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A UTILIZAÇÃO DE MEIAS DE COMPRESSÃO DURANTE A CORRIDA

RIO DE JANEIRO

2024

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“Não fui eu que ordenei a você? Seja forte e corajoso! Não se apavore nem desanime, pois o Senhor, o seu Deus, estará com você por onde você andar.”

Josué 1:9

“Se eu vi mais longe, foi porque estava sobre os ombros de gigantes”.

Isaac Newton

Prefácio

Essa tese de doutorado apresenta tópicos relacionados à utilização de meias de compressão durante a corrida. A presente tese está dividida em duas partes, considerando as normas vigentes do programa de Pós-Graduação em Ciências da Reabilitação do Centro Universitário Augusto Motta (UNISUAM). A primeira parte desta tese é chamada “Capítulo 1 – Projeto de Pesquisa”. Neste capítulo, são apresentados aspectos gerais sobre a corrida como benefícios para a saúde e impacto sobre o sistema musculoesquelético. Em sequência é enfatizado que as demandas físicas da corrida podem causar dor muscular em membros inferiores e que diversas técnicas para recuperação física estão disponíveis atualmente. As meias de compressão podem apresentar benefícios para os corredores, porém a literatura atual apresenta limitações. Com a finalidade de agrupar as informações disponíveis sobre os efeitos das meias de compressão na corrida, uma revisão sistemática foi conduzida com o foco em desfechos fisiológicos, relacionados ao desempenho e auto reportados. Um ensaio clínico duplo cego, cruzado placebo controlado está em andamento e seu protocolo também está apresentado. O objetivo do ensaio clínico é verificar o efeito das meias de compressão na dor muscular em membros inferiores e percepção de recuperação após a corrida. Este estudo encontra-se em fase de coleta de dados (41% dos participantes foram coletados). A segunda parte desta tese é denominada “Capítulo 2 – Produção Intelectual” e apresenta dois artigos publicados em paralelo aos estudos sobre meias de compressão. O primeiro artigo **(subtópico 3.1)** investigou a correlação entre dor e incapacidade com propriocepção e testes funcionais em pacientes com dor femoropatelar. O segundo artigo **(subtópico 3.2)** foi publicado e está relacionado ao período de doutorado-sanduíche. Este artigo é o protocolo de um estudo de coorte que está em andamento. Este estudo irá comparar alterações estruturais (ressonância magnética) e sintomas em joelhos de corredores com e sem histórico de cirurgia de joelho. No tópico “Disseminação da Produção” estão listados os artigos publicados, incluindo os artigos em que o autor participou como colaborador. Além disso, nesse tópico foram apresentados outros produtos resultantes do período do Doutorado, tais como: participação em eventos científicos, publicações de resumos em anais de eventos científicos, entre outros.

Resumo

Introdução: A corrida se tornou um esporte popular. Os benefícios para a saúde obtidos através da corrida e a facilidade de acesso contribuem para o aumento do número de corredores. Devido a heterogeneidade dos corredores, as demandas direcionadas aos profissionais de saúde variam desde busca por melhor desempenho até a recuperação física após a corrida. As meias de compressão apresentam plausibilidade para atender as variadas demandas dos corredores, mas carece de respaldo científico. Diante disto, o objetivo desta tese foi investigar os efeitos utilização de meias de compressão durante a corrida. **Métodos**: Essa tese é composta por 2 estudos com distintos delineamentos e objetivos. Uma revisão sistemática investigou os efeitos da utilização de meias de compressão durante a corrida em desfechos fisiológicos, de desempenho e auto reportados. Um ensaio clínico cruzado, randomizado e controlado com objetivo de investigar os efeitos das meias de compressão na dor muscular e recuperação física após a corrida. Este se encontra em fase de coleta de dados. **Resultados**: O **subtópico 2.1** incluiu 28 ensaios clínicos (600 corredores). Os resultados demonstraram que meias de compressão apresentaram efeitos similares quando comparadas a meias comuns. A qualidade da evidência foi classificada como baixa a moderada para desfechos fisiológicos (frequência cardíaca, por exemplo), muito baixa a baixa para desfechos de desempenho (velocidade, por exemplo) e muito baixa a moderada para desfechos auto reportados (esforço percebido, por exemplo) O estudo apresentado no **subtópico 2.2** está em andamento e espera-se que as meias de compressão apresentem efeitos positivos para redução da dor muscular em membros inferiores e percepção de recuperação física

Conclusão: Existe evidência com qualidade de baixa a moderada de que meias de compressão não apresentam efeitos benéficos para desfechos fisiológicos, de desempenho e auto reportados comparado a meias comuns.

Palavras-chave: Corrida; Dor Musculoesquelética; Performance Esportiva.

Abstract

Introduction: Running has become a popular sport. The health benefits obtained through running and the ease of access contribute to the increase in runners. Due to the runner's objectives, health professionals must support different aspects, from running performance to physical recovery after running. Compression socks have the plausibility to meet the varied needs of runners but need more scientific support. Therefore, the objective of this thesis was to investigate the effects of using compression socks during running. **Methods**: This thesis is composed of two studies with different designs and objectives. A systematic review investigated the effects of wearing compression socks during running on physiological, performance and perceptual outcomes. A randomized, controlled crossover clinical trial aimed to investigate the effects of wearing compression socks on muscle soreness and physical recovery after running. This study is in the data-collection phase. **Results**: **Subtopic 2.1** included 28 clinical trials (600 runners). The results showed that compression socks had similar effects to regular socks. The quality of evidence was classified as low to moderate for physiological outcomes (e.g., heart rate mean difference), very low to low for performance outcomes (e.g., running speed), and very low to moderate for self-reported outcomes (e.g., perceived exertion). The study presented in **subtopic 2.2** is ongoing, and it is expected that compression stockings will have positive effects in reducing muscle pain in the lower limbs and the perception of physical recovery. **Conclusion**: There is very low to moderate certainty evidence that wearing compression socks during running does not benefit physiological, running performance, or perceptual outcomes compared to regular socks.

Keywords: Running; pain; performance.

Resumo para leigos

A corrida se tornou um esporte popular e apresenta benefícios para a saúde como redução da mortalidade e melhora da saúde mental. Algumas pessoas correm apenas por lazer enquanto outras participam de competições. Diante disto, as pessoas buscam por conforto durante a corrida ou por recursos que possam melhorar o desempenho durante a corrida. As meias de compressão teoricamente poderiam ajudar as pessoas a sentirem menos dor durante a corrida e a melhorar o desempenho. Por outro lado, é importante saber se de fato esses benefícios são respaldados por estudo científicos. Um estudo foi conduzido a fim de agrupar as informações disponíveis sobre a utilização das meias de compressão durante a corrida. Os resultados demonstraram que as meias de compressão não apresentaram benefícios em comparação às meias comuns em relação ao desempenho ou redução da dor muscular durante a corrida, por exemplo. De maneira geral, os estudos disponíveis apresentam qualidade baixa. Isto indica que novas conclusões podem ser apresentadas futuramente.

Sumário

PARTE I – PROJETO DE PESQUISA

Capítulo 1 Revisão de Literatura

1.1 A Corrida de Rua nos Contextos Mundial e Brasileiro

A corrida de rua tornou-se um dos esportes mais populares, sendo praticada por muitos indivíduos ao redor do mundo. Estima-se que 8,5% da população adulta no continente americano adotou a corrida de rua como atividade física nos momentos de lazer (HULTEEN et al., 2017). O crescimento de adeptos ao esporte também têm sido realidade no Brasil. Um estudo investigou a preferência de modalidade atividade física em todos os estados do Brasil. Calculou-se que aproximadamente 2,5% da população brasileira pratica corrida de rua e o número de praticantes teve crescimento entre 2006 e 2017 (OLIVEIRA; LOPES; HESPANHOL, 2020). Embora a corrida de rua apresente diversos benefícios à saúde, as lesões relacionadas à corrida de rua podem acometer até 40,2% de corredores recreacionais (KAKOURIS et al., 2021). Devido ao impacto econômico e na qualidade de vida do indivíduo associado a essas lesões (HESPANHOL JUNIOR; VAN MECHELEN; VERHAGEN, 2017), o aprofundamento nessa temática também é relevante.

1.2 Benefícios da Corrida de Rua para a Saúde em Geral

A organização mundial de saúde recomenda a prática de atividade física regular com a finalidade de combater o sedentarismo e melhorar a qualidade de vida da população (WORLD HEALTH ORGANIZATION, 2010). Entre as diversas modalidades esportivas, a corrida de rua se apresenta como uma boa opção devido a alguns fatores. O início da prática de corrida de rua é facilitado pelo fato dessa modalidade de exercício físico poder ser praticada em diversos ambientes como asfalto e trilha (FOKKEMA et al., 2019; HOFFMAN et al., 2016) e ser pouco dependente de material esportivo. A consolidação da corrida de rua como uma opção de atividade física também pode ser justificada pelos benefícios provenientes da prática dessa modalidade.

Os praticantes de corrida de rua podem obter resultados positivos em diversos aspectos. A prática de corrida de rua foi associada a redução de 27% de mortalidade de maneira geral (PEDISIC et al., 2020). Essas associações também se estendem para a redução de 30% e 23% para as mortes relacionadas a doenças cardiovasculares e câncer respectivamente (PEDISIC et al., 2020). Além da redução da mortalidade, outros benefícios como a manutenção da saúde mental (OSWALD et al., 2020), aumento do condicionamento cardiorrespiratório e controle do índice de massa corporal (HESPANHOL JUNIOR et al., 2015) podem ser alcançados através da corrida de rua.

1.3 Aspectos Físicos Relacionados à Corrida de Rua

A corrida de rua se apresenta como uma sequência de saltos devido ao fato de seu ciclo apresentar uma fase de voo (ausência de contato com o solo). Esta característica a diferencia da marcha, onde é possível o observar uma fase com apoio duplo (contato entre os dois membros inferiores e o solo) (DEJONG; HATAMIYA; BARKLEY, 2022). As demandas musculares também são maiores em comparação a marcha, pois o peso corporal pode ser triplicado e exigir maiores demandas físicas para absorção de impacto (NOVACHECK, 1998). Essas particularidades da corrida de rua já poderiam ser motivos para a criação de hipóteses sobre questões físicas como a presença de dor muscular após a corrida, contudo outras razões (por exemplo, percorrer distâncias maiores) complementam as informações apresentadas. Diante do fenômeno do crescimento do número de praticantes de corrida de rua, o perfil dos seus praticantes apresenta heterogeneidade. Esta por sua vez, pode refletir nas expectativas e objetivos dos corredores. Alguns corredores podem ter motivações sociais como pertencer a uma comunidade (MENHEERE et al., 2020), enquanto outros podem objetivar a melhora do desempenho (PAQUETTE et al., 2020).

A dor muscular após o exercício resulta de lesões e inflamação nas fibras musculares. Estes mecanismos proporcionam a liberação de enzimas que tornam as inervações musculares mais sensíveis à dor durante as contrações ou alongamentos (PEAKE et al., 2017). Os mecanismos associados à dor muscular são observados principalmente em duas situações: após exercícios envolvendo contrações musculares excêntricas e após uma sessão de exercícios com carga ou intensidade maiores do que as usuais (PEAKE et al., 2017). Estas particularidades sobre dor muscular após o exercício também podem ser observadas na corrida de rua.

Os mecanismos relacionados à dor muscular se fazem presente pois devido às características ao ciclo da corrida, os movimentos são gerados a partir de contrações concêntricas e excêntricas (NOVACHECK, 1998). Parte dos corredores também experimenta intensidades maiores do que as usuais durante a corrida de rua. Um estudo envolvendo corredores em fase de treinamento para a maratona de Nova Iorque em 2019 constatou que 42% dos participantes tinham o objetivo de obter um recorde pessoal (TORESDAHL et al., 2023). Corredores também costumam correr distâncias mais longas. Isso reflete nos estudos voltados para a progressão do volume de treinamento (RAMSKOV et al., 2018) e no aumento de participantes em provas de 21 quilômetros (DAMSTED et al., 2019). Com o objetivo de minimizar a dor muscular após a corrida diversas modalidades de recuperação têm sido aplicadas e estas serão apresentadas no próximo tópico.

1.4 Técnicas de Recuperação Física

Visto que corredores apresentam dor muscular em membros inferiores após a corrida (ARECES et al., 2015; HEAPY et al., 2018), diferentes tipos de intervenções têm sido explorados para a redução deste sintoma. Os mecanismos das intervenções disponíveis para a redução da dor podem ser divididos em físicos, mecânicos e outros. Entre os mecanismos físicos podemos encontrar a eletroterapia e a crioterapia. Os mecanismos mecânicos são representados pelas técnicas de massagem e as roupas de compressão (NAHON; SILVA; NETO, 2021). Além desses recursos, outros como acupuntura e bandagens também são utilizados.

