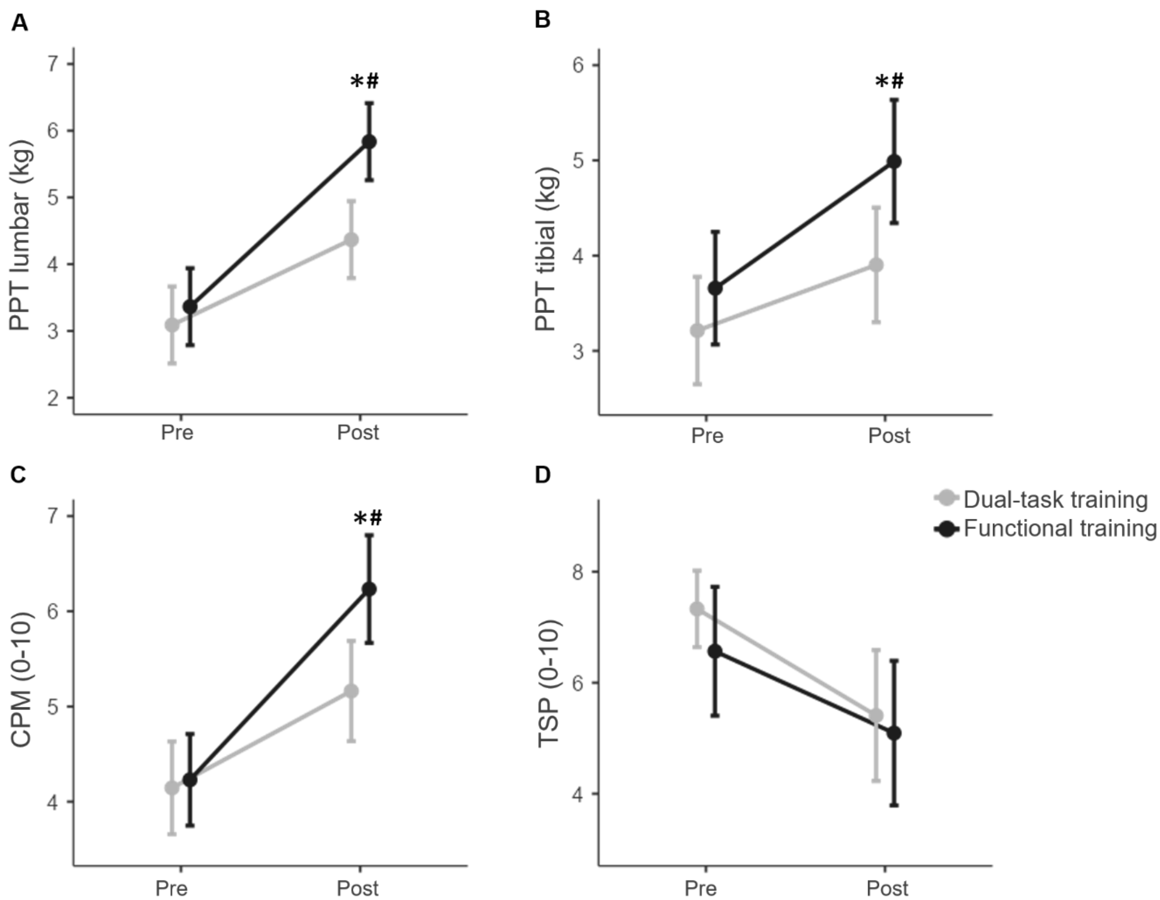

Figure 2. Effect of interventions on endogenous pain modulation in older women with nonspecific chronic low back pain. *Difference between pre-and post-test based on Bonferroni post hoc adjustment. # Difference between groups analyzed with Bonferroni post hoc. PPT, pain pressure threshold; TSP, temporal summation of pain; CPM, conditioned pain modulation.

Both functional training and dual-task training showed large increases in the trunk extensors' maximum isometric strength (FT: d = 2.14; p < .001; DT: d = 2.12; p < .001) without any difference between groups (p = .25). There was no effect on the extensors and lateral flexors endurance for the functional training (p > .05), while the dual-task training showed moderate increases for both (extensors: d = 0.77; p = .01; lateral flexors:

$d = 0.69$; $p < .001$), but without a difference between the groups ($p > .05$). Finally, none of the groups caused changes in trunk stability (stable circle: $p = .076$; unstable circle: $p = .64$), trunk flexors maximum isometric strength ($p = .641$), and trunk flexors endurance ($p = .14$) (Table 2).

Table 2. Effects of training protocols on investigated pain and trunk function variables in older women with nonspecific chronic low back pain.

Variable	Group	Pre	Post	Effect size	p inter	p time	p group
Trunk Muscle Stability Circular stable (cm) γ	Dual-task training	22.37±5.31	21.90±10.37	-0.06	.076	.018	.358
	95% CI	18.61 - 26.13	18.18 – 25.62				
	Functional training	21.47±9.83	18.12±5.88	-0.41			
	95% CI	17.51 - 25.43	14.27 – 21.96				
Trunk Muscle Stability Circular unstable (cm) γ	Dual-task training	25.78±9.43	21.95±5.25	-0.50	.647	< .001	.811
	95% CI	22.54 - 29.02	18.91 – 24.98				
	Functional training	25.77±8.02	21.01±4.93	0.72			
	95% CI	22.51 - 29.04	18.00 – 24.01				
Maximum isometric strength of extensors (N) γ	Dual-task training	214.60±49.40	473.35±165.60*	2.12	.040	< .001	.124
	95% CI	176.56 - 252.63	415.64 – 531. 06				
	Functional training	217.34±68.04	559.60±215.79*	2.14			
	95% CI	178.62 - 256.05	494.99 – 624.22				
Maximum isometric strength of flexors (N) γ	Dual-task training	183.71±41,48	561.73±141.54	3.62	.641	< .001	.139
	95% CI	151.63 - 215.79	507.79 – 615.67				
	Functional training	214.12±59.96	609.32±179.92	2.95			
	95% CI	181.97 - 246.28	551.42 – 667.23				
Endurance of extensors (s) γ	Dual-task training	58.20±56.29	106.18±67.42*	0.77	.018	.012	.875
	95% CI	34.69 - 81.70	73.90 – 138.45				
	Functional training	83.82±62.54	85.45±64.50	0.03			
	95% CI	59.36 - 108.28	59.34 – 111.55				
Endurance of flexors (s) +	Dual-task training	41.42±33.23	49.63±14.93	0.32	.149	.015	.108
	95% CI	17.98 - 64.86	26.19 – 73.08				
	Functional training	54.42±51.34	85.00±76.13	0.47			
	95% CI	30.98 - 77.86	61.56 – 108.44				
Endurance of the lateral flexors (s) γ	Dual-task training	11.87±14.93	22.47±15.96 *	0.69	< .001	.029	.466
	95% CI	17.56 - 34.53	14.25 – 30.70				
	Functional training	23.11±21.39	19.42±18.34	-0.19			
	95% CI	27.37 - 44.82	11.20 – 27.64				

γ Gamma distribution. + Gaussian distribution. * Difference from pre- to post-test based on Bonferroni post hoc adjustment. Cohen's effect size d up to 0.2 small, between 0.2 and 0.5 moderate, and above 0.8 large. Cm, centimeters; N, Newton; s, seconds

Discussion

Our main finding was that the FT protocol showed a reduction in lumbar and tibial PPT and CPM, while the DT protocol only promoted a reduction in lumbar PPT and CPM in older women with CNLBP. On the other hand, in terms of trunk function, TF showed improvement only in trunk extensor strength, while DT increased trunk extensor strength, the endurance of extensors, and lateral flexors.

Both groups increased the local PPT and CPM. Interestingly, only the FT increased the pain threshold in the anterior tibial (secondary pain). These results corroborate an acute study conducted in postmenopausal women, demonstrating that FT promotes an increase in β-endorphin release, which is related to an increased PPT and CPM.[43] Higher intensity exercises in FT (rate of perceived effort among 7 and 8) compared to DT (rate of perceived effort among 5 and 6) possibly explain the increased pain tolerance based on a higher β-endorphins release.[44,45] Additionally, the literature has shown that regular physical exercise promotes the activation of other mechanisms, such as the central nervous system and the immune system, which the reduction of pain[46].

DT reduced pain intensity, corroborating studies showing DT's positive effects on pain.[24] This positive effect could be related to stimulating central nervous system structures, such as the insula, pre-motor cortex, thalamus, and cerebellum, related to pain.[23] The rationale behind this assumption is the exercise-induced release of endogenous opioid substances[47] that possibly activates those regions.[44] Therefore, the statistically significant increase in PPT and CPM suggests a clinical improvement in pain tolerance.

Both groups increased trunk extensors' isometric strength, possibly due to the exercise execution transporting an object in front of the body, causing anterior displacement of the center of mass and, consequently, greater activation of the posterior chain to maintain an upright bipedal posture. Individuals with CNLBP demonstrate less lumbar extension strength than healthy individuals.[15] This difference is worse in older individuals due to the atrophy of the muscles involved in this action[11,48] which may favor exercise adaptations in this population. Therefore, an increased back extensor strength seems to be associated with reduced pain and improved trunk function.

Only the DT increased the trunk muscle endurance, specifically for back extensors and lateral flexors. The DT exercises may have favored endurance adaptations by stimulating postural maintenance. Furthermore, studies show that patients with CNLBP demonstrate a transition of type I to type II muscle fibers, which are more fatigable and more susceptible to exercise-induced changes.[49] Therefore, to our knowledge, this was the first study to show that DT reduces pain intensity and increases trunk muscles' maximum isometric strength and endurance.

Based on the significant increase in strength and endurance of the trunk muscles, we can infer a clinical improvement in the performance of activities of daily living and reducing physical disability since strength and power are necessary in several everyday activities and people with CNLBP presents less strength and power in the trunk muscles. Despite the widely used tests to assess trunk muscle strength in the literature and their good reliability[50,51], caution should be exercised when asserting that these muscles were predominant in the action performed.

Both groups showed no differences in TSP. However, these data diverge compared to other studies conducted longitudinally in CNLBP patients.[52,53] The TSP refers to the responses of type C fibers located in the posterior horn of the spinal cord, where the ascending pathways of pain facilitation begin. The greater sensitization of the central nervous system could be related to increased TSP.[54] Physical exercise can excite and inhibit the CNS, increasing or decreasing pain intensity.[55] Both protocols used in this study involved the activation of large muscle groups, theoretically leading to greater CNS excitability and resulting in the maintenance of TSP.

None of the protocols improved trunk stability, similar to a study by Low et al.[56] demonstrating the multicomponent training ineffectiveness for postural control in older adults. Low et al.[56] investigated healthy individuals, but individuals with CNLBP have structural and morphological changes in their trunk muscles[57] that can affect the coordination and strength of these muscles.[10,12] Another point to explain our results is the sitting position evaluation of trunk stability while all exercises in both protocols were performed standing. This difference could limit the transfer of training adaptations to the observed variable.

Both training protocols are highly replicable due to the low cost of the materials used. Additionally, our study conducted 16 weeks of training and performed randomization based on the results of functional test carried out by the study population and the evaluation of the trunk muscles, which were performed independently. Furthermore, the statistically significant improvement in trunk muscle strength and endurance suggests a clinical enhancement in performing activities of daily living, reducing physical disability.

Limitations

Despite the findings, it is necessary to consider some limitations of the study, such as the absence of a control group. Nonetheless, considering the exercise's effectiveness in pain management, it would be unethical not to offer any intervention for the patients. Also, even without a control group, we have made valuable inferences about pain and function in older women with CNLBP. It may be advantageous for future studies to consider exploring other exercise modalities. Another limitation of our study was the inclusion of only older women. However, considering the target population, our findings contribute valuable information to the scientific literature on aging and CNLBP. However, these limitations impact the generalization of the results. Furthermore, somatosensory aspects of pain, such as anxiety, depression, pain catastrophizing, and kinesiophobia, were not directly assessed, which limits our ability to make deeper inferences about these aspects despite discussing potential mechanisms involved in producing the observed results. Therefore, future studies should consider assessing these aspects to understand better their contributions to exercise's effects on pain management. However, it is important to note that the insertion of more predictors will require a higher number of participants.