De maneira geral, a literatura apresenta baixa qualidade de evidência sobre os efeitos destas intervenções sobre a dor muscular após exercício (NAHON; SILVA; NETO, 2021). Contudo a técnica de massagem parece ser o recurso mais eficaz quando comparados com outras técnicas ou quando nenhum tratamento é realizado (HEAPY et al., 2018; HOFFMAN et al., 2016). A corrida de rua é praticada rotineiramente pelos seus adeptos e o acesso à serviços de saúde para a redução da dor muscular pode se tornar inviável devido aos custos financeiros. O segundo ponto a ser destacado é que quase todas as intervenções são aplicadas após a corrida com exceção das meias de compressão, que podem ser utilizadas durante a corrida de rua. As meias de compressão ganharam espaço na corrida de rua sendo os corredores os principais adeptos entre os praticantes de esporte de *endurance* (FRANKE; BACKX; HUISSTEDE, 2021). As meias de compressão se apresentam como uma alternativa com menor custo, pois uma vez adquiridas, podem ser utilizadas diversas vezes.

1.4.1 Utilização de Meias de Compressão na Corrida

As meias de compressão surgiram em consequência das práticas de terapias por compressão. A terapia por compressão já foi utilizada por diversas gerações e o primeiro relato sobre esta terapia foi registrado entre 450 e 350 a.C (FELTY; ROOKE, 2005). No campo da medicina, a terapia por compressão foi introduzida para o tratamento de disfunções venosas e posteriormente também foram introduzidas no tratamento de feridas oriundas de queimaduras (ENGRAV et al., 2010). Devido aos possíveis efeitos fisiológicos da compressão, diferentes dispositivos de compressão como calças e camisas foram inseridos na área esportiva (XIONG; TAO, 2018).

Embora existam variados tipos de roupas de compressão, a utilização destas está baseada no mesmo mecanismo (PÉREZ-SORIANO et al., 2019). As meias de compressão são confeccionadas de modo que uma compressão gradual seja exercida sobre o corpo. Deste modo, maiores pressões são aplicadas nas extremidades e reduzidas gradualmente em direção à região mais proximal. Essa compressão decrescente otimizaria o retorno venoso e benefícios relacionados à performance e recuperação física poderiam ser desfrutados (HILL et al., 2015). Além disto, os efeitos hemodinâmicos das meias compressão são respaldados pela literatura. As meias de compressão podem aumentar o retorno venoso durante atividade física ou repouso (O'RIORDAN et al., 2023). Contudo, a literatura sobre os efeitos das meias de compressão na performance e recuperação física apresenta algumas lacunas.

Considerando as roupas de compressão de uma forma geral, podemos destacar alguns pontos sobre a literatura atual. A motivação para utilização de roupas de compressão para membros inferiores durante a corrida de rua parece se alinhar com os possíveis benefícios propostos. Um dos principais fatores que levou atletas a utilizar roupas de compressão para membros inferiores foi a possibilidade de facilitar a recuperação física após exercício (FRANKE; BACKX; HUISSTEDE, 2021). As roupas de compressão apresentaram efeitos moderados para a redução da dor após a prática de exercícios e efeitos positivos em variáveis relacionadas à recuperação, como a força muscular (HILL et al., 2014; MARQUÉS-JIMÉNEZ et al., 2016).

Variáveis fisiológicas e relacionadas ao desempenho também foram investigadas. Em exercícios de alta intensidade, as roupas de compressão apresentaram ausência de benefícios para VO_2, concentração de lactato e esforço percebido (DA SILVA et al., 2018). Os resultados sobre o uso de meias de compressão relacionados à performance também apresentaram ausência de efeitos positivos. Em relação ao tempo de conclusão de uma maratona, por exemplo, corredores que utilizaram meias de compressão concluíram a prova com o tempo médio estatisticamente semelhante aos que que utilizaram meias convencionais (ARECES et al., 2015). De forma semelhante, corredores que utilizaram meias de compressão, suportaram o mesmo tempo sob esforço quando submetidos a uma corrida em esteira (KEMMLER W et al., 2009; MÉNÉTRIER et al., 2011). Embora os resultados de estudos isolados apresentem ausência de efeitos das meias de compressão, essa informação é corroborada quando observamos os resultados das revisões sistemáticas.

1.4.2 Lacunas da Literatura Sobre a Utilização de Meias de Compressão na Corrida de Rua

Sendo as revisões sistemáticas um tipo de estudo importante para tomada de decisão na prática clínica (HERBERT et al., 2011), estas apresentam limitações importantes. O primeiro aspecto a ser considerado é a heterogeneidade metodológica entre os estudos. Ao se investigar os efeitos de roupas de compressão para membros inferiores sobre desfechos fisiológicos e de performance, corredores, ciclistas e triatletas foram incluídos (DA SILVA et al., 2018). Limitações semelhantes foram encontradas em uma revisão sistemática investigando variáveis relacionadas à recuperação física. Neste caso, estudos que envolviam desde corredores a jogadores de basquete foram analisados (BROWN et al., 2017). Diante disto, a recomendação para o uso de meias de compressão durante a corrida de rua baseada nestes estudos seria limitada.

Somente uma revisão sistemática sobre meias de compressão incluiu apenas corredores. Todavia, estudos que investigaram os efeitos de roupas de compressão além das meias foram incluídos (ENGEL; HOLMBERG; SPERLICH, 2016). Para contornar este critério de inclusão, uma análise de subgrupos poderia ter sido conduzida. A avaliação metodológica dos estudos incluídos se faz necessária para que seja reconhecido os vieses de cada estudo (HIGGINS et al., 2019). Apesar desta revisão ter utilizada a escala PEDro para avaliar a qualidade metodológica, os dados foram sintetizados sem que a qualidade da evidência fosse considerada. A implementação da qualidade da evidência através do GRADE (*Grading of Recommendations Assessment, Development and Evaluation*) facilitaria a interpretação dos resultados (MUKA et al., 2020). Portanto, uma revisão sistemática foi conduzida para investigar os efeitos da utilização das meias de compressão durante a corrida em desfechos fisiológicos, de desempenho e auto-reportados preenchendo as lacunas metodológicas explicitadas (**subtópico 2.1**).

Estudos que investigaram os efeitos das meias de compressão durante a prática de corrida apresentaram vieses. A ausência de cálculo amostral (BIEUZEN et al., 2014) é um aspecto que pode afetar o nível de precisão estatística dos estudos e seus achados (KIM, 2015). Considerando os pontos que podem interferir na mudança de desfechos, processos metodológicos como randomização e inclusão de intervenção placebo precisam ser incorporados (KAMPER, 2018). Esta temática ainda carece de um estudo experimental com metodologia e planejamento estatístico adequado. Visando a preencher esta lacuna, um estudo cruzado, randomizado e controlado foi elaborado e se encontra em fase de coleta de dados (**subtópico 2.2**)

1.5 Justificativas

1.5.1 Relevância para as Ciências da Reabilitação

Diante da constante busca para que as melhores abordagens sejam ofertadas no campo da saúde, esta tese apresenta relevância para as ciências da reabilitação. Visto que a corrida de rua é um esporte popular, conhecer estratégias para que os corredores consigam se manter ativos nas melhores condições possíveis é importante. Apresentar um recurso com baixo custo que tem o potencial de acelerar a recuperação física dos corredores pode facilitar a continuidade da prática de corrida de rua e implementar a prática dos profissionais de saúde. Contudo, é recomendado que as práticas profissionais sejam embasadas pela ciência. Primeiro, uma síntese da literatura sobre meias de compressão foi conduzida através de uma revisão sistemática. Os resultados apresentados servirão de respaldo para tomada de decisão por parte dos profissionais de saúde. Segundo, uma proposta de estudo experimental foi apresentada com o objetivo de preencher lacunas presentes nos estudos investigados.

1.5.2 Relevância para a Agenda de Prioridades do Ministério da Saúde[1]

As meias de compressão apresentam potencial para fornecer benefícios aos praticantes de corrida de rua e facilitar a continuidade da prática de corrida de rua. Portanto, a temática abordada nesta tese está relacionada às iniciativas de inovação em saúde.

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[1] https://bvsms.saude.gov.br/bvs/publicacoes/agenda_prioridades_pesquisa_ms.pdf

1.5.3 Relevância para o Desenvolvimento Sustentável[2]

As informações fornecidas por esta tese estão relacionadas ao Objetivo de Desenvolvimento Sustentável 3 (saúde e bem-estar) dos objetivos de desenvolvimento sustentável. Visto que a prática de corrida de rua está relacionada à redução da mortalidade, proporcionar informações relevantes aos praticantes de corrida de rua podem contribuir para o objetivo 3.4, que trata da redução de mortalidade através da promoção da saúde e bem-estar.

1.5.4 Uso de modelos generativos em redação científica

Durante a elaboração deste trabalho, o autor utilizou modelos generativos para escrita científica a fim de correção gramatical para língua inglesa. Após o uso desses modelos, o autor revisou e editou o conteúdo gerado conforme necessário, garantindo sua precisão e coesão. O autor assume total responsabilidade pelo conteúdo final da publicação.

1.5.5 Disponibilidade e acesso aos dados

Os dados serão disponibilizados a partir da solicitação aos pesquisadores responsáveis pelo estudo.

1.5.6 Adequação à Lei Geral de Proteção de Dados

A presente tese está em consonância com os princípios e normas da Lei Geral de Proteção de Dados Pessoais (LGPD), Lei nº 13.709/2018.

1.6 Impactos esperados

[2] https://odsbrasil.gov.br/objetivo/objetivo?n=3

1.6.1 Educacional

Os resultados desta tese fornecerão informações sobre a recomendação do uso de meias de compressão durante a corrida de rua.

1.6.2 Científico

Esta tese apresentará as lacunas científicas sobre o uso de meias de compressão durante a corrida. Desta forma, estudos futuros poderão ser conduzidos com melhor delineamento metodológico.

1.7 Financiamento

Este estudo é financiado pela Fundação Carlos Chagas Filho de Apoio à Pesquisa do Estado do Rio de Janeiro (FAPERJ, No. E-26/211.104/2021) e pela Coordenação de Aperfeiçoamento de Pessoal de Nível Superior - Brasil (CAPES) - Código Financeiro 001, No. 88881.708719/2022-01, e No. 88887.708718/2022-00).

Quadro 1: Apoio financeiro.

CNPJ	Nome	Tipo de Apoio financeiro	E-mail	Telefone
00889834/0001-08	CAPES	Bolsa	prosup@capes.gov.br	(061) 2022-6250

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PARTE II – PRODUÇÃO INTELECTUAL

Manuscrito(s) para Submissão

NOTA SOBRE MANUSCRITOS PARA SUBMISSÃO

Este arquivo contém manuscrito(s) a ser(em) submetido(s) para publicação para revisão por pares interna. O conteúdo possui uma formatação preliminar considerando as instruções para os autores do periódico-alvo. A divulgação do(s) manuscrito(s) neste documento antes da revisão por pares permite a leitura e discussão sobre as descobertas imediatamente. Entretanto, o(s) manuscrito(s) deste documento não foram finalizados pelos autores; podem conter erros; relatar informações que ainda não foram aceitas ou endossadas de qualquer forma pela comunidade científica; e figuras e tabelas poderão ser revisadas antes da publicação do manuscrito em sua forma final. Qualquer menção ao conteúdo deste(s) manuscrito(s) deve considerar essas informações ao discutir os achados deste trabalho.

2.1 Wearing compression socks during running does not change physiological, performance and perceptual outcomes compared to regular socks: a systematic review with meta-analysis

2.1.1 Contribuição dos autores do manuscrito para submissão #1

Iniciais dos autores, em ordem:	GFT	LRS	MFP	FS	LACN	DOS
Concepção	x	x		x		x
Métodos	x	x	x	x	x	x
Programação	x	x	x	x	x	x
Validação	x	x	x	x	x	x
Análise formal	x	x	x	x		x
Investigação	x	x	x	x	x	x
Recursos	x	x	x	x	x	x
Manejo dos dados	x	x	x			x
Redação do rascunho	x	x	x			x
Revisão e edição	x	x	x			x
Visualização	x	x	x	x	x	x
Supervisão	x	x		x		x
Administração do projeto	x	x		x		x
Obtenção de financiamento	x	x				

***Contributor Roles Taxonomy* (CRediT)**[3]

[3] Detalhes dos critérios em: https://doi.org/10.1087/20150211

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05-Sep-2024

Dear Dr. De Oliveira Silva:

Your manuscript entitled "WEARING COMPRESSION SOCKS DURING RUNNING DOES NOT CHANGE PHYSIOLOGICAL, PERFORMANCE AND PERCEPTUAL OUTCOMES COMPARED TO REGULAR SOCKS: A SYSTEMATIC REVIEW WITH META-ANALYSIS" has been successfully submitted online and is presently being given full consideration for publication in British Journal of Sports Medicine.

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WEARING COMPRESSION SOCKS DURING RUNNING DOES NOT CHANGE PHYSIOLOGICAL, PERFORMANCE AND PERCEPTUAL OUTCOMES COMPARED TO REGULAR SOCKS: A SYSTEMATIC REVIEW WITH META-ANALYSIS

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ABSTRACT

Objective: To investigate the effects of wearing compression socks compared to placebo or regular socks during running on physiological parameters, performance and perceptual outcomes in runners.

Design: Systematic review with meta-analysis.

Data sources: MEDLINE, Embase, CINAHL, SPORTDiscus, and Web of Science.

Eligibility: Clinical trials exploring the effect of compression socks during running on physiological parameters, performance and perceptual outcomes.

Results: We included 28 trials (600 runners). For physiological outcomes (e.g., heart rate mean difference (MD) [95% CI] = 0.82 [-0.39 to 2.03] and blood lactate concentration MD [95% CI] = 0.30 [-0.39 to 0.98]), pooled analysis indicated low to moderate-certainty evidence that compression socks do not differ from regular socks. For running performance (e.g., running speed MD [95% CI] = -0.24 [-0.79 to 0.31] and time to exhaustion SMD [95% CI] = -0.26 [-0.65 to 0.13]), pooled analysis indicated very low to low-certainty evidence that compression socks do not differ from regular socks. For perceptual outcomes (e.g., perceived exertion SMD [95% CI] = 0.06 [-0.17 to 0.29] and lower limb muscle soreness SMD [95% CI] = 0.08 [-0.35 to 0.51]), pooled analysis indicated very low to moderate certainty evidence that compression socks do not differ from regular socks.

Conclusion: There is very low to moderate certainty evidence that wearing compression socks during running does not benefit physiological, running performance, or perceptual outcomes compared to regular socks.

PROSPERO registration number CRD42022330437

What is already known?

- Compression socks are largely used by runners worldwide.
- Compression socks are thought to improve blood flow and may promote physical benefits during running.
- Runners wear compression socks for physical benefits such as reduced muscle soreness and improved physical recovery.

What are the new findings?

- Very low to moderate-certainty evidence indicates that wearing compression socks during running does not change physiological outcomes compared to wearing regular socks.
- Very low to moderate-certainty evidence indicates that wearing compression socks during running does not affect performance outcomes compared to wearing regular socks.
- Very low to moderate-certainty evidence indicates that wearing compression socks during running does not change perceptual outcomes compared to wearing regular socks. The same was observed in the treadmill subgroup analysis.
- Wearing compression socks does not appear to have any detrimental effect on physiological, running performance and perceptual outcomes.

How this study might affect research, practice or policy?

Our findings challenge the widely held belief and industry claims that compression socks improve physiological, performance, and perceptual outcomes for runners. Our systematic review indicates no differences between wearing compression and regular socks, suggesting a need for revised guidelines and consumer awareness in running communities and clinical

INTRODUCTION

Running is one of the most popular sports worldwide[1] and has been associated with many health benefits, including mortality reduction.[2] Despite the overall benefits, running-related injuries have a high incidence and prevalence of 40.2% and 44.6%,[3] respectively. As a result, runners often seek strategies to enhance performance and minimise injury risk or delayed muscle soreness.

Compression socks are a popular feature for runners — runners are the most prevalent users of compression socks among endurance athletes.[4] The rationale for wearing compression socks is to improve blood flow return, reduce delayed onset muscle soreness, and improve physical recovery.[5,6] Compression socks would then theoretically improve physiological response, running performance and perceptual outcomes (e.g., perceived effort, comfort).[7] Despite the high rates of real-world adoption by runners and advertising campaigns by the compression socks industry, the research evidence around the effect of compression socks is conflicting for physiological and recovery outcomes, and scarce for performance outcomes.[8–10]

No high-quality systematic review has focused on exploring the effects of compression socks during running. Previous systematic reviews[8–10] included participants from different sports modalities, and the latest search update was made in 2017. Since then, at least eight new clinical trials[11–18] have explored the effects of compression socks during running, which could change evidence synthesis certainty.[8–10] Millions of runners worldwide will benefit from our evidence synthesis that aims to systematically appraise the effects of wearing compression socks used during running on physiological, performance and perceptual outcomes.

METHODS

This systematic review followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA),[19] the implementing PRISMA in Exercise, Rehabilitation, Sport medicine and SporTs Science (PERSiST)[20] and the recommendations presented in the Cochrane Handbook for systematic reviews of interventions.[21] The protocol was prospectively registered on the International Prospective Register for Systematic Reviews (PROSPERO) in May 2022

(CRD42022330437). Deviations from the protocol were minimal and are described in the Supplementary File 1.

Declaration of equity, diversity, and inclusion

The author group consists of three women and three men. Three PhD students, two early-mid-career, and one senior researcher. Three members of the author group are affiliated with a university in a non-English-speaking developing country, and three members are affiliated with a university in an English-speaking developed country. Our search was inclusive and not restricted to gender, nationality, cultural background, language, or age.

Consumer involvement

The research team consulted two experienced runners (>5 years running at least 20km per week, one man and one woman) during the development of the research question of our systematic review. Informal qualitative feedback from both runners suggested that summarising the effect of using compression socks during running would be more relevant than pre- or post-running. We modified our research question to accommodate this need. They were also interested in the effect of compression socks on running performance, which was added to our research question.

Inclusion and exclusion criteria

The selection criteria were established a priori using the Population, Intervention, Comparison, Outcome (PICO) framework. The following eligibility criteria were applied:

Population: We only included trials with non-injured runners with no restrictions on participants' age or sex. We excluded trials with runners presenting any cardiovascular, metabolic, or neurological disorders, cervical or back pain, and trials including populations with a history of lower limb or spine surgery. Trials assessing specific sports other than running or trials that do not include running activities were also excluded.

Types of intervention: We included trials using below-knee compression socks or sleeves as the intervention. We excluded trials using tights, shorts, and whole-body compression.

Types of control intervention: A placebo or non-exposed group, such as regular socks and sleeves, was considered as the control intervention.

Types of outcomes measures: We included trials that reported physiological outcomes (e.g. heart rate and maximal oxygen consumption (VO2), performance outcomes (e.g. speed and pace), perceptual outcomes (e.g. perceived exertion, tight and calf muscle soreness). We excluded trials that did not report any of these outcomes.

Trial design: We included randomised clinical trials, non-randomised clinical trials, cross-over clinical trials, and pre-post interventional trials. We did not include editorials, comments, letters, abstracts, review articles, case trials, cross-sectional trials, or trials with animals.

Literature search strategy

Following the PRISMA statement, the search was carried out by one reviewer (GFT), who combined relevant terms for population, intervention, and outcome. The terms were based on previous systematic reviews.[6,22] We searched, without restriction on publication year or language, the following databases: MEDLINE and Embase (via OVID), CINAHL and SPORTDiscus (via EBSCO) and Web of Science. The database searches were conducted on 24 April 2022 and updated on 15 August 2024. Our review team is fluent in English, Portuguese, and Spanish and decided to use professional translation services if trials published in other languages were deemed eligible. We hand-searched the reference lists of all included trials. We did not explore grey literature as the academic field is relatively mature.[23] The search combined terms related to “compression socks”, “physiological parameters”, “perceived exertion”, “muscle soreness” and “running performance”. The full electronic search strategy for each database is presented in Supplementary File 2.

Trial selection

Two reviewers (GFT and LRS) independently screened the titles and abstracts of all identified trials using the Covidence (Veritas Health Innovation, Melbourne, Australia) tool to determine potential eligibility. Then, both reviewers independently assessed the full text of each trial according to our eligibility criteria. Trials deemed eligible by both reviewers were included in the review. Any disagreements between the two reviewers were resolved with the input of a third reviewer (DOS).

Data extraction

One reviewer (GFT) independently extracted the data from the included trials into a data extraction spreadsheet. All extracted data were independently reviewed for accuracy by a second reviewer (LRS). Disagreements were resolved by a consensus meeting between the two reviewers, which was overseen by two other team members (DOS and LCN). We made three attempts to contact the trial authors when the required data were missing or incomplete. We used the Web Plot Digitizer software (Ankit Rohatgi, California, USA; accessible at https://automeris.io/WebPlotDigitizer) to extract acceptable data from graphical forms where the authors could not be contacted or when data could not be retrieved.[24] Trials that could not be retrieved using the Web Plot Digitizer software were described narratively. Information regarding the trials where authors were contacted can be found in the online Supplementary File 3.

We extracted the following information from eligible trials:

• Trial characteristics: author, year of publication, trial design, study protocol and sample size.

• Participant characteristics: age, sex, body mass index (BMI), and population (e.g., marathon runners, recreational runners).

• Intervention and comparator characteristics: we extracted the level of pressure of the sock.

• Outcomes: all available data on physiological parameters, running performance and perceptual outcomes from each trial's intervention and comparator arm were extracted, including the point estimated and the corresponding measures of variability (standard deviation (SD), p value or 95% confidence interval (CI)). Where available, data were extracted for the following timepoints: during running, post-running and 24 hours post-running).

Risk of bias assessment

The risk of bias for each trial was independently assessed by two reviewers (GFT and MFP) using the Revised Cochrane Risk of Bias 2 tool for randomised parallel trials (RoB2) and the version of RoB2 tool for crossover trials.[25,26] Five domains were examined: (1) bias arising from the randomisation process, and from period and carryover effects (only for crossover trials), (2) bias due to deviations from intended interventions, (3) bias due to missing outcome data, (4) bias in the measurement of the outcome, and (5) bias in the selection of the reported result. Each domain was individually graded as low risk, some concerns, or high risk of bias by the two reviewers. In the event of a disagreement, a third author (DOS) independently evaluated the trial, and the research team met until a consensus was established.

Data synthesis and analysis

We pooled data when three or more studies were similar by intervention (1) compression socks; comparator (1) regular socks or (2) placebo and; outcome (1) physiological variables, (2) running performance variables and, (3) perceptual variables. Where possible, we pooled data to perform subgroup analyses for running on a treadmill.

For trials with two or more groups of the same intervention category (e.g., groups with different levels of sock compression compared to a control group), these groups were combined and considered as a single intervention. This approach for combining intervention groups is recommended and described in section 6.5.2.10 of the Cochrane Handbook.[21] The formulae for combining groups were applied using StatsToDo software (accessible at https://www.statstodo.com). The Review Manager statistical software (RevMan Version 5.4.1, The Cochrane Collaboration, 2020) was used to calculate both mean difference (MD) and standardised mean difference (SMD) and 95% CIs to pool and compare results. We estimated the SD in cases where trials reported 95% CIs but no SD using the Review Manager statistical programme, as recommended by Cochrane in section 7.7.3.2 of the Cochrane Handbook.[21] For continuous data, we calculated the MD (for the same scale metric) or SMD (for different scale metrics) with 95% CIs. SMDs were interpreted as minimal <0.2, small 0.2–0.49, medium 0.50–0.79 and large >0.8. Interpretation of effect estimates, and Grading of Recommendations, Assessment, Development and Evaluations (GRADE) findings followed published recommendations.[27]

We analysed the data for each outcome, irrespective of reported participant dropout (intention-to-treat analysis). Data were synthesised by data collection time point (during running, post-running or 24 hours post-running). Skewed data were not transformed and was described narratively using medians and interquartile ranges (IQRs). The random effects model was used as heterogeneity was expected in the intervention, comparator, and population. Visual inspection of forest plots and examination of the X2 test for statistical heterogeneity were used to determine statistical heterogeneity. I^2 values of 30%, 50% and 75% were considered moderated, substantial and considerable statistical heterogeneity, respectively.[21,28] The I2 statistic was used to assess statistical heterogeneity among the trials included in each meta-analysis.

Certainty of evidence

We used GRADE to assess the certainty of evidence for each metaanalysis.[27,29] Two reviewers (GFT and LRS) independently assessed the findings for each outcome using GRADEpro software (McMaster University, 2015, developed by Evidence Prime Inc, available at gradepro.org). Evidence was considered as high certainty but was downgraded if there was a concern about bias, indirectness, inconsistency, or imprecision. Disagreements were resolved by a third reviewer (DOS). Full details of upgrade and downgrade criteria for all GRADE categories can be found in the online Supplementary File 4.

RESULTS

Trial selection and characteristics

The PRISMA flowchart for trial selection can be found in Figure 1. We identified 6,667 trials through database searches, with 4,363 remaining after removing duplicates. Twenty-eight trials were included in this review. Online Supplementary File 5 provides the reasons for the exclusion of full texts. Of 28 trials, 16 (n=284 runners) were included in the quantitative analysis. Online Supplementary File 6 describes the reasons why trials could not be pooled.

Eighteen trials[11–13,15–17,30–41] were based on treadmill protocols, while ten trials[14,18,42–49] were based on different protocols, including running on an artificial surface,[45] marathon,[18,46,47] ultramarathon,[14] trail running,[44,48] outdoor,[43] simulated trail race,[42] and running on flat and hilly terrain.[49] Twenty-three trials[11–13,15–17,30–38,40,41,41–45,49] had a crossover design and five trials[14,18,44,46,47] had a parallel design. The values of compression varied from 8 to 37mmhg. Detailed trials characteristics are presented in Supplementary Table 1.

Risk of bias

Regarding crossover trials, we rated 20 trials[11–13,15–17,30–38,40,42–44,49] as 'high risk,' 2 trials[39,41] as 'some concerns,' and 1 trial[45] as 'low risk' (Figure 2a). Regarding parallel trials, all five trials[14,18,46–48] were rated as 'high risk' (Figure 2b). The risk of bias was largely consistent between the trials. Most trials scored a high risk of bias due to a need for more information regarding the randomisation process and reporting insufficient details about the outcomes or intervention.