Conclusion

Our results showed that both functional training and dual-task training were effective in promoting increased pain pressure threshold, improvement of conditioned pain modulation, and trunk function in older women with CNLBP, however, without effects on temporal summation of pain and trunk stability. These indicators show that the proposed training may promote pain attenuation and increased trunk function.

Funding: This study was financed in part by the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior - Brazil (CAPES; Process number: 88887.669792/2022-00; and Finance Code 001).

Declarations of interest: none

References:

1. Barrey CY, Le Huec JC. Chronic low back pain: Relevance of a new classification based on the injury pattern. Orthop Traumatol Surg Res. 2019;105(2):339–46. doi: 10.1016/j.otsr.2018.11.021

2. Gonzalez GZ, Da Silva T, Avanzi MA, et al. Low back pain prevalence in Sao Paulo, Brazil: A cross-sectional study. Braz J of Phys Ther. 2021;25(6):837-845. doi:10.1016/j.bjpt.2021.07.004

3. Saes-Silva E, Vieira YP, Saes MDO, et al. Epidemiology of chronic back pain among adults and elderly from Southern Brazil: a cross-sectional study. Braz J of Phys Ther. 2021;25(3):344-351. doi:10.1016/j.bjpt.2020.12.005

4. Global, regional, and national incidence, prevalence, and years lived with disability for 354 diseases and injuries for 195 countries and territories, 1990-2017: A systematic analysis for the Global Burden of Disease Study 2017. Lancet. 2018;392(10159):1789-1858. doi:10.1016/s0140-6736(18)32279-7.

5. Wu A, March L, Zheng X, et al. Global low back pain prevalence and years lived with disability from 1990 to 2017: Estimates from the global burden of disease study 2017. Ann Transl Med. 2020;8(6):1-14. doi:10.21037/atm.2020.02.175

6. Bartley EJ, Fillingim RB. Sex differences in pain: a brief review of clinical and experimental findings. Br J Anaesth. 2013;111(1):52-58. doi:10.1093/bja/aet127

7. Fillingim RB, King CD, Ribeiro-Dasilva MC, Rahim-Williams B, Riley JL. Sex, gender, and pain: A review of recent clinical and experimental findings. J Pain. 2009;10(5):447-485. doi:10.1016/j.jpain.2008.12.001

8. Brumagne S, Diers M, Danneels L, Moseley GL, Hodges PW. Neuroplasticity of sensorimotor control in low back pain. J Orthop Sports Phys Ther. 2019;49(6):402-414. doi:10.2519/jospt.2019.8489

9. McPhee ME, Vaegter HB, Graven-Nielsen T. Alterations in pro-nociceptive and anti-nociceptive mechanisms in patients with low back pain: A systematic review with meta-analysis. Pain. Pain. 2020;161(3):464-475. doi:10.1097/j.pain.0000000000001737

10. Della Volpe R, Popa T, Ginanneschi F, Spidalieri R, Mazzocchio R, Rossi A. Changes in coordination of postural control during dynamic stance in chronic low back pain patients. Gait Posture. 2006;24(3):349-355. doi:10.1016/j.gaitpost.2005.10.009

11. Lacour M, Bernard-Demanze L, Dumitrescu M. Posture control, aging, and attention resources: Models and posture-analysis methods. Neurophysiol clin. 2008;38(6):411-421. doi:10.1016/j.neucli.2008.09.005

12. Gill KP, Callaghan MJ. The measurement of lumbar proprioception in individuals with and without low back pain. Spine (Phila Pa 1976). 1998;23(3):371-377. doi:10.1097/00007632-199802010-00017

13. Hodges PW, Richardson CA. Altered trunk muscle recruitment in people with low back pain with upper limb movement at different speeds. Arch Phys Med Rehabil. 1999;80(9):1005-1012. doi:10.1016/s0003-9993(99)90052-7

14. Lam SS, Jull G, Treleaven J. Lumbar spine kinesthesia in patients with low back pain. J Orthop Sports Phys Ther. 1999;29(5):294-299. doi:10.2519/jospt.1999.29.5.294

15. Pranata A, Perraton L, El-Ansary D, et al. Lumbar extensor muscle force control is associated with disability in people with chronic low back pain. Clin Biomech (Bristol, Avon). 2017;46:46-51. doi:10.1016/j.clinbiomech.2017.05.004

16. Mueller J, Niederer D. Dose-response-relationship of stabilization exercises in patients with chronic non-specific low back pain: A systematic review with meta-regression. Sci Rep. 2020;10(1):1-23. doi:10.1038/s41598-020-73954-9

17. Corrêa JB, Costa LO, de Oliveira NT, Sluka KA, Liebano RE. Central sensitization and changes in conditioned pain modulation in people with chronic nonspecific low back pain: A case-control study. Exp Brain Res. 2015;233(8):2391-2399. doi:10.1007/s00221-015-4309-6

18. Hoffman MD, Shepanski MA, Mackenzie SP, Clifford PS. Experimentally induced pain perception is acutely reduced by aerobic exercise in people with chronic low back pain. J Rehabil Res Dev. 2005;42(2):183-190. doi:10.1682/jrrd.2004.06.0065

19. Meeus M, Hermans L, Ickmans K, et al. Endogenous pain modulation in response to exercise in patients with rheumatoid arthritis, patients with chronic fatigue syndrome and

comorbid fibromyalgia, and healthy controls: A double-blind randomized controlled trial. Pain Pract. 2015;15(2):98-106. doi:10.1111/papr.12181

20. Naugle KM, Fillingim RB, Riley JL. A meta-analytic review of the hypoalgesic effects of exercise. J Pain. 2012;13(12):1139-1150. doi:10.1016/j.jpain.2012.09.006

21. Oliveira MAS, Fernandes RSC, Daher SS. Impact of exercise on chronic pain. Rev. Bras. Med Sport. 2014;20(3):200-203. https://doi.org/10.1590/1517-86922014200301415

22. Da Silva-Grigoletto ME, Mesquita MMA, Aragão-Santos JC, et al. Functional training induces greater variety and magnitude of training improvements than traditional resistance training in elderly women. J Sports Sci Med. 2019;18(4):798-797. https://pmc.ncbi.nlm.nih.gov/articles/PMC6873136/

23. Bantick SJ, Wise RG, Ploghaus A, Clare S, Smith SM, Tracey I. Imaging how attention modulates pain in humans using functional MRI. Brain. 2002;125(2):310-319. doi:10.1093/brain/awf022

24. Merchant RA, Au L, Seetharaman S, et al. Association of pain and impact of dual-task exercise on function, cognition and quality of life. J Nutr Health Aging. 2021;25(9):1053-1063. doi:10.1007/s12603-021-1671-x

25. Schulz KF, Altman DG, Moher D. CONSORT 2010 statement: Updated guidelines for reporting parallel group randomized trials. BMJ. 2010;340:c332. doi: 10.1136/bmj.c332

26. Buch A, Kis O, Carmeli E, et al. Circuit resistance training is an effective means to enhance muscle strength in older and middle aged adults. Ageing Res Rev. 2017;37:16-27. doi:10.1016/j.arr.2017.04.003

27. Resende-Neto AG, Da Silva-Grigoletto ME. Systematization of functional training sessions to benefit physical fitness for daily activities in older people. Int J Sports Exerc Med. 2020;6(1):1-4. doi:10.23937/2469-5718/1510157

28. Da Silva-Grigoletto ME, Viana-Montaner BH, Heredia J, Mata FO, Pena G, Brito CJ. et al. Validación de la escala de valoración subjetiva del esfuerzo OMNI-GSE para el control de la intensidad global en sesiones de objetivos múltiples en personas mayores. Rev Universit Activ Fisic deport. 2013;12(1):32-40. http://hdl.handle.net/11268/2869

29. Corrêa JB, Costa LO, Oliveira NT, Sluka KA, Liebano RE. Central sensitization and changes in conditioned pain modulation in people with chronic nonspecific low back pain: a case-control study. Exp Brain Res. 2015;233(8):2391-2399. doi:10.1007/s00221-015-4309-6

30. Corrêa JB, Costa LO, Oliveira NT, Sluka KA, Liebano RE. Effects of the carrier frequency of interferential current on pain modulation in patients with chronic nonspecific low back pain: A protocol of a randomised controlled trial. BMC Musculoskelet Disord. 2013;195(14):1-7. doi:10.1186/1471-2474-14-195

31. Dailey DL, Rakel BA, Vance CG, et al. Transcutaneous electrical nerve stimulation reduces pain, fatigue and hyperalgesia while restoring central inhibition in primary fibromyalgia. Pain. 2013;154(11):2554-2562. doi:10.1016/j.pain.2013.07.043

32. O'Neill S, Kjaer P, Graven-Nielsen T, Manniche C, Arendt-Nielsen L. Low pressure pain thresholds are associated with, but does not predispose for, low back pain. Eur Spine J. 2011;20(12):2120-2125. doi:10.1007/s00586-011-1796-4

33. Karcioglu O, Topacoglu H, Dikme O. A systematic review of the pain scales in adults: Which to use? Am J Emerg Med. 2018;36(4):707-714. doi:10.1016/j.ajem.2018.01.008

34. Leite PMS, Mendonça ARC, Maciel LYS, et al. Does Electroacupuncture treatment reduce pain and change quantitative sensory testing responses in patients with chronic nonspecific low back pain? A randomized controlled clinical trial. Evid Based Complement Alternat Med. 2018;(1):1-8. doi:10.1155/2018/8586746

35. Barbado D, Lopez-Valenciano A, Juan-Recio C, Montero-Carretero C, Van Dieën JH, Vera-Garcia FJ. Trunk stability, trunk strength and sport performance level in judo. PLoS ONE. 2016;11(5):11-12. doi:10.1371/journal.pone.0156267

36. Pereira LCD, Santos MS, Carvalho EÁN. Reproducibility of a trunk stability evaluation instrument in individuals with non-specific chronic low back pain. Inter jour inn stud medic scien. 2020;4(1);12-17. https://ijisms.org/storage/Volume4/Issue1/IJISMS-040103.pdf

37. Sutarno CG, McGill SM. Isovelocity investigation of the lengthening behaviour of the erector spinae muscles. Eur J Appl Physiol. 1995;70(2):146-153. doi:10.1007/BF00361542

38. Mesquita MMA, Santos MS, Vasconcelos ABS, et al. Reliability of a test for assessment of isometric trunk muscle strength in elderly women. J Aging Res. 2019;(1):1-6. doi:10.1155/2019/9061839

39. McGill SM, Childs A, Liebenson C. Endurance times for low back stabilization exercises: clinical targets for testing and training from a normal database. Arch Phys Med and Rehabil. 1999;80(8):941-944. doi:10.1016/S0003-9993(99)90087-4

40. Faul F, Erdfelder E, Lang A, Buchner A. G*Power 3: a flexible statistical power analysis program for the social, behavioral, and biomedical sciences. Behav Res Methods. 2007;39(2):175-191. doi: 10.3758/bf03193146

41. Paungmali A, Joseph LH, Punturee K, Sitilertpisan P, Pirunsan U, Uthaikhup S. Immediate effects of core stabilization exercise on β-endorphin and cortisol levels among patients with chronic nonspecific low back pain: A randomized crossover design. J Manipulative Physiol Ther. 2018;41(3):181-188. doi:10.1016/j.jmpt.2018.01.002

42. Cohen J. Statistical power analysis for the behavioral sciences. 2nd ed. L. Erlbaum Associates; 1988.

43. Santos MS, Santos PJ, Vasconcelos ABS, et al. Neuroendocrine effects of a single bout of functional and core stabilization training in women with chronic nonspecific low back pain: a crossover study. Physiol Rep. 2022;10(17):1-12. doi:10.14814/phy2.15365