Data synthesis

Results from pooled analyses and the certainty of the evidence are summarised in Table 1. The pooled analyses were performed considering the outcomes evaluated during running and, post-running. All data pooled derived from crossover trials. Summary GRADE tables for all pooled comparisons are presented in the Supplementary File 4. Results for outcomes in trials ineligible for pooling are presented in the Supplementary File 7, including their MD or SMD, 95% CI and a narrative synthesis.

Table 1. Summary of findings

Outcomes	Time points	MD or SMD (95% CI)	Nº of participants (trials)	Certainty of the evidence (GRADE)	Comments
Physiological outcomes – compression socks compared to regular socks					
Heart rate	During running	MD **0.82 higher** (0.39 lower to 2.03 higher)	179 (10)	⨁⨁⨁◯ MODERATE	Downgraded because of risk of bias and publication bias
Percentage of maximal heart rate	During running	MD **0.68 higher** (0.83 lower to 2.19 higher)	45 (3)	⨁◯◯◯ VERY LOW	Downgraded because of risk of bias, inconsistency, imprecision, and publication bias
Blood lactate concentration	Post-running	MD **0.30 higher** (0.39 lower to 0.98 higher)	108 (7)	⨁⨁◯◯ LOW	Downgraded because of risk of bias and publication bias
Maximal oxygen consumption (VO2máx)	During running	MD **0.18 higher** (0.68 lower to 1.04 higher)	98 (7)	⨁◯◯◯ VERY LOW	Downgraded because of risk of bias and publication bias
Maximal oxygen consumption (VO2máx)	Post-running	MD **0.39 higher** (2.49 lower to 3.27 higher)	33 (3)	⨁◯◯◯ VERY LOW	Downgraded because of risk of bias, imprecision, and publication bias
Respiratory exchange ratio	During running	SMD **0.27 lower** (0.80 lower to 0.27 higher)	44 (3)	⨁◯◯◯ VERY LOW	Downgraded because of risk of bias, imprecision, and publication bias
Performance outcomes – compression socks compared to regular socks					
Total running time	Post-running	SMD **0.06 higher** (0.27 lower to 0.38 higher)	73 (5)	⨁⨁⨁◯ MODERATE	Downgraded because of risk of bias and publication bias

Running speed	During running	MD **0.24 lower** (0.79 lower to 0.31 higher)	49 (3)	⊕◯◯◯ VERY LOW	Downgraded because of risk of bias, imprecision, and publication bias
Time to exhaustion	Post running	SMD **0.26 lower** (0.65 lower to 0.13 higher)	51 (4)	⊕⊕◯◯ LOW	Downgraded because of risk of bias, imprecision, and publication bias
Perceptual outcomes – compression socks compared to regular socks					
Perceived exertion	During running	SMD **0.06 higher** (0.17 lower to 0.29 higher)	236 (13)	⊕⊕⊕◯ MODERATE	Downgraded because of risk of bias and publication bias. Upgraded because of precision
Lower limb muscle soreness	Post-running	SMD **0.08 higher** (0.35 lower to 0.51 higher)	42 (3)	⊕◯◯◯ VERY LOW	Downgraded because of risk of bias, inconsistency, and publication bias

Abbreviations: MD, mean difference; SMD, standardise mean difference; CI, confidence interval; GRADE, Grading of Recommendations Assessment, Development and Evaluation

GRADE Working Group grades of evidence:

High certainty: we are very confident that the true effect lies close to that of the estimate of the effect.

Moderate certainty: we are moderately confident in the effect estimate: the true effect is likely to be close to the estimate of the effect, but there is a possibility that it is
substantially different.

Low certainty: our confidence in the effect estimate is limited: the true effect may be substantially different from the estimate of the effect.

Very low certainty: we have very little confidence in the effect estimate: the true effect is likely to be substantially different from the estimate of effect.

SMD of <0.2, 0.2–0.49, 0.50–0.79 and >0.8 represents a minimal, small, medium and large effect, respectively.

Physiological outcomes

Heart rate: 12 trials (211 runners) compared the effect of compression socks on heart rate during running.[12,13,16,30,31,33–35,37,41,43,45] Data from 10 trials (n= 197 participants) were pooled for analysis.[12,13,16,30,31,33–35,37,43] The results indicate there is moderate-certainty evidence with low statistical heterogeneity (I^2=0%) to suggest that compression socks are not significantly different from regular socks (MD (95% CI) = 0.82 (-0.39 to 2.03), p=0.18) (figure 3a).

Percentage of maximal heart rate: 3 trials (n=45 runners) compared the effect of compression socks on percentage of maximal heart rate during running[13,37,43] (Figure 3b). Pooled analysis indicates that there is very low-certainty evidence with low statistical heterogeneity (I^2=0%) to suggest that compression socks are not significantly different from regular socks (MD (95%CI) = 0.68 (-0.83 to 2.19), p=0.38).

Blood lactate concentration: 7 trials (n=108 runners) compared the effect of compression socks on blood lactate post-running[11,12,16,30,34,35,37] (Figure 3c). Pooled analysis indicates that there is low-certainty evidence with low statistical heterogeneity (I^2=0%) to suggest that compression socks are not significantly different from regular socks (MD (95%CI) = 0.30 (-0.39 to 0.98), p=0.40).

Maximal oxygen consumption (VO2 max): 7 trials (n=98 runners) compared the effect of compression socks on VO2 during running[11,13,30,34–37] (Figure 3d), while 3 trials[13,34,35] made this comparison post-running (n=33 runners) (Figure 3e). Pooled analysis indicates very low-certainty evidence with low statistical heterogeneity (I^2=0%), to suggest that compression socks are not significantly different from regular socks at either time point during running (MD (95% CI) = 0.18 (-0.68 to 1.04), p=0.68) and post-running (MD (95% CI) = 0.39 (-2.49 to 3.27), p=0.79).

Respiratory exchange ratio: 3 trials (n=44 runners) compared the effect of compression socks on respiratory exchange ratio during running[30,34,35] (Figure 3f). Pooled analysis indicates that there is low-certainty evidence with moderate statistical heterogeneity (I^2=34%) to suggest that compression socks are not significantly different from regular socks (SMD (95%CI) = -0.27 (-0.80 to 0.27), p=0.33).

Running performance outcomes

Total running time: 5 trials (n=73 runners) compared the effect of compression socks on total running time[11,12,42–44] (Figure 4a). Pooled analysis indicates that there is moderate-certainty evidence with low statistical heterogeneity (I^2=0%) to suggest that compression socks are not significantly different from regular socks (SMD (95%CI) = 0.06 (-0.27 to 0.38), p=0.74).

Running speed: 3 trials (n=49 runners) compared the effect of compression socks on running speed[16,30,37] (Figure 4b). Pooled analysis indicates that there is very low-certainty evidence with low statistical heterogeneity (I^2=0%) to suggest that compression socks are not significantly different from regular socks (MD (95%CI) = -0.24 (-0.79 to 0.31), p=0.39).

Time to exhaustion: 4 trials (n=51 runners) compared the effect of compression socks on time to exhaustion (Figure 4c). Pooled analysis indicates that there is low-certainty evidence with low statistical heterogeneity (I^2=0%) to suggest that compression socks are not significantly different from regular socks (SMD (95%CI) = -0.26 (-0.65 to 0.13), p=0.20).

Perceptual outcomes

Perceived exertion: 13 trials (n=236 runners) compared the effect of compression socks on perceived exertion[11–13,16,31–35,37,40,42,43] (Figure 5a). Pooled analysis indicates that there is moderate-certainty evidence with moderate statistical heterogeneity (I^2=33%) to suggest that compression socks are not significantly different from regular socks (SMD (95%CI) = 0.06 (-0.17 to 0.29), p=0.59).

Lower limbs muscle soreness: 3 trials (n=42 runners) compared the effect of compression socks on lower limb muscle soreness post-running[11,42,43] (Figure 5b). Pooled analysis indicates that there is very low-certainty evidence with low statistical heterogeneity (I^2=0%) to suggest that compression socks are not significantly different from regular socks (SMD (95%CI) = 0.08 (-0.35 to 0.51), p=0.71).

Subgroup analysis

Subgroup analysis of running on a treadmill was possible only for the perceived exertion (Supplemental File 8). Data from 11 trials (n=206 runners) compared the effect of compression socks on perceived exertion. Pooled analysis indicates that there is very moderate-certainty evidence with moderate statistical heterogeneity (I^2=38%) to suggest that compression socks are not significantly different from regular socks (SMD (95%CI) = 0.06 (-0.20 to 0.32), p=0.64).

DISCUSSION

Our systematic review explored the effect of wearing compression socks during running on physiological, running performance, and perceptual outcomes. We identified 28 trials and included data from 16 trials (n= 284 runners) on the quantitative analyses. Pooled analysis indicated that compression socks do not benefit runners on physiological, running performance, and perceptual outcomes compared to regular socks.

Physiological outcomes

Although the use of compression socks has been proposed to prevent performance deterioration and improve recovery by accelerating nutrient delivery[50,51] and metabolite removal[38,52] due to enhanced blood flow[53], our findings suggest that they are not superior to regular socks for improving physiological parameters. These findings are consistent with previous systematic reviews[6,9] that evaluated the effects of wearing compression garments on physiological parameters in both runners and mixed populations. One systematic review[6] specifically examining the effects of wearing lower-limb and whole-body compression garments in runners found no effects of their use during or after long-distance running on heart rate, oxygen uptake, or blood lactate concentration compared with a non-compression garment intervention. Additionally, another systematic review[9] involving a mixed population found no differences of wearing lower-limb compression garments during high-intensity exercise compared to a non-compression condition.

The limited number of trials, their crossover design, and the variability in running protocols and compression used, limit our ability to provide direct recommendations to clinical practice about the effect of specific compression socks. Therefore, caution should be used when interpreting our findings.

Running performance outcomes

Our findings align with previous systematic reviews[6,9] that have examined the effects of compression garments on running performance variables in various sports populations. One systematic review[6] found a trivial effect of compression garments on running time across various running protocols and a small positive effect on time to exhaustion during incremental or step tests compared to noncompression interventions. Conversely, another systematic review[9] reported no effect of lower-limb compression garments on high-intensity exercise performance—measured as the time difference in maximum running tests over specific distances (50-400m, 800-3000m, or >5000m)—when compared to noncompression interventions or placebo garments.

Various factors can influence running performance, including physiological variables such as an athlete's peak oxygen uptake and velocity at the lactate threshold, effort duration, and environmental conditions[6]. As reported by Engel et al.[6], the use of compression garments did not demonstrate any beneficial effects on either physiological or running performance. Our systematic review found similar results, suggesting that the lack of impact of compression socks on physiological variables may explain their lack of effect on running performance when compared to regular socks.

Compression socks might potentially improve performance by reducing muscle oscillations, enhancing muscle proprioception, and improving running economy[7]. However, improvements in the running speed of middle-distance and long-distance runners are more likely to be influenced by strength training with high loads (≥80% of one repetition maximum) and plyometric training, rather than by the use of compression socks[54].

Perceptual outcomes

In contrast to our findings, a systematic review observed a small positive effect of wearing compression garments on perceived exertion and a large positive effect on lower limb muscle soreness during both running and recovery[6]. A possible explanation for the conflicting findings is that, unlike our review, Engel et al.[6] included studies with various compression garments, including wholebody compression garments. It is possible that whole-body compression garments, compared to compression socks, may offer greater benefits by reducing structural damage to muscles[55,56] and/or improving lymphatic outflow[57], leading to reduced muscle swelling and greater comfort[58]. The lack of benefit from wearing compression socks on runners' perceived exertion may be aligned with the absence of change in the runners' heart rates.

Strength and limitations

The strengths of our review include using a prespecified protocol with no language and date restriction criteria, informed by consumers, and the summary of the certainty of the evidence using the GRADE approach. As limitations, most trials were classified as high risk of bias, which impacts the certainty of the evidence produced by our systematic review. Most of the pooled analysis was based on a limited number of trials and only included crossover design trials and the interventions exhibited inherent differences (e.g., different compressions were applied across studies and different running protocols were performed) that make it difficult to draw definitive conclusions about the effects of different types of compression socks. Additionally, future trials should focus on including an adequate sample size and should be designed as a parallel RCT with an appropriate comparator to control for placebo effects[59]. When interpreting our findings to specific running populations, caution should be taken once we have trials ranging from recreational to ultramarathon runners. Most crossover trials (22/23) did not report period effect analysis to ensure the intervention order did not affect the final analysis. Therefore, findings from this systematic review should be interpreted with caution.

Implication for clinicians

Our findings suggest that wearing compression socks during running may not benefit physiological, running performance and perceptual outcomes compared to regular socks. These findings challenge the large adoption of compression socks by runners during competition and training. On the other hand, runners wearing compression socks during running do not appear to have any detrimental effect on physiological, running performance and perceptual outcomes. However, we did not synthesise the literature on adverse events of wearing compression socks as it was beyond the scope of this systematic review. These recommendations are based on very low to moderate-certainty evidence, highlighting the need for future high-quality research.

CONCLUSION

There is very low to moderate certainty evidence that wearing compression socks during running does not benefit physiological, running performance, or perceptual outcomes compared to regular socks.

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Competing interests

None declared.

Data availability statement

All data relevant to the trial are included in the article or uploaded as online supplemental information.

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Figure legends

Figure 1. PRISMA flow chart. PRISMA, Preferred Reporting Items for Systemati Reviews and Meta-Analyses.

Figure 2. Risk of bias of crossover trial trials (A) and parallel trial trials (B).

Figure 3. Pooled data of physiological outcomes. (SD, standard deviation; IV, inverse variance; Std, standard mean difference; MD, mean difference).

Figure 4. Pooled data of running outcomes. (SD, standard deviation; IV, inverse variance; Std., standard mean difference; MD, mean difference). Running speed and time to exhaustion values were inverted to negative to ensure consistent reporting.

Figure 5. Pooled data of perceptual outcomes. (SD, standard deviation; IV, inverse variance; Std., standard mean difference).

Figure 1

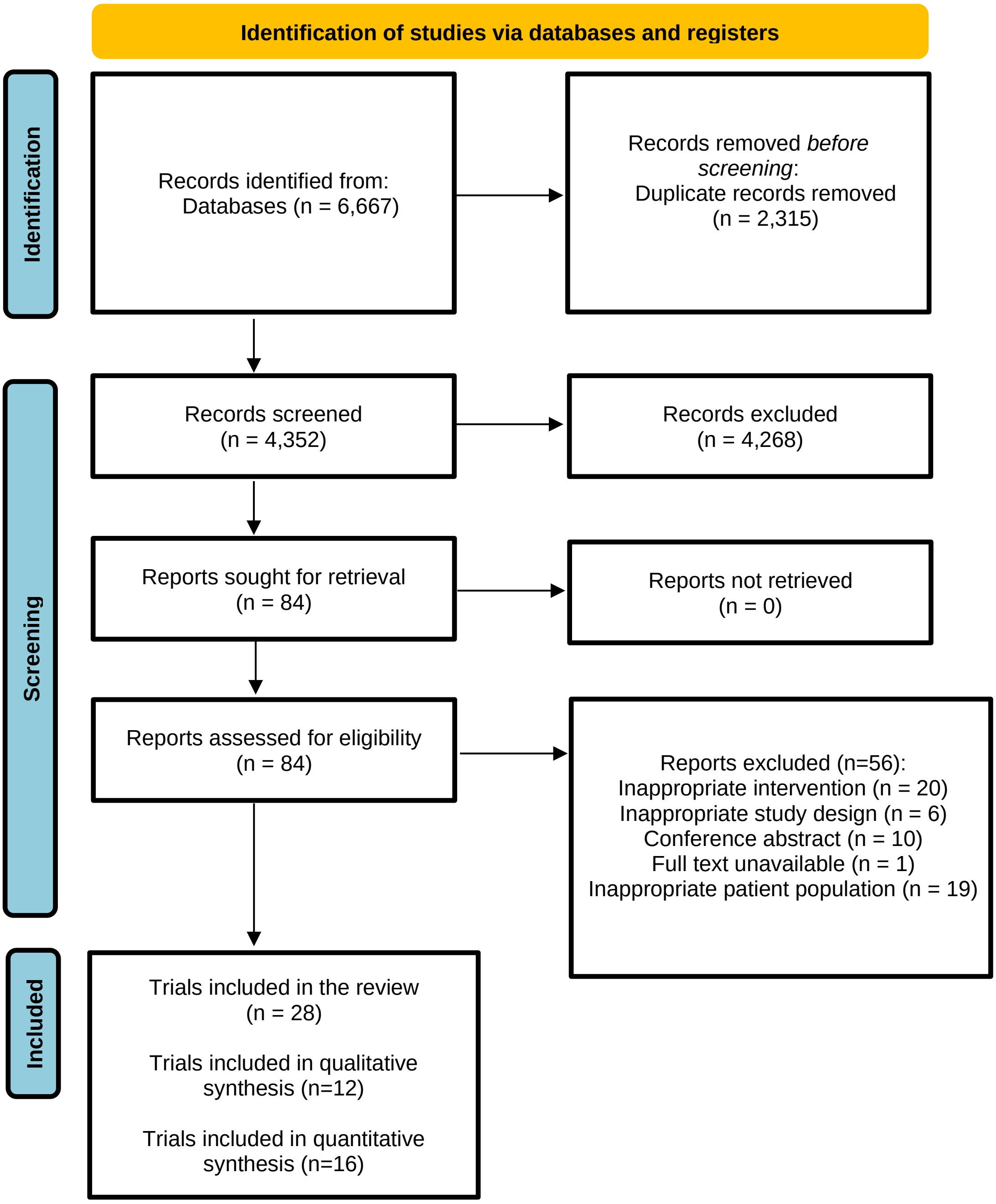
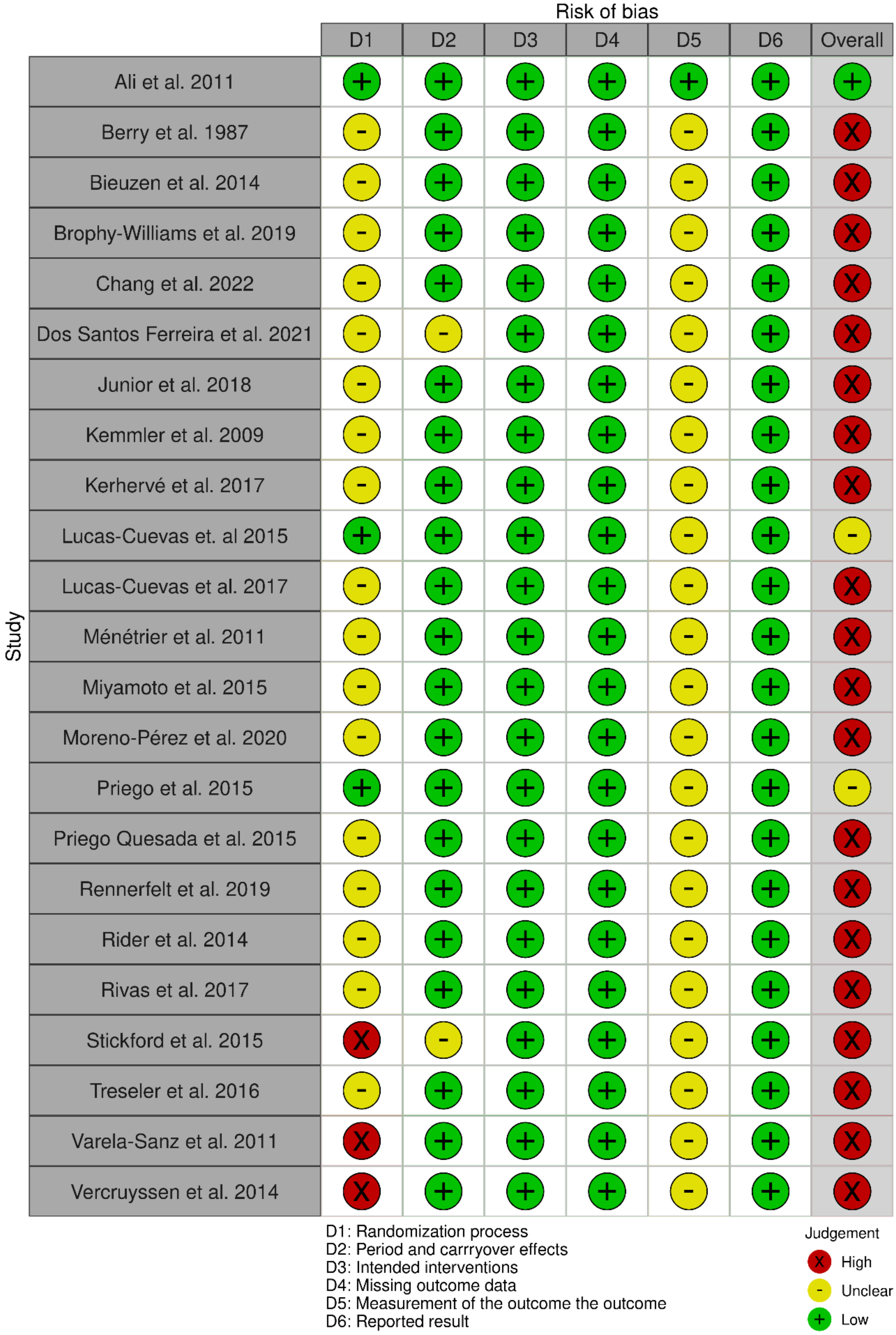

Identification of studies via databases and registers
Identification
Records identified from:
Databases (n = 6,667)
Records removed *before screening*:
Duplicate records removed
(n = 2,315)
Screening
Records screened
(n = 4,352)
Records excluded
(n = 4,268)
Reports sought for retrieval
(n = 84)
Reports not retrieved
(n = 0)
Reports assessed for eligibility
(n = 84)
Reports excluded (n=56):
Inappropriate intervention (n = 20)
Inappropriate study design (n = 6)
Conference abstract (n = 10)
Full text unavailable (n = 1)
Inappropriate patient population (n = 19)
Included
Trials included in the review
(n = 28)
Trials included in qualitative
synthesis (n=12)
Trials included in quantitative
synthesis (n=16)

Figure 2

A) Risk of bias for crossover trials



B) Risk of bias for parallel trials

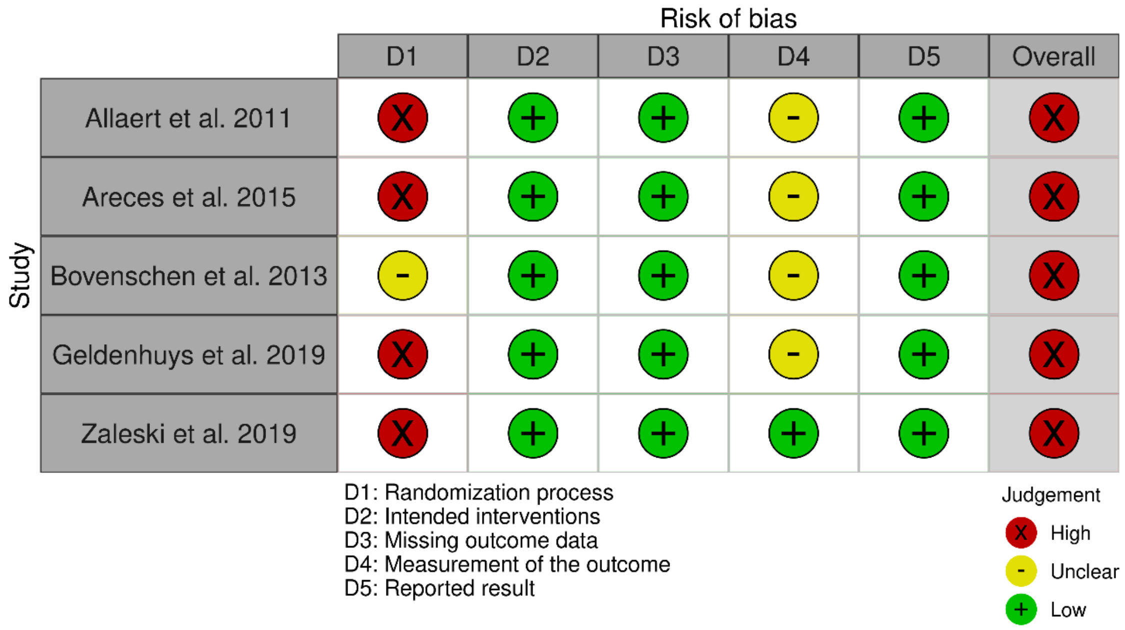
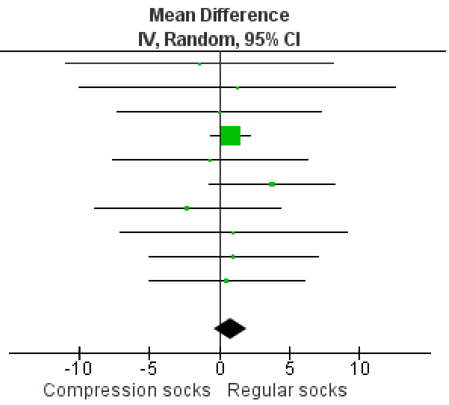