44. Kraemer WJ, Fleck SJ, Callister R, et al. Training responses of plasma beta-endorphin, adrenocorticotropin, and cortisol. Med Sci Sports Exerc. 1989;21(2):146-153. https://pubmed.ncbi.nlm.nih.gov/2540392/

45. Koltyn KF. Analgesia following exercise: A review. Sports Med. 2000;29(2):85-98. doi:10.2165/00007256-200029020-00002

46. Sluka kA, Frey-Law L, Bement MH. Exercise-induced pain and analgesia? Underlying mechanisms and clinical translation. Pain. 2018;159(1):91-97. DOI: 10.1097/j.pain.0000000000001235

47. Jones AKP, Qi L, Fujirawa T, et al. In vivo distribution of opioid receptors in man in relation to the cortical projections of the medial and lateral pain systems measured with positron emission tomography. Neurosci Lett. 1991;126(1):25-28. doi:10.1016/0304-3940(91)90362-W

48. Shahtahmassebi B, Hebert JJ, Hecimovich MD, Fairchild TJ. Associations between trunk muscle morphology, strength and function in older adults. Sci Rep. 2017;7(1):1-10. doi:10.1038/s41598-017-11116-0

49. Mannion AF, Weber BR, Dvorak J, Grob D, Müntener M. Fibre type characteristics of the lumbar paraspinal muscles in normal healthy subjects and in patients with low back pain: Back pain and paraspinal muscle fibre types. J Orthop Res. 1997;15(6):881-887. doi:10.1002/jor.1100150614

50. Martínez-Romero, MR et al. A meta-analysis of the reliability of four field-based trunk extension endurance tests. Int J Environ Res Public Health. 2020;17(9):3088. doi: 10.3390/ijerph17093088

51. Cuenca-Garcia, M et al. Reliability of field-based fitness tests in adults: A systematic review. Sports Med. 2022;52(8):1961-1979. doi: 10.1007/s40279-021-01635-2

52. Henriksen M, Klokker L, Graven-Nielsen T, et al. Association of exercise therapy and reduction of pain sensitivity in patients with knee osteoarthritis: A randomized controlled trial. Arthritis Care Res (Hoboken). 2014;66(12):1836-1843. doi:10.1002/acr.22375

53. Naugle KM, Riley JL. Self-reported physical activity predicts pain inhibitory and facilitatory function. Med Sci Sports Exerc. 2014;46(3):622-629. doi:10.1249/MSS.0b013e3182a69cf1

54. Koltyn KF, Knauf MT, Brellenthin AG. Temporal summation of heat pain modulated by isometric exercise. Eur J Pain. 2013;17(7):1005-1011. doi:10.1002/j.1532-2149.2012.00264.x

55. Lima LV, Abner TSS, Sluka KA. Does exercise increase or decrease pain? Central mechanisms underlying these two phenomena. J Physiol. 2017;595(13):4141-4150. doi:10.1113/jp273355

56. Low DC, Walsh GS, Arkesteijn M. Effectiveness of exercise interventions to improve postural control in older adults: A systematic review and meta-analyses of centre of pressure measurements. Sports Med. 2017;47(1):101-112. doi:10.1007/s40279-016-0559-0

57. Van Dieën JH, Reeves NP, Kawchuk G, Van Dillen LR, Hodges PW. Motor control changes in low back pain: divergence in presentations and mechanisms. J Orthop Sports Phys Ther. 2019;49(6):370-379. doi:10.2519/jospt.2019.7917

Supplemental file

Table S1. A detailed description of the Functional Training and Dual-Task protocols over 16 weeks.

FUNCTIONAL TRAINING			
PREPARATION/MOBILITY			
WEEK (1-4)	**WEEK (5-8)**	**WEEK (9-12)**	**WEEK (13-16)**
Two movement patterns for the main joints (glenohumeral, hip, and ankle) Frontal displacement + high knee skipping	Three movement patterns for the main joints Frontal displacement + high knee skipping + change of direction for skipping	Three movement patterns for the main joints Lateral displacement + air jump rope + reaction time for changing direction	Three movement patterns for the main joints Lateral displacement + air jump rope + change of direction + reaction time for squat or step
WORK/REST RATIO 40/40	**WORK/REST RATIO 40/30**	**WORK/REST RATIO 40/20**	**WORK/REST RATIO 40/15**
AGILITY + COORDINATION + POWER			
Ladder agility level 1	**Ladder agility level 2**	**Ladder agility level 3**	**Ladder agility level 4**
"Two-foot run" "One-sided icky shuffle" "In, in, out, out"	"Ladder taps" "Two-sided icky shuffle" "Two-sided icky shuffle touching a cone"	"Two-foot lateral run" "One-footed lateral in, in, out, out" "Two-footed lateral in, in, out, out"	"Two forward 1 back" "Straddle squat hops" "Straddle squat hops lateral"
Battle rope level 1	**Battle rope level 2**	**Battle rope level 3**	**Battle rope level 4**
Bilateral up and down waves	Unilateral up and down waves	Bilateral side-to-side waves	Inside and outside circles
Medicine ball throw level 1	**Medicine ball throw level 2**	**Medicine ball throw level 3**	**Medicine ball throw level 4**
Slams	Hip drive and bilateral press	Hip drive and unilateral press	Same-side rotational throw
Step up and down level 1	**Step up and down level 2**	**Step up and down level 3**	**Step up and down level 4**
Frontal	Frontal jump	Lateral	Lateral jump
Between cones displacement level 1	**Between cones displacement level 2**	**Between cones displacement level 3**	**Between cones displacement level 4**
Forward shuffle between cones	Forward weave-around cones	Lateral shuffle between cones	Lateral weave-around cones
MULTI-JOINT EXERCISES FOR LOWER AND UPPER			
Deadlift level 1	**Deadlift level 2**	**Deadlift level 3**	**Deadlift level 4**

Conventional	Side lunge unilateral	Suitcase unilateral	Suitcase alternating arms
Goblet squat level 1	**Goblet squat level 2**	**Goblet squat level 3**	**Globet squat level 4**
Conventional	Kettlebell pick-up and set-down	Kettlebell pick-up and set-down, finishing on toes	Unilateral shoulder-loaded
Farmer's walk level 1	**Farmer's walk level 2**	**Farmer's walk level 3**	**Farmer's walk level 4**
Bilateral	Unilateral	Unilateral alternating arms	Bilateral with asymmetric weights
Rowing level 1	**Rowing level 2**	**Rowing level 3**	**Rowing level 4**
Neutral grip	Neutral grip with more inclination	Supinated grip	Pronated grip
Chest press level 1	**Chest press level 2**	**Chest press level 3**	**Chest press level 4**
Bilateral standing with elastic band	Bilateral standing with elastic band and knee raise	Unilateral standing with elastic band	Unilateral standing with elastic band and knee raise
INTERMITTENT ACTIVITIES			
Relay race	Relay race + zigzag pattern between cones	Relay race + zigzag pattern laterally between cones	Relay race + zigzag pattern laterally around cones
RPE 7	RPE 7	RPE 8	RPE 8
DUAL-TASK TRAINING			
MOBILITY			
WEEK (1-4)	**WEEK (5-8)**	**WEEK (9-12)**	**WEEK (13-16)**
Mobility + Stability Evocation			
BALANCE			
Bipedal level 1	**Bipedal level 2**	**Bipedal level 3**	**Bipedal level 4**
Feet together + ball transfer from one hand to the other	Semi-tandem + single-handed ball movement from top to bottom and bottom to top	Tandem + ball transfer from one hand to the other	Tandem + balance the ball on the palm of the hand, moving it from left to right
Unipedal level 1	**Unipedal level 2**	**Unipedal level 3**	**Unipedal level 4**
Using a balance aid stick + facing a partner +	Without the aid stick + facing a partner +	Holding a ball with one hand + facing a partner +	Holding a ball with one hand + facing a partner +

naming a fruit and the partner responding with the name of another fruit without repetition	naming a city and the partner responding with the name of another city without repetition	naming a city and transferring a ball from one hand to the other + the partner that should respond with the name of another city in the same way	naming a city and passing the ball to the partner that should respond with the name of another city and pass the ball back
Straight line walking level 1	**Straight line walking level 2**	**Straight line walking level 3**	**Straight line walking level 4**
Walking over a 20 centimeters line + balancing a horizontal stick	Walking over a 10 centimeters line + balancing a horizontal stick	Walking over a 10 centimeters line + transferring a ball from one hand to the other	Walking over a 10 centimeters line + balance the ball on the palm of the hand
COORDINATION WITHOUT AND WITH DISPLACEMENT			
Without displacement level 1	**Without displacement level 2**	**Without displacement level 3**	**Without displacement level 4**
Stationary march + 1, 2, stop + 1, 2, 3, stop	Stationary march + 1, 2, stop + 1, 2, 3, stop + Visual command to alternate between 1,2, stop and 1, 2, 3, stop	Stationary march + verbal command to stop	Stationary march + visual command to stop
With displacement level 1	**With displacement level 2**	**With displacement level 3**	**With displacement level 4**
Laterally	Laterally + arms opening and closing horizontally	Laterally + arms opening and closing horizontally and vertically	Laterally + arms opening and closing horizontally, vertically, and diagonally
COORDINATION WITH IMPLEMENT			
Level 1	**Level 2**	**Level 3**	**Level 4**
In-line formation + passing the ball laterally + naming fruits	In-line formation + passing the ball over the head and the next person in line passing the ball between the legs + naming countries	In-line formation + passing the ball over the head or between the legs accordingly to verbal command + counting in increments of 3	In-line formation + passing the ball over the head or between the legs accordingly to visual command + counting in increments of 7
COOL DOWN			
Flexibility + Breathing exercises			
RPE 5	RPE 5	RPE 6	RPE 6

RPE, rate of perceived effort.

3.4. ESTUDO 4: *Functional vs. dual-task training effects on trunk muscle function and functional fitness in older women with and without chronic low back pain: A randomized clinical trial*

Artigo publicado no *Gait & Posture* em 2024.

https://doi.org/10.1016/j.gaitpost.2024.08.080

Fator de impacto da revista: 2.2

Gait & Posture 114 (2024) 35–41

Contents lists available at ScienceDirect

Gait & Posture

journal homepage: www.elsevier.com/locate/gaitpost

Functional vs. dual-task training effects on trunk muscle function and functional fitness in older women with and without chronic low back pain: A randomized clinical trial[☆]

Poliana de Jesus Santos [a,*], José Carlos Aragão-Santos [b], Elyson Ádan Nunes Carvalho [c], Marzo Edir Da Silva-Grigoletto [d]

[a] Physiological Sciences Graduate Program, Federal University of Sergipe, Department of Physiology, Cidade Univ. Prof. José Aloísio de Campos Av. Marechal Rondon, s/n, Jd. Rosa Elze, São Cristóvão, SE, Brazil

[b] Health Sciences Graduate Program, Federal University of Sergipe, Department of Medicine, Cidade Univ. Prof. José Aloísio de Campos Av. Marechal Rondon, s/n, Jd. Rosa Elze, São Cristóvão, SE, Brazil

[c] Departament of Electrical Engineering, Federal University of Sergipe, Cidade Univ. Prof. José Aloísio de Campos Av. Marechal Rondon, s/n, Jd. Rosa Elze, São Cristóvão, SE, Brazil

[d] Department of Physical Education, Federal University of Sergipe, Cidade Univ. Prof. José Aloísio de Campos Av. Marechal Rondon, s/n, Jd. Rosa Elze, São Cristóvão, SE, Brazil

ARTICLE INFO

Keywords:
Core stability
Chronic pain
Aging
Exercise

ABSTRACT

Introduction: Non-specific chronic low back pain (CLBP) predominantly affects women aged 40–80 years. Physical exercise is a primary treatment form, with functional training (FT) and dual-task training (DT) emerging as potential modalities due to their distinct characteristics. However, limited information exists regarding the effects of these exercise modalities on CLBP.

Objective: To compare the FT and DT effects on trunk function and functional fitness in CLBP older women.