Figure 3

A) Effect of compression socks on heart rate during running

	Compression socks			Regular socks				Mean Difference
Study or Subgroup	**Mean**	**SD**	**Total**	**Mean**	**SD**	**Total**	**Weight**	**IV, Random, 95% CI**
Chang et al. 2022	157.9	15.8	20	159.3	15	20	1.6%	-1.40 [-10.95, 8.15]
Dos Santos Ferreira et al. 2021	166.7	12.6	10	165.4	13.2	10	1.1%	1.30 [-10.01, 12.61]
Kemmler et al. 2009	180.6	11.6	21	180.6	12.5	21	2.7%	0.00 [-7.29, 7.29]
Ménétrier et al. 2011	197.6	1.9	14	196.8	2	14	70.0%	0.80 [-0.65, 2.25]
Moreno-Pérez et al. 2020	182	10.1	16	182.6	10	16	3.0%	-0.60 [-7.56, 6.36]
Priego Quesada et al. 2015	174.8	10.9	44	171	10.5	44	7.3%	3.80 [-0.67, 8.27]
Rider et al. 2014	198.6	7.7	10	200.9	7.4	10	3.3%	-2.30 [-8.92, 4.32]
Rivas et al. 2017	190	11	13	189	10	13	2.2%	1.00 [-7.08, 9.08]
Treseler et al. 2016	188	9	19	187	10	19	4.0%	1.00 [-5.05, 7.05]
Varela-Sanz et al. 2011	171.59	7.47	12	171.06	6.47	12	4.7%	0.53 [-5.06, 6.12]
Total (95% CI)			**179**			**179**	**100.0%**	**0.82 [-0.39, 2.03]**

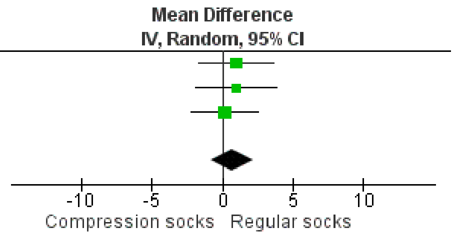
Heterogeneity: Tau² = 0.00; Chi² = 3.00, df = 9 (P = 0.96); I² = 0%
Test for overall effect: Z = 1.33 (P = 0.18)



B) Effect of compression socks on percentage of maximal heart rate during running

	Compression socks			Regular socks				Mean Difference
Study or Subgroup	**Mean**	**SD**	**Total**	**Mean**	**SD**	**Total**	**Weight**	**IV, Random, 95% CI**
Dos Santos Ferreira et al. 2021	91.8	2.8	10	90.8	3.2	10	32.7%	1.00 [-1.64, 3.64]
Treseler et al. 2016	94	4	19	93	5	19	27.4%	1.00 [-1.88, 3.88]
Varela-Sanz et al. 2011	92.25	3.6	16	92.06	3.29	16	39.8%	0.19 [-2.20, 2.58]
Total (95% CI)			**45**			**45**	**100.0%**	**0.68 [-0.83, 2.19]**

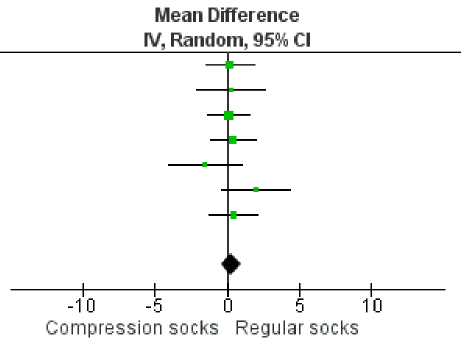
Heterogeneity: Tau² = 0.00; Chi² = 0.27, df = 2 (P = 0.88); I² = 0%
Test for overall effect: Z = 0.88 (P = 0.38)



C) Effect of compression socks on blood lactate concentration post-running

	Compression socks			Regular socks				Mean Difference
Study or Subgroup	**Mean**	**SD**	**Total**	**Mean**	**SD**	**Total**	**Weight**	**IV, Random, 95% CI**
Brophy-Williams et al. 2019	8.55	2.47	12	8.35	1.74	12	16.2%	0.20 [-1.51, 1.91]
Chang et al. 2022	4.8	4.2	20	4.5	3.4	20	8.4%	0.30 [-2.07, 2.67]
Kemmler et al. 2009	8.3	2.2	21	8.2	2.5	21	23.3%	0.10 [-1.32, 1.52]
Moreno-Pérez et al. 2020	8.3	2.1	16	7.9	2.4	16	19.3%	0.40 [-1.16, 1.96]
Rider et al. 2014	13.3	2.9	10	14.8	2.8	10	7.6%	-1.50 [-4.00, 1.00]
Rivas et al. 2017	10.9	2.15	13	8.9	3.7	13	8.7%	2.00 [-0.33, 4.33]
Varela-Sanz et al. 2011	6.47	2.59	16	6.01	2.28	16	16.5%	0.46 [-1.23, 2.15]
Total (95% CI)			**108**			**108**	**100.0%**	**0.30 [-0.39, 0.98]**

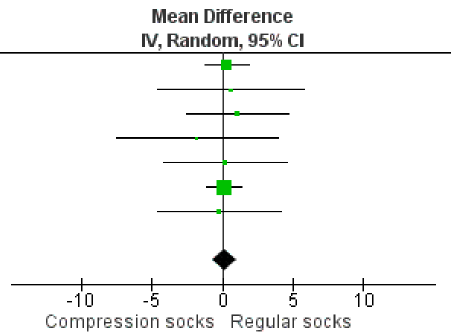
Heterogeneity: Tau² = 0.00; Chi² = 4.18, df = 6 (P = 0.65); I² = 0%
Test for overall effect: Z = 0.84 (P = 0.40)



D) Effect of compression socks on VO2 during running

	Compression socks			Regular socks				Mean Difference
Study or Subgroup	**Mean**	**SD**	**Total**	**Mean**	**SD**	**Total**	**Weight**	**IV, Random, 95% CI**
Brophy-Williams et al. 2019	47.7	2	12	47.4	1.9	12	30.7%	0.30 [-1.26, 1.86]
Dos Santos Ferreira et al. 2021	50.4	5.5	10	49.8	6.2	10	2.8%	0.60 [-4.54, 5.74]
Kemmler et al. 2009	53.3	5.8	21	52.2	6.2	21	5.7%	1.10 [-2.53, 4.73]
Rider et al. 2014	63.1	6	10	64.9	7	10	2.3%	-1.80 [-7.51, 3.91]
Rivas et al. 2017	59	5.5	13	58.8	5.9	13	3.9%	0.20 [-4.18, 4.58]
Stickford et al. 2015	62.2	1.8	16	62.1	1.7	16	50.8%	0.10 [-1.11, 1.31]
Varela-Sanz et al. 2011	51.04	6.71	16	51.25	5.87	16	3.9%	-0.21 [-4.58, 4.16]
Total (95% CI)			**98**			**98**	**100.0%**	**0.18 [-0.68, 1.04]**

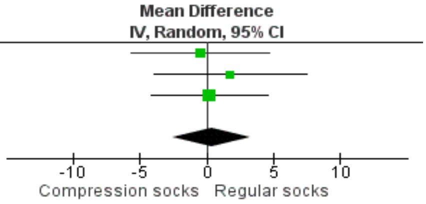
Heterogeneity: Tau² = 0.00; Chi² = 0.80, df = 6 (P = 0.99); I² = 0%
Test for overall effect: Z = 0.41 (P = 0.68)



E) Effect of compression socks on VO2 post-running

Study or Subgroup	Compression socks Mean	SD	Total	Regular socks Mean	SD	Total	Weight	Mean Difference IV, Random, 95% CI
Dos Santos Ferreira et al. 2021	27.7	3.1	10	28.2	7.7	10	31.4%	-0.50 [-5.64, 4.64]
Rider et al. 2014	64.9	7	10	63.1	6	10	25.4%	1.80 [-3.91, 7.51]
Rivas et al. 2017	59	5.5	13	58.8	5.9	13	43.2%	0.20 [-4.18, 4.58]
Total (95% CI)			**33**			**33**	**100.0%**	**0.39 [-2.49, 3.27]**

Heterogeneity: Tau² = 0.00; Chi² = 0.36, df = 2 (P = 0.84); I² = 0%
Test for overall effect: Z = 0.26 (P = 0.79)



F) Effect of compression socks on respiratory exchange ration during running

Study or Subgroup	Compression socks Mean	SD	Total	Regular socks Mean	SD	Total	Weight	Std. Mean Difference IV, Random, 95% CI
Kemmler et al. 2009	1.04	4	21	1.1	0.04	21	43.2%	-0.02 [-0.63, 0.58]
Rider et al. 2014	1.2	0.06	10	1.2	0.1	10	26.8%	0.00 [-0.88, 0.88]
Rivas et al. 2017	1.1	0.05	13	1.14	0.04	13	30.0%	-0.86 [-1.66, -0.05]
Total (95% CI)			**44**			**44**	**100.0%**	**-0.27 [-0.80, 0.27]**

Heterogeneity: Tau² = 0.08; Chi² = 3.02, df = 2 (P = 0.22); I² = 34%
Test for overall effect: Z = 0.98 (P = 0.33)

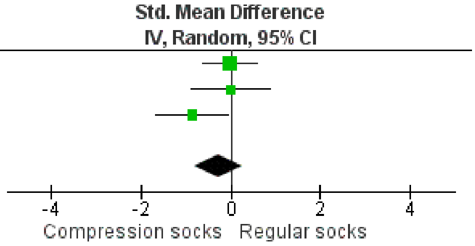


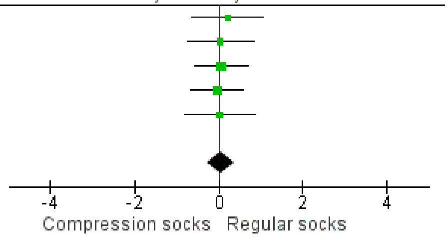
Figure 4

A) Effects of compression socks on running time

Study or Subgroup	Compression socks Mean	SD	Total	Regular socks Mean	SD	Total	Weight	Std. Mean Difference IV, Random, 95% CI
Bieuzen et al. 2014	5,704	560	11	5,590	393	11	15.0%	0.23 [-0.61, 1.07]
Brophy-Williams et al. 2019	19.58	0.82	12	19.54	0.86	12	16.5%	0.05 [-0.75, 0.85]
Chang et al. 2022	119.2	13.3	20	118.3	13.2	20	27.4%	0.07 [-0.55, 0.69]
Treseler et al. 2016	25.2	2.8	19	25.3	3	19	26.1%	-0.03 [-0.67, 0.60]
Vercruyssen et al. 2014	5,696.7	530.7	11	5,681.1	503.5	11	15.1%	0.03 [-0.81, 0.86]
Total (95% CI)			**73**			**73**	**100.0%**	**0.06 [-0.27, 0.38]**

Heterogeneity: Tau² = 0.00; Chi² = 0.24, df = 4 (P = 0.99); I² = 0%
Test for overall effect: Z = 0.33 (P = 0.74)

Std. Mean Difference
IV, Random, 95% CI

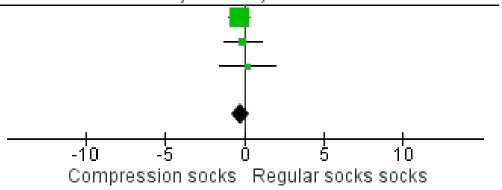


B) Effects of compression socks on running speed

Study or Subgroup	Compression socks Mean	SD	Total	Regular socks Mean	SD	Total	Weight	Mean Difference IV, Random, 95% CI
Kemmler et al. 2009	-16.96	1.15	21	-16.61	1.05	21	68.4%	-0.35 [-1.02, 0.32]
Moreno-Pérez et al. 2020	-19.2	1.7	16	-19.1	1.7	16	21.9%	-0.10 [-1.28, 1.08]
Varela-Sanz et al. 2011	-16.47	2.14	12	-16.66	2.26	12	9.8%	0.19 [-1.57, 1.95]
Total (95% CI)			**49**			**49**	**100.0%**	**-0.24 [-0.79, 0.31]**

Heterogeneity: Tau² = 0.00; Chi² = 0.39, df = 2 (P = 0.82); I² = 0%
Test for overall effect: Z = 0.86 (P = 0.39)

Mean Difference
IV, Random, 95% CI



C) Effects of compression socks on time to exhaustion

Study or Subgroup	Compression socks Mean	SD	Total	Regular socks Mean	SD	Total	Weight	Std. Mean Difference IV, Random, 95% CI
Kemmler et al. 2009	-36.4	3.5	21	-35	3.5	21	40.9%	-0.39 [-1.00, 0.22]
Ménétrier et al. 2011	-269.4	18.4	14	-263.3	19.8	14	27.5%	-0.31 [-1.06, 0.44]
Rider et al. 2014	-23.6	2.4	10	-23.9	2.5	10	19.9%	0.12 [-0.76, 0.99]
Varela-Sanz et al. 2011	-387.42	129.33	6	-337.16	179.72	6	11.7%	-0.30 [-1.44, 0.84]
Total (95% CI)			**51**			**51**	**100.0%**	**-0.26 [-0.65, 0.13]**

Heterogeneity: Tau² = 0.00; Chi² = 0.91, df = 3 (P = 0.82); I² = 0%
Test for overall effect: Z = 1.29 (P = 0.20)