Methodology: This was a randomized clinical trial with two training groups (FT and DT) and CLBP and non-CLBP individuals. We assessed the trunk stability, maximum isometric strength, endurance of trunk muscles, and functional fitness before and after 16 weeks of training

Results: We found only time effects for circular stability and instability ($p < .001$), flexors ($p = .006$), and extensors endurance ($p < .001$). For the lateral flexors, there was an average reduction of 17.3 units in lateral flexor endurance in the FT compared to the DT in CLBP individuals. For the strength of the flexor, CLBP individuals exhibited an increase of 69.3 units compared to non-CLBP. For the strength of extensors, CLBP individuals showed a decrease of 75.1 units compared to non-CLBP individuals. We identified a time effect for all functional fitness measures ($p < .050$)

Conclusion: FT and DT increase trunk stability, maximum isometric strength, and endurance of trunk muscles, besides the functional fitness of CLBP older women

Significance: Professionals can choose either training type, as there are no differences in the initial 16 weeks of intervention.

1. Introduction

Non-specific chronic low back pain (CLBP) is the primary cause of disability worldwide, with a higher prevalence among women aged between 40 and 80 years [1]. Despite lacking a justifiable reason, mechanical factors such as disorders in muscles, tendons, and ligaments contribute to the onset or exacerbation of the condition [2]. Moreover, the decline in muscle function among older women [3], combined with pain, contributes to reduced functional fitness and quality of life.

Physical exercise is currently the primary recommendation as a non-pharmacological treatment for various subcategories of chronic pain [4]. Functional training (FT) has shown effectiveness in improving trunk

☆ Brazilian Clinical Trials Registry under the number RBR-3xf7v9k (https://ensaiosclinicos.gov.br/rg/RBR-3xf7v9k).

* Correspondence to: Department of Physiology, Cidade Univ. Prof. José Aloísio de Campos Av. Marechal Rondon, s/n, Jd. Rosa Elze, São Cristóvão, SE, Brazil.
E-mail address: polianasantos.28@hotmail.com (P.J. Santos).

https://doi.org/10.1016/j.gaitpost.2024.08.080
Received 22 December 2023; Received in revised form 4 July 2024; Accepted 25 August 2024
Available online 30 August 2024

muscle function and functional fitness in non-CLBP older women [5,6]. Dual-task training (DT), on the other hand, has been demonstrated to reduce trunk instability in CLBP individuals but not in healthy individuals [7], and it improves functional fitness in asymptomatic older women [8]. Thus, both interventions appear beneficial for older women regardless of CLBP.

The improvement in trunk function and functional fitness resulting from FT is achieved by performing multi-joint and multi-planar movements that resemble activities of daily living (ADL), such as pushing, pulling, squatting, and carrying. Executing these movements requires increased activation of the core musculature, leading to positive neuromuscular adaptations in this region [5]. DT can impact higher cognitive and sensory processes, which contribute to postural control [9]. Postural oscillation decreases when healthy participants perform a balance and cognitive task simultaneously.

Thus, it is evident that both modalities bring benefits to the trunk function of healthy individuals. However, studies show that the population affected by CLBP experiences a reduction in functional fitness making it difficult to perform basic daily activities [10]. Therefore, training used as a treatment for CLBP should also focus on improving the functional fitness of this population. Despite the benefits of FT on functional fitness, most studies have been conducted on pain-free populations, while DT has primarily been conducted acutely, investigating its effects exclusively on trunk function. Consequently, it remains unclear which of the two modalities is more effective in the long term at promoting improvements in trunk function and functional fitness in CLBP older women. We compared the effects of functional training and dual-task training on trunk function and functional fitness in this population. We hypothesized that FT would provide greater benefits than DT.

2. Methodology

2.1. Experimental design

This randomized clinical trial lasted 22 weeks (April to October 2022). Three weeks were used for the pre-test, sixteen weeks for training application, and three weeks for the post-test (Fig. 1). The study was conducted at the Department of Physical Education of the proposing university and registered in the Brazilian Clinical Trials Registry under the number RBR-3xf7v9k (https://ensaiosclinicos.gov.br/rg/RBR-3xf7v9k). The primary outcome was the trunk muscle function, and the secondary was the functional fitness. This study adhered to the recommendations of the Consolidated Standards of Reporting Trials (CONSORT) statement [11].

2.2. Participants

The participants were recruited through leafleting around the university being eligible when women aged between 60 and 79 years clinically diagnosed CLBP lasting more than three months, pain intensity higher than three on an 11-point numeric pain scale. Additionally, participants should not have been undergoing any pain treatment at the start of the intervention. The exclusion criteria were: having undergone spinal surgery, engaging in regular physical exercise in the last six months, undergoing any pain treatment, and using analgesic, anti-inflammatory, opioid, or immunosuppressive medication. Additionally, individuals with motor, psychiatric, or cognitive impairments, and/or auditory, visual, or communication disorders were also excluded. The non-CLBP individuals served as a reference group for those CLBP. For this purpose, the non-CLBP participants do not have CLBP and attended the same exclusion criteria applied to the CLBP group. Participants who missed the post-intervention assessment were excluded from the study. The Institutional Human Research Ethics Committee approved the study under Opinion No. 5877,035, and we followed the principles of the Helsinki Declaration. Those who agreed to participate voluntarily signed the Informed Consent Form before commencing the study.

2.3. Randomization

Three researchers were involved in the participants' randomization. One conducted their registration, another performed the randomization, and the last one informed each participant of their allocated group. These researchers were not involved in the evaluation and training implementation. The researcher responsible for statistical analysis ordered the participants in ascending order according to Timed Up and Go (TUG) test values. A computerized random number generator (Microsoft Corp, Redmond, WA) was used to compute a random value for each participant. Using blocks of two participants, we allocated the participant with the higher random value in each block to one group and the participant with the lower value to the other group. If there were discrepancies between groups at baseline, participants were reallocated to ensure the homogeneity between groups (Fig. 2).

2.4. Sample size calculation

The sample size was calculated using G*Power software [12] (version 3.1.9.4, University of Trier, Trier, Germany) based on Sipaviciene and Kliziene results [13] for flexor strength (f = 0.45) and trunk extensor strength (f = 0.22). Assuming an 80 % power, 0.05 for alpha, and adopting the smaller effect size, the minimum required sample size was 64 participants were included in the experimental design, comprising four groups with two measures (repeated measures, within-between interaction). Thus, a minimum of 16 participants per group was required. However, considering a possible sample loss of approximately 10 % of the total, 72 participants were included, resulting in a minimum of 18 participants per group.

2.5. Intervention

The training sessions were conducted in the morning, lasting approximately one hour each, thrice a week, on non-consecutive days, totaling 48 training sessions. All exercises were applied in a circuit format and supervised by physical exercise professionals, with one professional for every six participants. Progressions in the protocols were made after four weeks [14], and exercise intensity was assessed

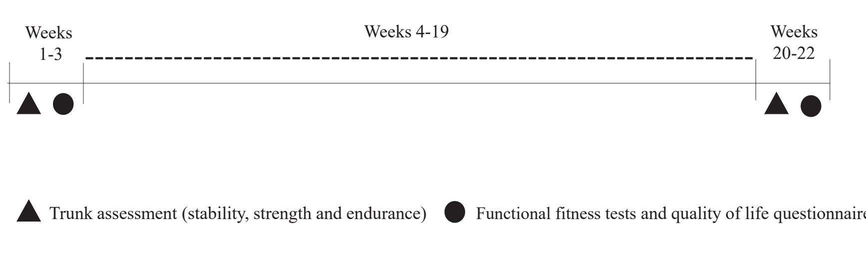

Fig. 1. Experimental design.

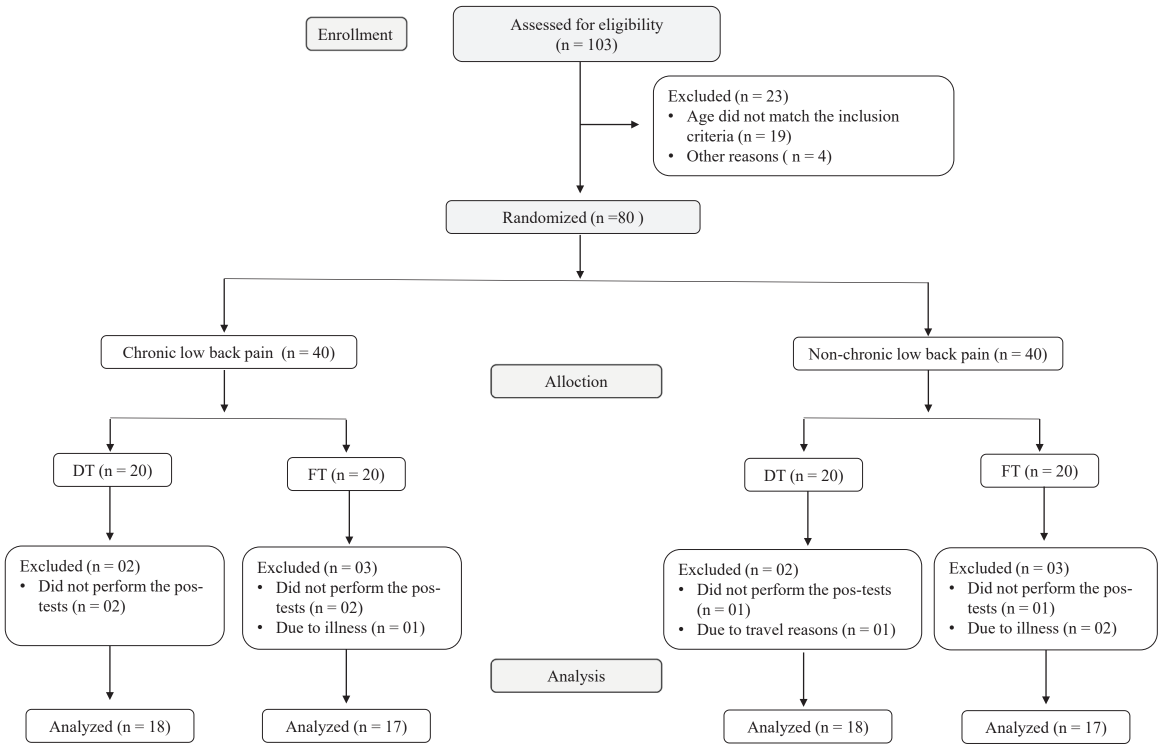

Fig. 2. Flow diagram. DT, dual-task training; FT, functional training; n, number of participants.

using perceived exertion rate [15], ranging from moderate to high.

The functional training (FT) sessions comprised four parts: (1) mobility and stabilization; (2) intermittent exercises for power, coordination, and agility; (3) multi-joint exercises for lower and upper extremities recruiting stabilization spine muscles; and (4) cardiometabolic intermittent activities [14].

Dual-task training (DT) was comprised five parts: (1) mobility exercises; (2) balance exercises in bipedal and unipedal support; (3) coordination with and without displacement; (4) coordinative transfer activity with an implement; (5) stretching/relaxation. The secondary cognitive task consisted of word recall, counting up and down, and mathematical operations.

Detailed information regarding the training protocols is presented in supplementary material. For more information, see Pantoja-Cardoso [16].

2.6. Outcome

All trunk function tests were conducted on one day and the functional fitness tests on the next day, respecting a 24-hour interval. All tests were conducted in the morning between 8 and 10 AM, with at least a one-minute interval between each test. The evaluators were unaware of each participant's training group.

Two seats (stable and unstable) connected with a force platform (9286AA, Aracaju, SE, Brazil) were used for the trunk stability assessment [17] The sample rate was 1000 Hz and participants received real-time feedback about the center of pressure (CoP) displacement through Matlab software (IMCM, Aracaju, SE, Brazil), displayed on a monitor (Samsung, LN32C530F1M, Manaus, AM, Brazil) positioned two meters in front of the seat [18]. The seats were adjusted for each patient to maintain 90º knee and 110º hip flexion. From this position, two experiments were conducted: "stable circular with feedback" and "unstable circular with feedback". The outcome of the stability tests was the COP displacement measured in centimeters.