Std. Mean Difference
IV, Random, 95% CI

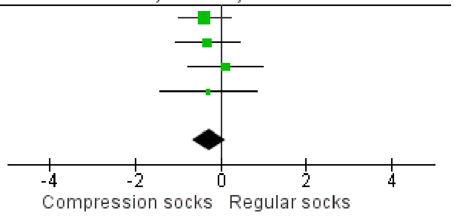
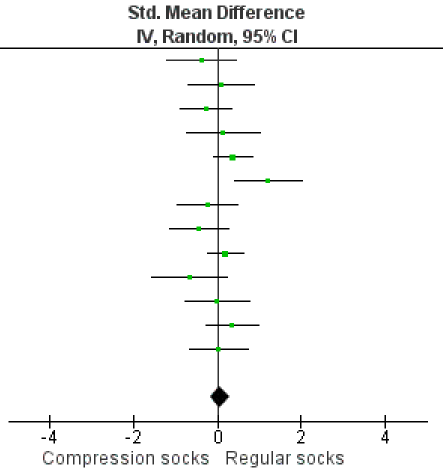


Figure 5

A) Effects of compression socks on perceived exertion

Study or Subgroup	Compression socks Mean	SD	Total	Regular socks Mean	SD	Total	Weight	Std. Mean Difference IV, Random, 95% CI
Bieuzen et al. 2014	16	3	11	17	2	11	5.7%	-0.38 [-1.22, 0.47]
Brophy-Williams et al. 2019	18.45	0.99	12	18.35	1.11	12	6.2%	0.09 [-0.71, 0.89]
Chang et al. 2022	13.7	2.2	20	14.3	2.2	20	8.8%	-0.27 [-0.89, 0.36]
Dos Santos Ferreira et al. 2021	6.4	1.2	10	6.2	1.4	10	5.4%	0.15 [-0.73, 1.02]
Lucas-Cuevas et al. 2017	14.7	1.2	36	14.2	1.4	36	12.2%	0.38 [-0.09, 0.85]
Ménétrier et al. 2011	4.7	0.4	14	4.3	0.2	14	6.0%	1.23 [0.41, 2.05]
Miyamoto et al. 2015	13.9	2.1	15	14.4	2.1	15	7.2%	-0.23 [-0.95, 0.49]
Moreno-Pérez et al. 2020	9.9	0.3	16	10	0.1	16	7.5%	-0.44 [-1.14, 0.27]
Priego Quesada et al. 2015	14.6	3.2	44	14	2.9	44	13.5%	0.19 [-0.22, 0.61]
Rider et al. 2014	19	0.9	10	19.5	0.5	10	5.1%	-0.66 [-1.56, 0.25]
Rivas et al. 2017	16.18	2	13	16.2	2.4	13	6.6%	-0.01 [-0.78, 0.76]
Treseler et al. 2016	15.3	2	19	14.6	1.8	19	8.4%	0.36 [-0.28, 1.00]
Varela-Sanz et al. 2011	6.72	1.22	16	6.69	0.96	16	7.6%	0.03 [-0.67, 0.72]
Total (95% CI)			**236**			**236**	**100.0%**	**0.06 [-0.17, 0.29]**

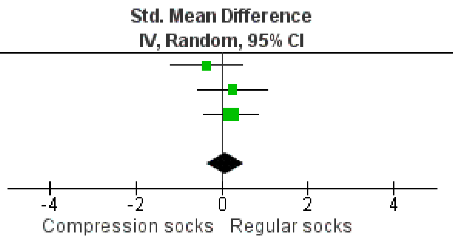
Heterogeneity: Tau² = 0.06; Chi² = 17.93, df = 12 (P = 0.12); I² = 33%
Test for overall effect: Z = 0.54 (P = 0.59)



B) Effects of compression socks on lower limb muscle soreness post-running

Study or Subgroup	Compression socks Mean	SD	Total	Regular socks Mean	SD	Total	Weight	Std. Mean Difference IV, Random, 95% CI
Bieuzen et al. 2014	3.3	2.3	11	4.1	1.9	11	26.0%	-0.36 [-1.21, 0.48]
Brophy-Williams et al. 2019	5.1	1.5	12	4.7	1.5	12	28.6%	0.26 [-0.55, 1.06]
Treseler et al. 2016	2.8	1.8	19	2.4	1.7	19	45.4%	0.22 [-0.41, 0.86]
Total (95% CI)			**42**			**42**	**100.0%**	**0.08 [-0.35, 0.51]**

Heterogeneity: Tau² = 0.00; Chi² = 1.45, df = 2 (P = 0.48); I² = 0%
Test for overall effect: Z = 0.37 (P = 0.71)



Supplementary file 1

Deviations from protocol

In the protocol

“Inclusion criterion: runners with lower limb injury or pain-free”.

In the systematic review

Based on the available evidence regarding compression socks for runners, we only included trials that evaluated their effects on pain-free runners.

In the protocol

“Comparator(s)/control: A non-exposed comparator or placebo”.

In the systematic review

We considered regular socks or sleeves as a non-exposed comparator.

In the protocol

“- Characteristics of the intervention: Type of compression sock, pressure applied (when available), when the compression sock was used (before, during or after running), duration and number of sessions (If applicable)”.

In the systematic review

Types of intervention: “We included trials using below-knee compression socks or sleeves as the intervention".

Additionally, only trials that evaluated their effects during running were included; thus, collecting the number of sessions was not applicable. These adjustments were made following consumer involvement.

In the protocol

“- Statistical estimates: We will extract data from text and tables. If these data are not available in original publications, we will contact corresponding authors to request the required data. We will not extract data from figures due to accuracy issues”.

In the systematic review

We opted to use the Web Plot Digitizer software (Ankit Rohatgi, California, USA; accessible at https://automeris.io/WebPlotDigitizer) to extract acceptable data from graphical forms where the authors could not be contacted or when data could not be retrieved. This approach was adopted based on its use in previous systematic reviews.[1,2]

In the protocol

"Risk of bias (quality) assessment: (…) For non-RCTs, we will use the 'Risk Of Bias in Non-randomised Studies of Interventions' (ROBINS-I) tool to assess risk of bias".

In the systematic review:

Only randomised controlled trials and crossover trial designs were included in our systematic review due to the available evidence. Thus, the risk of bias was assessed using the Revised Cochrane Risk of Bias 2 tool for randomised parallel trials (RoB2) and the version of the RoB2 tool for crossover trials.

In the protocol

"If possible, stratified analyses will be conducted based on type of compression sock and type of running (e.g. distance vs sprinting), sex (e.g. female vs male), and type of lower limb musculoskeletal injury. We will just conduct subgroup analysis if two or more articles report the characteristics mentioned above.

In the systematic review

Due to the available evidence, we decided to combine data only from sufficiently similar studies to evaluate the subgroup running on a treadmill.

References

1 Kayll SA, Hinman RS, Bryant AL, *et al.* Do biomechanical foot-based interventions reduce patellofemoral joint loads in adults with and without patellofemoral pain or osteoarthritis? A systematic review and meta-analysis. *Br J Sports Med*. 2023;57:872–81. doi: 10.1136/bjsports-2022-106542

2 Souto LR, De Oliveira Silva D, Pazzinatto MF, *et al.* Are adjunct treatments effective in improving pain and function when added to exercise therapy in people with

patellofemoral pain? A systematic review with meta-analysis and appraisal of the quality of interventions. *Br J Sports Med*. 2024;58:792–804. doi: 10.1136/bjsports-2024-108145

Supplementary file 2

Medline via Ovid

1. run.af.
2. exp Running/
3. "runner*".af.
4. jogger.af.
5. jog.af.
6. "jogging*".af.
7. treadmill.af.
8. "marathon*".af.
9. cross country.af.
10. "trail runner*".af.
11. "ultramarathon*".af.
12. (track and field).af.
13. 1 OR 2 OR 3 OR 4 OR 5 OR 6 OR 7 OR 8 OR 10 OR 11 OR 12

14. compress*.af.
15. cloth*.af.
16. compression clothing.af.
17. "compression garment*".af.
18. exp Stockings,Compression/
19. textile.af.
20. "sock*".af.
21. 14 OR 15 OR 16 OR 17 OR 18 OR 19 OR 20

22. oscillation.af.
23. oxygenation.af.
24. oxygen uptake.af.
25. perceived exertion.af.
26. heart rate.af.
27. stroke volume.af.
28. thermoregulation.af.

29. blood lactate.af.
30. "inflammatory marker*".af.
31. "Physiolog*".af.
32. Energy.af.
33. exp Athletic Performance/
34. performance.af.
35. time to exhaustion.af.
36. time trial.af.
37. time to complete.af.
38. running time.af.
39. running speed.af.
40. Efficiency.af.
41. "step*".af.
42. power.af.
43. strength.af.
44. fatigue.af.
45. recovery.af.
46. soreness.af.
47. 22 OR 23 OR 24 OR 25 OR 26 OR 27 OR 28 OR 29 OR 30 OR 31 OR 32 OR 33 OR 34 OR 35 OR 36 OR 37 OR 38 OR 39 OR 40 OR 41 OR 42 OR 43 OR 44 OR 45 OR 46

48. 13 and 21 and 47

Embase via Ovid

1. run.af.
2. exp Running/
3. "runner*".af.
4. jogger.af.
5. jog.af.
6. "jogging*".af.
7. treadmill.af.
8. "marathon*".af.
9. cross country.af.
10. "trail runner*".af.
11. "ultramarathon*".af.
12. (track and field).af.
13. 1 OR 2 OR 3 OR 4 OR 5 OR 6 OR 7 OR 8 OR 10 OR 11 OR 12

14. compress*.af.
15. cloth*.af.
16. compression clothing.af.
17. "compression garment*".af.
18. exp Stockings,Compression/
19. textile.af.
20. "sock*".af.
21. 14 OR 15 OR 16 OR 17 OR 18 OR 19 OR 20

22. oscillation.af.
23. oxygenation.af.
24. oxygen uptake.af.
25. perceived exertion.af.
26. heart rate.af.
27. stroke volume.af.
28. thermoregulation.af.
29. blood lactate.af.
30. "inflammatory marker*".af.
31. "Physiolog*".af.

32. Energy.af.
33. exp Athletic Performance/
34. performance.af.
35. time to exhaustion.af.
36. time trial.af.
37. time to complete.af.
38. running time.af.
39. running speed.af.
40. Efficiency.af.
41. "step*".af.
42. power.af.
43. strength.af.
44. fatigue.af.
45. recovery.af.
46. soreness.af.
47. 22 OR 23 OR 24 OR 25 OR 26 OR 27 OR 28 OR 29 OR 30 OR 31 OR 32 OR 33 OR 34 OR 35 OR 36 OR 37 OR 38 OR 39 OR 40 OR 41 OR 42 OR 43 OR 44 OR 45 OR 46

48. 13 and 21 and 47

CINAHL via EBSCO

1. run
2. (MH "Running+")
3. runner*
4. jogger
5. jog
6. jogging*
7. treadmill
8. marathon*
9. cross country
10. trail runner*
11. ultramarathon
12. Track and Field
13. 1 OR 2 OR 3 OR 4 OR 5 OR 6 OR 7 OR 8 OR 9 OR 10 OR 11 OR 12

14. compress*
15. cloth*
16. compression clothing
17. (MM "Compression Garments")
18. compression stockings
19. textiles
20. sock*
21. 14 OR 15 OR 16 OR 17 OR 18 OR 19 OR 20

22. oscillation
23. oxygenation
24. oxygen uptake
25. perceived exertion
26. heart rate
27. stroke volume
28. thermoregulation
29. blood lactate
30. inflammatory marker
31. Physiolog*

32. Energy
33. (MM "Athletic Performance")
34. performance
35. time to exhaustion
36. time trial
37. time to complete
38. running time
39. running speed
40. efficiency
41. step*
42. power
43. strength
44. (MM "Fatigue")
45. (MM "Recovery")
46. soreness
47. 22 OR 23 OR 24 OR 25 OR 26 OR 27 OR 28 OR 29 OR 30 OR 31 OR 32 OR 33 OR 34 OR 35 OR 36 OR 37 OR 38 OR 39 OR 40 OR 41 OR 42 OR 43 OR 44 OR 45 OR 46

48 13 and 21 and 47

SPORTDISCUS via EBSCO

1. run
2. DE "RUNNING"
3. runner*
4. jogger
5. jog
6. jogging*
7. treadmill
8. marathon*
9. “cross country”
10. “trail runner”
11. ultramarathon
12. “track and field”
13. 1 OR 2 OR 3 OR 4 OR 5 OR 6 OR 7 OR 8 OR 9 OR 10 OR 11 OR 12 OR 13

14. compress*
15. cloth*
16. “compression clothing”
17. “compression garment”
18. DE "COMPRESSION stockings"
19. textiles
20. sock*
21. 14 OR 15 OR 16 OR 17 OR 18 OR 19 OR 20

22. oscillation
23. oxygenation
24. oxygen uptake
25. perceived exertion
26. “heart rate”
27. “stroke volume”
28. thermoregulation
29. “blood lactate”
30. “inflammatory marker”