The maximum isometric strength of the trunk muscles was assessed with participants seated on an adjustable wooden seat designed to isolate the trunk muscles [19]. Each participant was connected to a load cell (Kyoto, 333 A, Hown Dong, South Korea) linked to Chronojump software (Chronojump Boscosystem, Barcelona, Spain), enabling muscular force measurement in newtons (N) [20]. The load cell was connected to the volunteer using a strap, allowing the recording of the maximum isometric contraction of the trunk extensors and flexors.

The assessment of trunk flexor endurance was performed with the participant seated, back supported by a wooden wedge, knees, and hips flexed at 90°, feet fixed to the ground, and hands crossed over the shoulders. After removing the wedge support, the participant was instructed to maintain the initial position. For trunk extensors, participants were positioned with the upper trunk over the edge of the examination table, at the level of the anterior superior iliac spine, with arms crossed in front of the chest and lower limbs secured to the table with Velcro straps. The maximum time this position was maintained was timed. To evaluate the lateral flexors, the volunteers were positioned in lateral decubitus, legs extended, and the uninvolved arm placed over the opposite shoulder. Participants were instructed to lift the hip off the mat and support themselves on the elbow and foot, maintaining alignment of the entire body [21]. The test was concluded when the initial position could no longer be sustained.

Functional fitness was assessed using the following tests all time-based with shorter times indicating better performance: gallon-jug shelf-transfer test (GJST), which consists of transferring gallons from a lower shelf to an upper shelf of a rack [22]; put on and take off a t-shirt (PTS) [23]; timed up and go (TUG), get up from a chair, walk a distance of 3 m, return and sit down [24]; 10 m walk (W10m), walk at a comfortable pace 10 meters [25]; standing up from the prone position (SPP), rising from the prone position and standing [26]; five times sit-to-stand test (FTSS), sit and stand five times [27].

2.7. Statistical analysis

The data was analyzed using the statistical software Jamovi (version 2.4.5). Continuous data were expressed as mean, standard deviation, and 95 % confidence interval, while categorical data were presented through relative and absolute frequencies. Generalized Linear Mixed Models were employed, adopting the Gamma distribution due to the asymmetric nature of the variables. The pain (CLBP and non-CLBP), training (FT and DT), time (PRE and POST16), and interaction (group × training × time) were entered as fixed factors. Significant effects ($p < 0.05$) were verified using the coefficients obtained in the regression models. Cohen's d was calculated for changes over time in the absence of interaction effects, interpreting the values as small (0.2), moderate (0.5), and large (0.8) [28].

3. Results

DT completed the intervention with 36 participants (18 CLBP) and FT with 34 (17 CLBP). Three participants from DT and six from FT were excluded. Six due to missing the post-test, two due to travel reasons, and one for health reasons. CLBP participants who completed the intervention showed an adherence of 61 % (26 sessions) in the FT and 40 % (17 sessions) in the DT group. Non-CLBP participants showed adherence rates of 67 % (29 sessions) in the FT and 53 % (21 sessions) in the DT. Demographic and anthropometric characteristics of the participants are presented in Table 1.

The analysis revealed an interaction effect between time, group, and pain only for the lateral flexors' endurance (p =.009). We observed an interaction between time and pain for the trunk extensors (p =.038) and flexors strength (p =.029). Only time effects were found for circular stability and instability (p <.001), as well as the flexors (p =.006) and extensors endurance (p <.001). For the lateral flexors, the presence of pain was associated with an average reduction of 17.3 units in lateral flexor endurance in the FT compared to the DT. For the strength of the flexor, CLBP individuals exhibited an increase of 69.3 units compared to non-CLBP. For the strength of extensors, CLBP individuals showed a decrease of 75.1 units compared to non-CLBP (Fig. 3).

There was an interaction effect between time, group, and CLBP only on the FTSST (p <.001). There was only a time effect on PTS (p <.001), SPP (p <.001), GJST (p <.001), and TUG (p <.001). Among CLBP participants, on average, there was a reduction of 1.48 units in the FT group compared to the DT group in the FTSST (Fig. 4).

4. Discussion

This was the first study to compare FT and DT on trunk muscle function and functional fitness in CLBP and non-CLBP older women over 16 weeks. Our main finding was that DT and FT similarly increased

Table 1
Characterization of participants.

Variable	CLBP		NON-CLBP		p
	DT (18) Mean ± SD	FT (17) Mean ± SD	DT (18) Mean ± SD	FT (17) Mean ± SD	
Age (years)	68.7 ± 6.1	65.3 ± 4.82	68.6 ± 5.71	68.0 ± 5.72	0.29¥
Body mass (kg)	63.5 ± 9.95	67.7 ±10.8	66.2 ±14.7	69.9 ± 7.78	0.87¥
Height (m)	1.52 ±0.05	1.54 ± 0.05	1.53 ± 0.07	1.54 ± 0.05	0.94¥
BMI (kg/m^2)	27.5 ± 3.78	28.6 ± 4.98	28.4 ± 3.48	29.4 ± 3.48	0.86¥
Medical History (absolute and relative frequency)					
Hypertension	20.0 (13)	10.8 (7)	15.4 (10)	9.2 (6)	0.46†
Dyslipidemia	16.9 (11)	16.9 (11)	15.4 (10)	18.5 (12)	0.47†
Diabetes	6.2 (4)	4.6 (3)	4.6 (3)	6.2 (4)	0.50†
Depression	4.6 (3)	0.0 (0)	3.1 (2)	1.5 (1)	0.99†
Anxiety	0.0 (0)	0.0 (0)	0.0 (0)	1.5 (1)	0.99†

Between-group comparisons based on independent t-tests (i.e., FT and DT). FT, functional training; DT, dual-task training; BMI, body mass index. ¥ Analisis of variance; † Chi-square test.

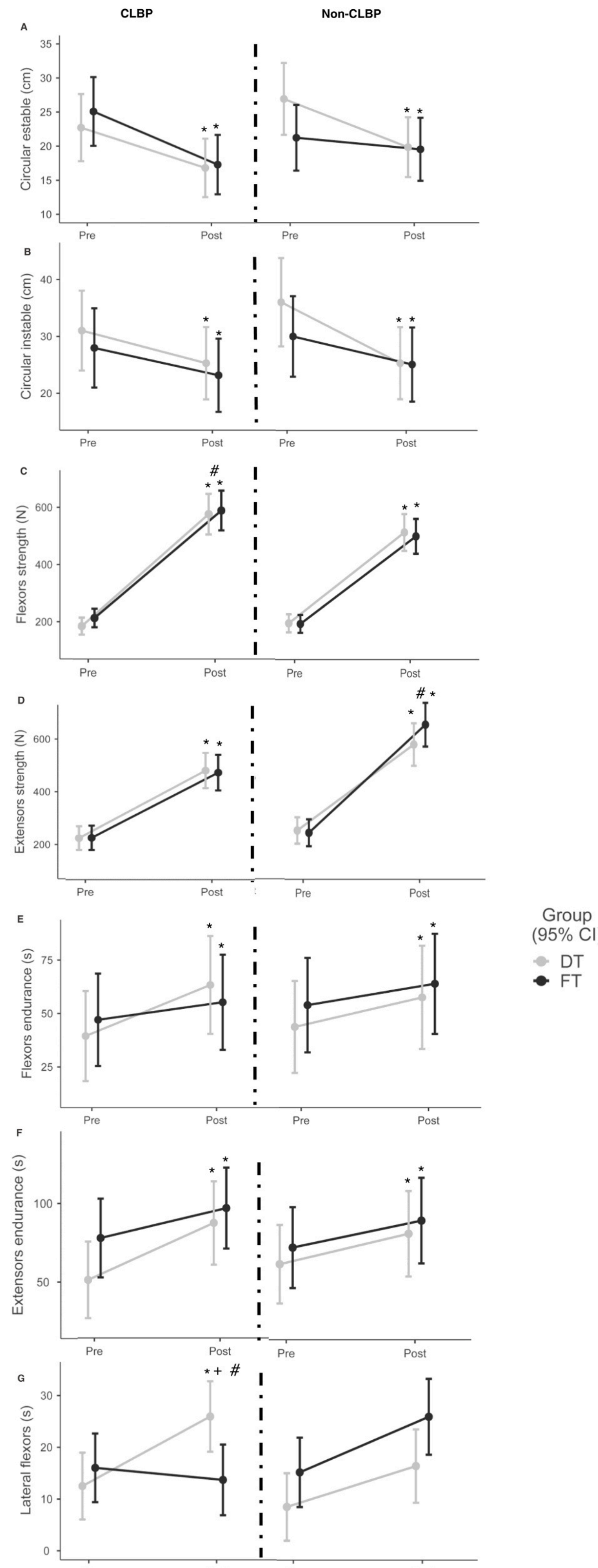

Fig. 3. Effects of interventions on the trunk muscles of CLBP and non- CLBP older women. * Difference between pre-and post-test based on Bonferroni post hoc adjustment. # Difference between CLBP and non-CLBP analyzed with Bonferroni post hoc. + Difference between DT and FT. CLBP, chronic low back pain; DT, dual-task training; FT, functional training.

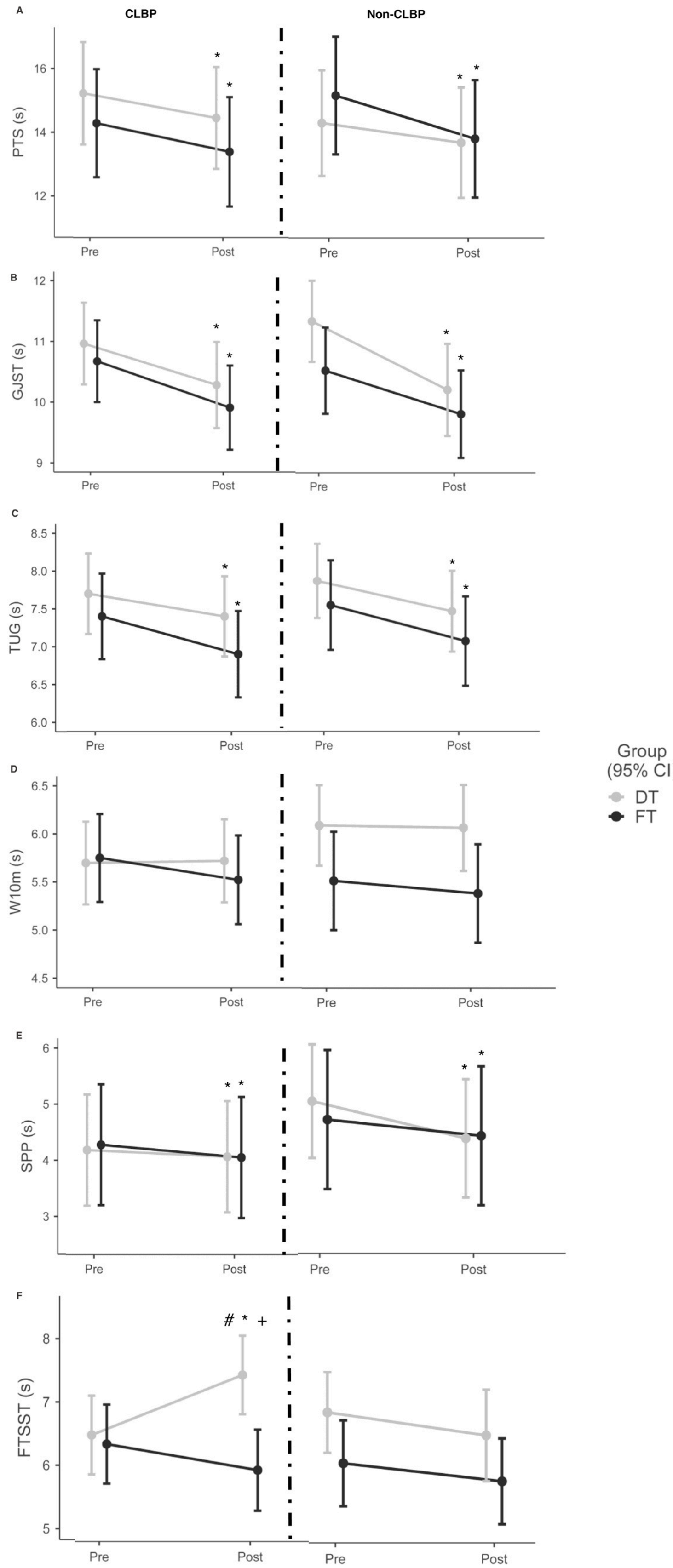

Fig. 4. Effects of interventions on the functional fitness variables of CLBP e non-CLBP. older women *Difference between pre-and post-test based on Bonferroni post hoc adjustment. # Difference between CLBP and non-CLBP analyzed with Bonferroni post hoc. + Difference between DT and FT. CLBP, chronic low back pain; DT, dual-task training; FT, functional training. PTS: put on and take off a t-shirt; FTSST: five times sit-to-stand test; TUG timed up and go; GJST: gallon-jug shelf-transfer test; W10 m: 10 m walk; SPP, standing up from the prone position.

trunk function and functional fitness performance, except for W10 and FTSST. This contrasts with our initial hypothesis that FT would be superior to DT. Therefore, our results indicate that both interventions can be applied in clinical practice to improve trunk function and functional fitness in CLBP and non-CLBP older women.

Both training protocols increased trunk stability without differences between groups regardless of CLBP. Furthermore, the motor component of the DT applied in the present study likely promotes greater activation of trunk muscles and subsequent stability due to the performance of unipodal support exercises and object transport in front of the body. According to Low and colleagues (2017) [29], interventions with balance exercises effectively improve postural control, a characteristic embedded in the training protocol of the present study. We also believe that FT, a multi-component training with multi-joint and multi-plane exercises encompassing various physical capacities [30], enhances trunk stability in CLBP and non-CLBP individuals [5]. Thus, our results demonstrate that both protocols are suitable for increasing trunk stability in CLBP. older women

Both training protocols led to an increase in the maximum isometric strength of trunk muscles. Specifically, CLBP participants increased the strength of the flexors, and the non-CLBP participants increased the strength of the extensors. The training protocol in this study focused on exercises resembling activities of daily living, incorporating movement patterns such as squatting, pushing, pulling, and carrying. The literature indicates that during the performance of these activities, there is activation of the trunk extensor muscles [31], justifying the strength increase in the non-CLBP participants. However, CLBP individuals may benefit from core-specific exercises before incorporating global exercises to improve lumbar extensor strength. Otherwise, our protocols effectively promoted increased flexor strength in the CLBP participants, reinforcing that DT and FT can be used as treatments for this population. This is particularly relevant since CLBP individuals have been shown reduced strength and delayed activation of transverse abdominal and internal oblique muscles [32], contributing to diminished motor control and playing a role in the onset and maintenance of pain.

In our study, both FT and DT increased the endurance of trunk extensors and flexors in CLBP and non-CLBP individuals. It is believed that DT stimulus acts as a dissociative strategy, distracting participants from thoughts and sensations of fatigue resulting in improved performance during exercise. Consequently, there is an increase in trunk muscle endurance in the medium and long term [33]. Concurrently, FT promotes increased endurance, possibly due to patterns similar to those maintained during daily activities. According to La Scala Teixeira et al. [30], the use of multi-joint and multi-planar exercises that resemble functional movement patterns such as squatting, pulling, and pushing can lead to greater activation of core muscles, resulting in positive adaptations in trunk endurance [34].

Both training protocols increased the functional fitness of CLBP and non-CLBP older women in PTS, GLST, TUG, and SPP. However, only FT improved FTSST performance in CLBP individuals. Our results are consistent with other studies conducted with older women, showing positive effects of physical exercise on functional fitness [6] [8]. We believe this improvement is due to the training specificity, prioritizing exercises that resemble basic daily activities. Additionally, the protocols prioritized high-speed execution during the concentric phase, stimulating fast-twitch muscle fibers and indirectly increasing muscle power through improved neuromuscular control, resulting in reduced test execution time [35].

During the training protocol execution one limitation was a minor sample loss due to health reasons, travel, and some participants missing the post-test. We believe that the number of tests involved in the assessment contributed to the absence in the post-assessment. Therefore, we suggest that future studies attempt to reduce the number of assessments, utilize tests with shorter execution times, or employ strategies to emphasize the importance of assessments. Despite the limitation, we must emphasize the methodological robustness of this study by comparing CLBP and non-CLBP older women and the application of two different training protocols. Also, despite some sample loss, both training protocols showed good participant adherence during the 16 weeks. The use of statistical models adjusted to the nature of the analyzed variables allows a more faithful interpretation of the training effects. Finally, the feasibility of the training protocols highlights the clinical applications of our protocols by professionals who use exercise as a treatment for CLBP.

5. Conclusion

Sixteen weeks of functional training and dual-task training increased stability, maximal isometric strength, trunk muscle endurance, and functional fitness in CLBP older women. Therefore, it is worthwhile to consider strategies that utilize the characteristics of both training protocols. Our research group recently published an article [36] on this topic, and together with our findings, it can provide insights for future research.

CRediT authorship contribution statement

Poliana de Jesus Santos: Writing – original draft, Project administration, Methodology, Formal analysis, Data curation, Conceptualization. **José Carlos Aragão-Santos:** Supervision, Methodology, Formal analysis. **Elyson Ádan Nunes Carvalho:** Writing – review & editing, Supervision, Software, Methodology. **Marzo Edir Da Silva Grigoletto:** Writing – review & editing, Supervision, Methodology.

Declaration of Competing Interest

The authors declare that there is no conflict of interest regarding the publication of this paper.

Acknowledgment

This work was supported by Coordenação de Aperfeiçoamento Pessoal de Nível Superior, Brazil-CAPES. The funding source had no involvement in conducting the study or preparing the article for publication.

References

[1] A. Wu, L. March, X. Zheng, J. Huang, X. Wang, J. Zhao, et al., Global low back pain prevalence and years lived with disability from 1990 to 2017: estimates from the Global Burden of Disease Study 2017, Ann. Transl. Med. 8 (6) (2020) 299.

[2] J.H. Van Dieën, N.P. Reeves, G. Kawchuk, L.R. Van Dillen, P.W. Hodges, Analysis of Motor Control in Patients With Low Back Pain: A Key to Personalized Care? (juny de), J. Orthop. Sports Phys. Ther. 49 (6) (2019) 380–388.

[3] L. Ferrucci, E. Fabbri, Inflammageing: chronic inflammation in ageing, cardiovascular disease, and frailty (sept de), Nat. Rev. Cardiol. 15 (9) (2018) 505–522.

[4] K.M. Naugle, R.B. Fillingim, J.L. Riley, A meta-analytic review of the hypoalgesic effects of exercise, J. Pain. Dec. De. 13 (12) (2012) 1139–1150.

[5] M.E. Da Silva-Grigoletto, M.M.A. Mesquita, J.C. Aragão-Santos, M.S. Santos, A. G. Resende-Neto, J.M. de Santana, et al., Functional Training Induces Greater Variety and Magnitude of Training Improvements than Traditional Resistance Training in Elderly Women, J. Sports Sci. Med. Nov. De. 18 (4) (2019) 789–797.

[6] J.C. Aragão-Santos, A.B.S. Vasconcelos, A.G.D. Resende-Neto, L.S. Rodrigues, N.D. L. Silva, D.N. Da Silva, et al., Functional and concurrent training do not impair immune function and improve functional fitness in postmenopausal women: A randomized controlled trial (oct de), Exp. Gerontol. 153 (2021) 111504.

[7] U. Van Daele, F. Hagman, S. Truijen, P. Vorlat, B. Van Gheluwe, P. Vaes, Decrease in Postural Sway and Trunk Stiffness During Cognitive Dual-Task in Nonspecific Chronic Low Back Pain Patients, Performance Compared to Healthy Control Subjects, Spine 35 (5) (2010) 583.

[8] Y.L. Chen, C.H. Tseng, H.T. Lin, P.Y. Wu, H.C. Chao, Dual-task multicomponent exercise–cognitive intervention improved cognitive function and functional fitness in older adults. (sept de), Aging Clin. Exp. Res 35 (9) (2023) 1855–1863.

[9] M. Woollacott, A. Shumway-Cook, Attention and the control of posture and gait: a review of an emerging area of research (aug de), Gait Posture 16 (1) (2002) 1–14.

[10] D.K. Weiner, C.L. Haggerty, S.B. Kritchevsky, T. Harris, E.M. Simonsick, M. Nevitt, et al., How Does Low Back Pain Impact Physical Function in Independent, Well-

Functioning Older Adults? Evidence from the Health ABC Cohort and Implications for the Future (dezembro de), Pain. Med 4 (4) (2003) 311–320.
[11] K.F. Schulz, D.G. Altman, D. Moher, CONSORT 2010 Statement: updated guidelines for reporting parallel group randomised trials (march de), BMJ 340 (2010) c332.
[12] F. Faul, E. Erdfelder, A.G. Lang, A.G. Buchner, *Power 3: A flexible statistical power analysis program for the social, behavioral, and biomedical sciences (may de), Behav. Res. Methods 39 (2) (2007) 175–191.
[13] S. Sipaviciene, I. Kliziene, Effect of different exercise programs on non-specific chronic low back pain and disability in people who perform sedentary work (march de), Clin. Biomech. 73 (2020) 17–27.
[14] A.G. Resende-Neto, M.E. Da Silva-Grigoletto, Systematization of Functional Training Sessions to Benefit Physical Fitness for Daily Activities in Older People, Int J. Sports Exerc Med 6 (2020) 157.
[15] M.E. Da Silva-Grigoletto, B.H. Viana-Montaner, J.R. Heredia, F. Mata, G. Peña, C. J. Brito, et al., Validación de la escala de valoración subjetiva del esfuerzo OMNI-GSE para el control de la intensidad global en sesiones de objetivos múltiples en personas mayores. Cronos XII (1) (2013) 32–40.
[16] J.C. Aragão-Santos, A. Pantoja-Cardoso, A.C. Dos-Santos, D.G. Behm, T.R. de Moura, M.E. Da Silva-Grigoletto, Effects of twenty-eight months of detraining imposed by the COVID-19 pandemic on the functional fitness of older women experienced in concurrent and functional training (aug de), Arch. Gerontol. Geriatr. 111 (2023) 105005.
[17] L.C.D. Pereira, M.S. Santos, E.Á.N. Carvalho, Reproducibility of a Trunk Stability Evaluation Instrument in Individuals with Non-Specific Chronic Low Back, Pain 4 (1) (2020).
[18] D. Barbado, L.C. Barbado, J.L.L. Elvira, J.H.V. Dieën, Vera-Garcia FJ, Sports-related testing protocols are required to reveal trunk stability adaptations in high-level athletes, 20160623o sept de, Gait Posture 49 (2016) 90–96.
[19] C.G. Sutarno, S.M. McGill, Isovelocity investigation of the lengthening behaviour of the erector spinae muscles (march de), Eur. J. Appl. Physiol. 70 (2) (1995) 146–153.
[20] M.M.A. Mesquita, M.S. Santos, A.B.S. Vasconcelos, C.A. de Sá, L.C.D. Pereira, Í.B. M. da Silva-Santos, et al., Reliability of a Test for Assessment of Isometric Trunk Muscle Strength in Elderly Women (july de), J. Aging Res. 2019 (2019) 9061839.
[21] S.M. McGill, A. Childs, C. Liebenson, Endurance times for low back stabilization exercises: Clinical targets for testing and training from a normal database, 1o de agosto de, Arch. Phys. Med. Rehabil. 80 (8) (1999) 941–944.
[22] J.F. Signorile, D. Sandler, F. Ma, S. Bamel, D. Stanziano, W. Smith, et al., The Gallon-Jug Shelf-Transfer Test: An Instrument to Evaluate Deteriorating Function in Older Adults (jan de), J. Aging Phys. Act. 15 (1) (2007) 56–74.
[23] R.G.S. Vale, C.S. Pernambuco, J.S. Novaes, E.H.M. Dantas, Teste de autonomia funcional: vestir e tirar uma camiseta (vtc), Rev. Bras. ciênc Mov. (2006) 71–78.
[24] R.A. Andreotti, S.S. Okuma, Validating a test battery of activities of daily living for physically independent elderly (june de), Rev. Paul. De. Educ. ção F. íSci. 13 (1) (1999) 46–66.
[25] S. Sipilä, J. Multanen, M. Kallinen, P. Era, H. Suominen, Effects of strength and endurance training on isometric muscle strength and walking speed in elderly women (april de), Acta Physiol. Scand. 156 (4) (1996) 457–464.
[26] N.B. Alexander, J. Ulbrich, A. Raheja, D. Channer, Rising from the floor in older adults, J. Am. Geriatr. Soc. 45 (5) (1997) 564–569.
[27] J.M. Guralnik, E.M. Simonsick, L. Ferrucci, R.J. Glynn, L.F. Berkman, D.G. Blazer, et al., A short physical performance battery assessing lower extremity function: association with self-reported disability and prediction of mortality and nursing home admission, J. Gerontol. 49 (2) (1994) M85–M94.
[28] J. Cohen, Statistical Power Analysis for the Behavioral Sciences, 2o ed, Routledge, New York, 1988, p. 567, 2o ed.
[29] D.C. Low, G.S. Walsh, M. Arkesteijn, Effectiveness of Exercise Interventions to Improve Postural Control in Older Adults: A Systematic Review and Meta-Analyses of Centre of Pressure Measurements, Sports Med. 47 (1) (2017) 101–112.
[30] C.V. La Scala Teixeira, A.L. Evangelista, J.S. Novaes, M.E. Da Silva Grigoletto, D. G. Behm, You're Only as Strong as Your Weakest Link": A Current Opinion about the Concepts and Characteristics of Functional Training, Front Physiol. 8 (2017) 643.
[31] B.A. Barron, W.S. Marras, The Working Back: A Systems View, 1° de dec de, J. Occup. Rehabil. 18 (4) (2008).
[32] P.W. Hodges, C.A. Richardson, Altered trunk muscle recruitment in people with low back pain with upper limb movement at different speeds (sept de), Arch. Phys. Med Rehabil. 80 (9) (1999) 1005–1012.
[33] C. Cruz-Montecinos, J. Calatayud, C. Iturriaga, C. Bustos, B. Mena, V. España-Romero, et al., Influence of a self-regulated cognitive dual task on time to failure and complexity of submaximal isometric force control (sept de), Eur. J. Appl. Physiol. 118 (9) (2018) 2021–2027.
[34] C.J. Liu, N.K. Latham, Progressive resistance strength training for improving physical function in older adults (july de), Cochrane Database Syst. Rev. (3) (2009) CD002759.
[35] P.B. Lopes, G. Pereira, A. Lodovico, P.C.B. Bento, A.L.F. Rodacki, Strength and Power Training Effects on Lower Limb Force, Functional Capacity, and Static and Dynamic Balance in Older Female Adults (oct de), Rejuvenation Res 19 (5) (2016) 385–393.
[36.] M.E. Da Silva-Grigoletto, M.R. Pereira Monteiro, J.C. Aragão-Santos, A. B. Vasconcelos, P.J. Marcos-Pardo, L.D. Fortes, Brain Functional Training: A Perspective Article, Front Aging 5 (2024) 1368878.

4. CONCLUSÃO

A presente tese teve como objetivo principal investigar os efeitos de intervenções com exercício físico na dor DLCI em mulheres idosas, com enfoque especial na comparação entre o TF e o TDT. Os quatro estudos desenvolvidos ao longo deste trabalho forneceram uma compreensão abrangente sobre avaliação da dor, os possíveis mecanismos neurofisiológicos envolvidos na modulação nociceptiva e os impactos clínicos e funcionais dessas duas modalidades de exercício.

O Estudo 1 apresentou e discutiu os métodos práticos, acessíveis e de baixo custo para uma avaliação multidimensional da dor. Essa contribuição se mostra altamente relevante ao permitir que profissionais do movimento atuem com maior embasamento e precisão na condução terapêutica de indivíduos com dor crônica, especialmente em contextos com limitações de recursos. Já o Estudo 2 explorou as possíveis vias fisiológicas pelas quais o TF e o TDT atuam na redução da dor, sugerindo que ambas as modalidades ativam circuitos centrais e periféricos de modulação da dor.

Os Estudos 3 e 4 evidenciaram que tanto o TF quanto o TDT foram eficazes na melhora da força isométrica, resistência muscular e estabilidade do tronco, além de contribuírem positivamente para a aptidão funcional. O TF demonstrou superioridade no aumento do LDP e na CPM, enquanto o TDT mostrou aumentar o desempenho na resistência dos músculos flexores laterais, especialmente em mulheres com DLCI. Apesar da hipótese inicial sugerir maior eficácia global do TF, os resultados apontam para benefícios complementares entre as modalidades, com ausência de diferenças significativas na maioria dos desfechos avaliados.

Esses achados possuem importantes implicações práticas e clínicas. Primeiramente, evidenciam a viabilidade da avaliação sensorial da dor de maneira acessível e objetiva, permitindo intervenções mais precisas e adaptadas às particularidades dos pacientes. A utilização de instrumentos como o LDP, MCD e escalas de autorrelato possibilita o monitoramento contínuo do tratamento e favorece uma abordagem centrada no indivíduo. Além disso, os resultados reforçam que tanto o TF quanto o TDT são estratégias eficazes e seguras para o manejo da DLCI em mulheres idosas, podendo ser escolhidas conforme as necessidades funcionais, condições cognitivas e preferências individuais das pacientes. O TF pode ser mais indicado quando o objetivo é o alívio da dor por meio de estímulos neuromusculares intensos, enquanto o TDT se mostra particularmente eficaz quando se busca melhorar aspectos relacionados à resistência muscular e ao controle postural em contextos de atenção dividida.

Ambas as modalidades contribuíram para a melhora da aptidão funcional, ampliando a autonomia e promovendo um envelhecimento mais ativo. Dessa forma, os achados desta tese reforçam o papel do exercício físico como uma ferramenta terapêutica central no tratamento da dor lombar crônica em idosas, oferecendo alternativas viáveis, adaptáveis e eficazes para a prática clínica e para programas de saúde pública voltados a essa população. Conclui-se, portanto, que tanto o TF quanto o TDT devem ser considerados como opções terapêuticas relevantes no manejo da DLCI, favorecendo uma abordagem individualizada, baseada em evidências e centrada na funcionalidade e qualidade de vida das mulheres idosas.

REFERÊNCIAS

ABOU, L. et al. Motor cognitive dual-task testing to predict future falls in multiple sclerosis: A systematic review. **Neurorehabil Neural Repair**, v. 36, n. 12, p. 757–769, dez. 2022.

ARAGÃO-SANTOS, J. C. et al. Functional and concurrent training do not impair immune function and improve functional fitness in postmenopausal women: A randomized controlled trial. **Exp Gerontol**, v. 153, p. 111504, out. 2021.

BALAGUÉ, F. et al. Non-specific low back pain. **Lancet**, v. 379, n. 9814, p. 482–91, 4 fev. 2012.

BARTLEY, E. J.; FILLINGIM, R. B. Sex differences in pain: A brief review of clinical and experimental findings. **Br J Anaesth**, v. 111, n. 1, p. 52–8, jul. 2013.

CLAEL, S. et al. Exercise interventions can improve muscle strength, endurance, and electrical activity of lumbar extensors in individuals with non-specific low back pain: A systematic review with meta-analysis. **Scientific Reports**, v. 11, n. 1, p. 16842, 19 ago. 2021.

CRAFT, R. M. Modulation of pain by estrogens. **PAIN**, v. 132, p. S3, nov. 2007.

DA SILVA SANTOS, R.; GALDINO, G. Endogenous systems involved in exercise-induced analgesia. **J Physiol Pharmacol**, v. 69, n. 1, p. 3–13, fev. 2018.

DA SILVA-GRIGOLETTO, M. E. et al. Functional Training induces greater variety and magnitude of training improvements than traditional resistance training in elderly women. **J Sports Sci Med**, v. 18, n. 4, p. 789–797, dez. 2019.

FILLINGIM, R. B. et al. Sex differences in temporal summation but not sensory-discriminative processing of thermal pain. **Pain**, v. 75, n. 1, p. 121–127, mar. 1998.

FILLINGIM, R. B. et al. Clinical characteristics of chronic back pain as a function of gender and oral opioid use. **Spine**, v. 28, n. 2, p. 143, 15 jan. 2003.

GE, L. et al. How cognitive loads modulate the postural control of older women with low back pain? **BMC Geriatrics**, v. 21, n. 1, p. 82, 28 jan. 2021.

GONZALEZ, G. Z. et al. Low back pain prevalence in Sao Paulo, Brazil: A cross-sectional study. **Braz J Phys Ther**, v. 25, n. 6, p. 837–845, 2021.

HAYDEN, J. A. et al. Some types of exercise are more effective than others in people with chronic low back pain: A network meta-analysis. **J Physiother**, v. 67, n. 4, p. 252–262, 1 out. 2021.

HODGES, P. W. et al. Corticomotor excitability of back muscles is affected by intervertebral disc lesion in pigs. **Eur J Neurosci**, v. 29, n. 7, p. 1490–500, abr. 2009.

HODGES, P. W. et al. Can proinflammatory cytokine gene expression explain multifidus muscle fiber changes after an intervertebral disc lesion? **Spine (Phila Pa 1976)**, v. 39, n. 13, p. 1010–7, 1 jun. 2014.

HODGES, P. W. et al. Multifidus muscle changes after back injury are characterized by structural remodeling of muscle, adipose and connective tissue, but not muscle atrophy: Molecular and morphological evidence. **Spine (Phila Pa 1976)**, v. 40, n. 14, p. 1057–71, 15 jul. 2015.

KAPTAN, H. et al. Evaluation of low back pain frequency and related factors among people over 18 years of age. **Niger J Clin Pract**, v. 23, n. 9, p. 1295–1304, set. 2020.

LA SCALA TEIXEIRA, C. V. et al. "You're only as strong as your weakest link: A current opinion about the concepts and characteristics of functional training. **Front Physiol**, v. 8, p. 643, 2017.

LEVEILLE, S. G. Musculoskeletal aging. **Curr Opin Rheumatol,** v. 16, n. 2, p. 114–118, mar. 2004.

MERCHANT, R. A. et al. Association of pain and impact of dual-task exercise on function, cognition and quality of life. **J Nutr Health Aging**, v. 25, n. 9, p. 1053–1063, 1 nov. 2021.

MOSABBIR, A. Mechanisms behind the development of chronic low back pain and its neurodegenerative features. **Life**, v. 13, n. 1, p. 84, 28 dez. 2022.

PAULSON, P. E. et al. Gender differences in pain perception and patterns of cerebral activation during noxious heat stimulation in humans. **Pain**, v. 76, n. 1–2, p. 223–229, may 1998.

PEDERSEN, B. K.; SALTIN, B. Exercise as medicine - evidence for prescribing exercise as therapy in 26 different chronic diseases. **Scand J Med Sci Sports**, v. 25 Suppl 3, p. 1–72, dez. 2015.

PRANATA, A. et al. Lumbar extensor muscle force control is associated with disability in people with chronic low back pain. **Clin Biomech (Bristol, Avon)**, v. 46, p. 46–51, jul. 2017.

RICE, D. et al. Exercise-induced hypoalgesia in pain-free and chronic pain populations: state of the art and future directions. **J Pain**, v. 20, n. 11, p. 1249–1266, nov. 2019.

RUDY, T. E. et al. The impact of chronic low back pain on older adults. **Pain**, v. 131, n. 3, p. 293–301, out. 2007.

SANTIAGO, B. V. M. et al. Prevalence of chronic pain in Brazil: A systematic review and meta-analysis. **Clinics**, v. 78, p. 100209, may 2023.

SANTOS, M. S. et al. Neuroendocrine effects of a single bout of functional and core stabilization training in women with chronic nonspecific low back pain: A crossover study. **Physiol Rep**, v. 10, n. 17, p. e15365, set. 2022.

SMITH, Y. R. et al. Pronociceptive and antinociceptive effects of estradiol through endogenous opioid neurotransmission in women. **J Neurosci**, v. 26, n. 21, p. 5777–85, 24 maio 2006.

VAN DAELE, U. et al. Decrease in postural sway and trunk stiffness during cognitive dual-task in nonspecific chronic low back pain patients, performance compared to healthy control subjects. **Spine**, v. 35, n. 5, p. 583, mar. 2010.

VAN DIEËN, J. H. et al. Analysis of motor control in patients with low back pain: a key to personalized care? **J Orthop Sports Phys Ther**, v. 49, n. 6, p. 380–388, jun. 2019.

VIOLANTE, F. S.; MATTIOLI, S.; BONFIGLIOLI, R. Chapter 21 - Low-back pain. Em: LOTTI, M.; BLEECKER, M. L. (Eds.). **Handbook of Clinical Neurology**. Occupational Neurology. [s.l.] Elsevier, 2015. v. 131, p. 397–410.

WEINER, D. K. et al. How does low back pain impact physical function in independent, well-functioning older adults? Evidence from the health ABC cohort and implications for the future. **Pain Med**, v. 4, n. 4, p. 311–320, dez. 2003.

WU, A. et al. Global low back pain prevalence and years lived with disability from 1990 to 2017: estimates from the global burden of disease study 2017. **Ann Transl Med**, v. 8, n. 6, p. 299, mar. 2020.

ZHAO, W. P. et al. Histochemistry and morphology of the multifidus muscle in lumbar disc herniation: comparative study between diseased and normal sides. **Spine (Phila Pa 1976)**, v. 25, n. 17, p. 2191–9, 1 set. 2000.

APÊNDICE

Termo de Consentimento Livre e Esclarecido

UNIVERSIDADE FEDERAL DE SERGIPE
PRÓ-REITORIA DE PÓS-GRADUAÇÃO E PESQUISA
PROGRAMA DE PÓS-GRADUAÇÃO EM CIÊNCIAS FISIOLÓGICAS

TERMO DE CONSENTIMENTO LIVRE E ESCLARECIDO

Estamos te convidando a participar voluntariamente do projeto de pesquisa chamado **"Efeitos neuroendócrinos do treinamento de estabilização do *core* em mulheres com dor lombar crônica inespecífica: ensaio clínico randomizado controlado"** o qual se refere a um projeto de doutorado desenvolvido pela aluna Poliana de Jesus Santos, sob a orientação do Professor Doutor Marzo Edir Da Silva Grigoletto. Este projeto objetiva comparar o efeito de 12 semanas de muito e pouco exercício físico na dor lombar crônica.

A senhora está sendo convidada a participar de 12 semanas de treinamento, o qual será realizado 3 vezes na semana totalizando 36 sessões de exercício. Por isso, o pesquisador responsável compromete-se a ressarci os valores gastos com transporte e alimentação da senhora e do seu acompanhante, assim, a senhora não terá custos ao participar da pesquisa.

Antes da senhora iniciar o protocolo de treinamento, após 18 sessões de treinamento e ao final do treinamento após 12 semanas, iremos realizar exames que avaliam como a sua coluna responde aos movimentos realizados no dia-a-dia e a presença de hormônios que podem ajudar a reduzir a sua dor, por isso será necessário coletar seu sangue. A coleta sanguínea será realizada por um profissional treinado, em local apropriado para coleta e utilizando materiais descartáveis, as amostras sanguíneas serão destinadas somente para esse estudo. A senhora também responderá um questionário sobre dor, qualidade de vida, qualidade do sono, ansiedade e depressão.

É possível que haja algum risco psíquico a senhora por parte de algum questionário e também risco físico, como o surgimento de um pequeno coágulo sanguíneo e/ou pequeno hematoma ou infecção no local da picada da agulha. Além disso, é possível que a senhora sinto um aumento da dor e/ou desconforto muscular, sofra alguma lesão ou fique tonta durante a realização dos exercícios. Visando reduzir esses riscos todos os exames e o treinamento serão realizados por profissionais treinados e capacitados. No entanto, caso ocorra complicações e danos decorrentes da pesquisa o pesquisador responsável compromete-se a proporcionar assistência imediata, encaminhando-o para atendimento médico na emergência e se responsabilizará pela assistência integral da senhora, a assistência é totalmente gratuita e não lhe trará custo algum. Por fim, caso a senhora sofra qualquer tipo de dano resultante de sua participação na pesquisa, terá direito à indenização por parte do pesquisador responsável nas diferentes fases da pesquisa.

Os benefícios esperados para as voluntárias dessa pesquisa são redução da dor. Além disso, a presente pesquisa apresenta tratamentos de baixo custo e fácil aplicação, podendo ajudar com a comprovação de condutas eficazes para reduzir os sintomas da dor lombar crônica.

A sua participação não é obrigatória. Você poderá se recusar a participar e/ou desistir e retirar seu consentimento a qualquer momento que desejar. Sua recusa, desistência ou retirada de consentimento não acarretará prejuízo ou danos. A sua participação não será remunerada e nem implicará em gastos pessoais.

Sua identidade não será revelada em nenhum momento, por isso a senhora receberá um número de identificação em todos os exames e no protocolo de treinamento, garantindo a confidencialidade e privacidade dos seus dados. O pesquisador responsável se compromete a tornar públicos nos meios acadêmicos e científicos os resultados obtidos sem qualquer identificação dos participantes. Caso você concorde em participar desta pesquisa, rubrique as três laudas e assine ao final deste documento, que possui duas vias, sendo uma delas sua e a outra do pesquisador responsável pela pesquisa. Essa pesquisa segue os critérios éticos das resoluções 466/2012 e 510/2016, do Conselho Nacional de Saúde.

Dados da Pesquisadora Principal	**Dados do Professor Orientador**
Nome: Poliana de Jesus Santos. E-mail: polianasantos.28@hotmail.com Programa de Pós-Graduação em Ciências Fisiológicas-PROCFIS Universidade Federal de Sergipe. Telefone Celular: (79) 99878-9989	Nome: Marzo Edir Da Silva Grigoletto. Programa de Pós-Graduação em Ciências Fisiológicas-PROCFIS Universidade Federal de Sergipe.

Considerando que fui informada dos objetivos e importância desse estudo, de como será minha participação, riscos e benefícios, declaro o meu consentimento em participar da pesquisa.

Impressão datiloscópica

____

Assinatura do Participante da Pesquisa

____

Assinatura do Pesquisador

São Cristóvão, ____ de ______________ 2023.

Em caso de qualquer dúvida ou reclamação sobre a pesquisa, entrar em contato com: Comitê de Ética em Pesquisa da Universidade Federal de Sergipe, Rua Cláudio Batista s/nº Bairro: Sanatório–Aracaju CEP: 49.060-110–SE.
Contato por e-mail:cep@academico.ufs.br Telefone e horários para contato: (79) 3194-7208 – Segunda a Sexta-feira das 07 às 12h.

ANEXOS

Parecer do Comitê de Ética (Estudo 3)

UNIVERSIDADE FEDERAL DE SERGIPE - UFS

PARECER CONSUBSTANCIADO DO CEP

DADOS DO PROJETO DE PESQUISA

Título da Pesquisa: EFEITOS NEUROIMUNOENDÓCRINOS DO TREINAMENTO DE ESTABILIZAÇÃO DO CORE EM MULHERES COM DOR LOMBAR CRÔNICA INESPECÍFICA: ENSAIO CLÍNICO RANDOMIZADO CONTROLADO

Pesquisador: Marzo Edir da Silva

Área Temática:

Versão: 3

CAAE: 53174021.5.0000.5546

Instituição Proponente: Departamento de Educação Física

Patrocinador Principal: Financiamento Próprio

DADOS DO PARECER

Número do Parecer: 5.291.267

Apresentação do Projeto:

As informações elencadas nos campos "Apresentação do Projeto", "Objetivo da Pesquisa" e "Avaliação dos Riscos e Benefícios" foram retiradas do arquivo "Informações Básicas da Pesquisa" (PB_INFORMAÇÕES_BÁSICAS_DO_PROJETO_1852023.pdf) e do "Projeto Detalhado / Brochura Investigador" (Projeto.docx), postados em 21/02/2022.

Introdução:

A dor lombar (DL) pode ser definida como uma dor presente entre o arco da última costela até a linha glútea, podendo ou não irradiar para um ou ambos membros inferiores1. A dor lombar inespecífica é aquela em que não há uma patologia ou causa atribuível e representa cerca de 90% dos casos2; 3, sendo as mulheres as mais acometidas4; 5. Estudos mostram que pacientes com dor lombar crônica inespecífica apresentam maior sensibilização a dor quando comparado a controle saudáveis6; 7 e apesar de não ter uma causa justificável, estudos mostram que a sensibilização central (SC) pode contribuir para o desenvolvimento e manutenção da dor lombar crônica inespecífica8. O exercício ativa as vias de analgesia endógena9 em pessoas saudáveis e em pacientes com dor lombar crônica10; 11 resultando em diminuição da sensibilidade à dor12; 13. A diminuição na percepção da dor após o exercício é chamada de hipoalgesia induzida pelo exercício, esta é avaliada através dos limiares de dor por pressão, que são a intensidade mínima

Endereço: Rua Cláudio Batista s/nº
Bairro: Sanatório **CEP:** 49.060-110
UF: SE **Município:** ARACAJU
Telefone: (79)3194-7208 **E-mail:** cep@academico.ufs.br

Parecer do Comitê de Ética (Estudo 4)

UNIVERSIDADE FEDERAL DE SERGIPE - UFS

PARECER CONSUBSTANCIADO DO CEP

DADOS DO PROJETO DE PESQUISA

Título da Pesquisa: OS EFEITOS DO TREINAMENTO FUNCIONAL EM MULHERES IDOSAS COM DOR LOMBAR CRÔNICA E ASSINTOMÁTICAS

Pesquisador: Marzo Edir da Silva

Área Temática:

Versão: 1

CAAE: 66622123.7.0000.5546

Instituição Proponente: Departamento de Educação Física

Patrocinador Principal: Financiamento Próprio

DADOS DO PARECER

Número do Parecer: 5.877.035

Apresentação do Projeto:

As informações elencadas nos campos "Apresentação do Projeto", "Objetivo da Pesquisa" e "Avaliação dos Riscos e Benefícios" foram retiradas do arquivo "Informações Básicas da Pesquisa" (PB_INFORMAÇÕES_BÁSICAS_DO_PROJETO_2074069.pdf) e do "Projeto Detalhado / Brochura Investigador" (Projeto.docx), postados em 10/01/2023.

Introdução,

A dor lombar (DL) pode ser definida como uma dor presente entre o arco da última costela até a linha glútea, podendo ou não irradiar para um ou ambos membros inferiores1. A dor lombar inespecífica é aquela em que não há uma patologia ou causa atribuível e representa cerca de 90% dos casos2; 3, sendo as mulheres as mais acometidas4; 5. Estudos mostram que pacientes com dor lombar crônica inespecífica apresentam maior sensibilização a dor quando comparado a controle saudáveis6; 7 e apesar de não ter uma causa justificável, estudos mostram que a sensibilização central (SC) pode contribuir para o desenvolvimento e manutenção da dor lombar crônica inespecífica8. O exercício ativa as vias de analgesia endógena9 em pessoas saudáveis e em pacientes com dor lombar crônica10; 11 resultando em diminuição da sensibilidade à dor12; 13. A diminuição na percepção da dor após o exercício é chamada de hipoalgesia induzida pelo exercício, esta é avaliada através dos limiares de dor por pressão, que são a intensidade mínima que um estímulo é interpretado como doloroso, o aumento nesses limiares após o exercício é

Endereço: Rua Cláudio Batista s/nº
Bairro: Sanatório **CEP:** 49.060-110
UF: SE **Município:** ARACAJU
Telefone: (79)3194-7208 **E-mail:** cep@academico.ufs.br