31. Physiolog*
32. energy
33. “athletic performance”
34. DE "PERFORMANCE"
35. “time to exhaustion”
36. “time trial”
37. “time to complete”
38. “running time”
39. “running speed”
40. efficiency
41. step*
42. power
43. strength
44. DE "FATIGUE"
45. DE "RECOVERY training"
46. Soreness
47. 22 OR 23 OR 24 OR 25 OR 26 OR 27 OR 28 OR 29 OR 30 OR 31 OR 32 OR 33 OR 34 OR 35 OR 36 OR 37 OR 38 OR 39 OR 40 OR 41 OR 42 OR 43 OR 44 OR 45 OR 46

48. 13 and 21 and 47

Web of Science

1. run
2. running
3. runner*
4. jogger
5. jog
6. jogging*
7. treadmill
8. marathon*
9. “cross country”
10. "trail runner*"
11. ultramarathon*
12. “track and field”
13. 1 OR 2 OR 3 OR 4 OR 5 OR 6 OR 7 OR 8 OR 10 OR 11 OR 12

14. compress*
15. cloth*
16. “compression clothing”
17. "compression garment*"
18. “compression stockings”
19. textile
20. sock*
21. 14 OR 15 OR 16 OR 17 OR 18 OR 19 OR 20

22. oscillation
23. oxygenation
24. “oxygen uptake”
25. “perceived exertion”
26. “heart rate”
27. “stroke volume”
28. thermoregulation
29. “blood lactate”
30. "inflammatory marker*"

31. Physiolog*
32. Energy
33. “Athletic Performance”
34. performance
35. “time to exhaustion”
36. “time trial”
37. “time to complete”
38. “running time”
39. “running speed”
40. Efficiency
41. "step*"
42. power
43. strength
44. fatigue
45. recovery
46. soreness

47 22 OR 23 OR 24 OR 25 OR 26 OR 27 OR 28 OR 29 OR 30 OR 31 OR 32 OR 33 OR 34 OR 35 OR 36 OR 37 OR 38 OR 39 OR 40 OR 41 OR 42 OR 43 OR 44 OR 45 OR 46

48 13 and 21 and 47

Supplementary file 3

Trials (Author, year)	**Date of initial correspondence**	**Decision**	**Data requested from authors**
Ali et al.[1] 2011	27/01/2023	Data received	Mean and standard deviation values of comfort, tightness and pain.
Bieuzen et al.[2] 2014	NA	Extracted using web plot digitizer	Mean and standard deviation values of participants height.
Chang et al.[3] 2022	13/06/2022	Data received	Mean and standard deviation values of heart rate, rating of perceived exertion, fatigue, blood lactate and pace.
Lucas-Cuevas et al.[4] 2017	27/06/2022	Data not provided	Comfort.
Lucas-Cuevas et al.[5] 2015	27/06/2022	Data not provided	Mean and standard deviation values of perception of comfort.
Geldenhuys et al.[6] 2019	13/06/2022	Extracted using web plot digitizer	Mean and standard deviation values of pace and pain ratings.
Moreno-Pérez et al.[7] 2020	20/06/2022	Data received	Mean and standard deviation values participants' heigh and weight.
Priego et al.[8] 2015	21/06/2022	Data received	Mean and standard deviation values of perception of fatigue.
Rivas et al.[9] 2017	22/06/2022	Extracted using web plot digitizer	Mean and standard deviation values of perceived exertion.
Kerhervé et al.[10] 2017	18/08/2022	Extracted using web plot digitizer	Mean and standard deviation values of delayed onset calf muscles soreness.

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Supplementary file 4

Table 1

Grading of Recommendations, Assessment, Development and Evaluations (GRADE) summary tables.

1a. Summary of GRADE upgrade and downgrade criteria.

	Risk of bias	**Inconsistency**	**Indirectness**	**Imprecision**	**Other considerations**
Serious downgrade (–1) if:	When >25% of the participants are from trials with a high risk of bias	Moderate heterogeneity (I^2 > 50%)	- Surrogate outcome	Sample is lower than 200 participants or 95% confidence interval are deemed to be too large	Publication bias strongly suspected if < 10 studies included, which is the minimum recommended for funnel plot analysis
Very serious downgrade (–2) if:	N/A	Substantial heterogeneity (I^2 > 80%)	- N/A	N/A	
Upgrade (+1) if:	All studies are low risk of bias	N/A	N/A	Large effect size or more than 400 participants included	NA

1b. Compression socks compared to regular socks for runners on physiological outcomes

Certainty assessment							№ of patients		Effect	Certainty
№ of trials	**Trial design**	**Risk of bias**	**Inconsistency**	**Indirectness**	**Imprecision**	**Other considerations**	**Compression socks**	**Regular socks**	**Absolute (95% CI)**	
Heart rate – During running										
10	crossover	serious	N.A.	N.A.	N.A.	publication bias not detected	179	179	MD **0.82 higher** (0.39 lower to 2.03 higher)	⨁⨁⨁◯ MODERATE
Percentage of maximum heart rate – During running										
3	crossover	serious	N.A.	N.A.	serious	publication bias strongly suspected	45	45	MD **0.68 higher** (0.83 lower to 2.19 higher)	⨁◯◯◯ VERY LOW
Blood lactate concentration – Post-running										
7	crossover	serious	N.A.	N.A.	N.A.	publication bias strongly suspected	108	108	MD **0.30 higher** (0.39 lower to 0.98 higher)	⨁⨁◯◯ LOW
Maximal oxygen consumption ($VO2_{máx}$) – During running										
7	crossover	serious	N.A.	N.A.	serious	publication bias strongly suspected	98	98	MD **0.18 higher** (0.68 lower to 1.04 higher)	⨁◯◯◯ VERY LOW
Maximal oxygen consumption ($VO2_{máx}$) – Post-running										
3	crossover	serious	N.A.	N.A.	serious	publication bias strongly suspected	33	33	MD **0.39 higher** (2.49 lower to 3.27 higher)	⨁◯◯◯ VERY LOW
Respiratory exchange ratio – During running										
3	crossover	serious	N.A.	N.A.	serious	publication bias strongly suspected	44	44	MD **0.27 lower** (0.80 lower to 0.27 higher)	⨁◯◯◯ VERY LOW

1c. Compression socks compared to regular socks for runners on performance outcomes

Certainty assessment							№ of patients		Effect	Certainty
№ of trials	**Trial design**	**Risk of bias**	**Inconsistency**	**Indirectness**	**Imprecision**	**Other considerations**	**Compression socks**	**Regular socks**	**Absolute (95% CI)**	
Total running time										
5	crossover	serious	N.A.	N.A.	N.A.	publication bias strongly suspected	73	73	SMD **0.06 higher** (0.27 lower to 0.38 higher)	⨁⨁⨁◯ MODERATE
Running speed										
3	crossover	serious	N.A.	N.A.	serious	publication bias strongly suspected	49	49	SMD **0.24 lower** (0.79 lower to 0.31 higher)	⨁◯◯◯ VERY LOW
Time to exhaustion										
4	crossover	serious	N.A.	N.A.	serious	publication bias strongly suspected	51	51	SMD **0.26 lower** (0.65 lower to 0.13 higher)	⨁⨁◯◯ LOW

1d. Compression socks compared to regular socks for runners on perceptual outcomes

Certainty assessment							№ of patients		Effect	Certainty
№ of trials	**Trial design**	**Risk of bias**	**Inconsistency**	**Indirectness**	**Imprecision**	**Other considerations**	**Compression socks**	**Regular socks**	**Absolute (95% CI)**	
Perceived exertion – During running										
13	crossover	serious	N.A.	N.A.	N.A.	publication bias not detected	236	236	SMD **0.06 higher** (0.17 lower to 0.29 higher)	⨁⨁⨁◯ MODERATE
Lower limb muscle soreness – Post-running										
3	crossover	serious	N.A.	N.A.	N.A.	publication bias strongly suspected	42	42	SMD **0.08 higher** (0.35 lower to 0.51 higher)	⨁◯◯◯ VERY LOW

1e. Compression socks compared to regular socks for runners on perceptual outcomes – Treadmill subgroup analysis

Nº of trials	Trial design	Risk of bias	Inconsistency	Indirectness	Imprecision	Publication bias	Compression socks	Regular socks	Absolute (95% CI)	Certainty
Perceived exertion – During running										
11	crossover	serious	N.A.	N.A.	N.A.	publication bias not detected	206	206	SMD **0.06 higher** -0.21 lower to 0.32 higher)	⨁⨁⨁◯ MODERATE

Supplementary file 5

Table 1. Reason for exclusion of full text-trials

Trial (author, year)	Reasons for exclusion
Ali et al.[1] 2007	Inappropriate patient population
Ali et al.[2] 2010	Inappropriate patient population
Allaert et al.[3] 2011	Conference abstract
Armstrong et al.[4] 2015	Inappropriate intervention
Balasekaran et al.[5] 2020	Full text unavailable
Ball et al.[6] 2018	Conference abstract
Barwood et al.[7] 2013	Inappropriate patient population
Book et al.[8] 2016	Inappropriate patient population
Born et al.[9] 2013	Inappropriate study design
Broatch et al.[10] 2020	Inappropriate intervention
Brophy-Williams et al.[11] 2017	Inappropriate intervention
Cabri et al.[12] 2010	Inappropriate patient population
Carney-Knisley et al.[13] 2015	Conference abstract
Carvalho et al.[14] 2021	Inappropriate intervention
Dascombe et al.[15] 2011	Inappropriate intervention
Del Coso et al.[16] 2014	Inappropriate patient population
Duffield et al.[17] 2010	Inappropriate patient population
Duffield et al.[18] 2008	Inappropriate patient population
Dutto et al.[19] 2015	Conference abstract
Ehrström et al.[20] 2018	Inappropriate intervention
Faulkner et al.[21] 2013	Inappropriate intervention
Feito et al.[22] 2019	Inappropriate intervention
Franke et al.[23] 2021	Inappropriate study design
Ganzit et al.[24] 2007	Inappropriate patient population
Goh et al.[25] 2011	Inappropriate intervention
Halász et al.[26] 2021	Inappropriate study design
Harnisch et al.[27] 2016	Conference abstract
Hill et al.[28] 2014	Inappropriate intervention
Hill et al.[29] 2012	Conference abstract

Houghton et al.[30] 2009	Inappropriate patient population
Hsu et al.[31] 2020	Inappropriate intervention
Hu et al.[32] 2020	Inappropriate intervention
Jakeman et al.[33] 2010	Inappropriate intervention
Laing et al.[34] 2008	Inappropriate patient population
Lovell et al.[35] 2011	Inappropriate patient population
Marshall et al.[36] 2012	Inappropriate study design
Martorelli et al.[37] 2015	Inappropriate intervention
Mizuno et al.[38] 2017	Inappropriate intervention
Mizuno et al.[39] 2016	Conference abstract
Mizuno et al.[40] 2016	Inappropriate intervention
Montoye et al.[41] 2021	Inappropriate patient population
Moody et al.[42] 2011	Conference abstract
Nguyen et al.[43] 2019	Inappropriate patient population
Nguyen et al.[44] 2018	Inappropriate patient population
Pirard et al.[45] 2016	Inappropriate intervention
Sperlich et al.[46] 2011	Inappropriate patient population
Sperlich et al.[47] 2010	Inappropriate intervention
Stanek et al.[48] 2017	Inappropriate study design
Taylor et al.[49] 2018	Inappropriate intervention
Venckūnas et al.[50] 2014	Inappropriate patient population
Vercruyssen et al.[51] 2017	Inappropriate intervention
Wadsworth et al.[52] 2010	Inappropriate patient population
Waller et al.[53] 2016	Conference abstract
Watson et al.[54] 2016	Inappropriate study design
Webb et al.[55] 2010	Inappropriate patient population
Welman et al.[56] 2011	Conference abstract

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Supplementary file 6

Table 1. Reasons for not pooling the trial data - Physiological variables

Trials (author, year)	Variable	Reasons for not pooling data
Areces et al.[1] 2015	Blood markers of muscle damage	This study was the only one that assessed this variable
	Serum myoglobin	This study was the only one that presented mean and standard deviation values for this variable
Berry et al.[2] 1987	Blood lactate	This study did not present total standard deviation values.
Bieuzen et al.[3] 2014	Percentage of maximal heart rate post running	This study presented different time point assessment.
	Interleukin-6 post running	This study was the only one that assessed Interleukin-6 post running.
Bovenschen et al.[4] 2013	Leg volume post running	This study was the only one that assessed leg volume post running
Dos Santos Ferreira et al.[5] 2021	Heart rate post running	This study presented different time point assessment.
	Plasma volume	This study was the only one that assessed plasma volume.
	VO2 post running	This study was the only one that assessed VO2 ten minutes post running.
	Lower leg volume post running	This study was the only one that assessed lower leg volume post running.
	Energy expenditure during	This study was the only one that assessed energy expenditure during running.
Junior et al.[6] 2018	Heart rate during running	This study did not present total mean values.
	Blood lactate	
Kerhervé et al.[7] 2017	Percentage of maximal heart rate after running	This study was the only that assessed this variable on a moderately flat terrain and technical and hilly terrain.

	Muscle tissue perfusion	This study was the only one that assessed this variable.
	Muscle tissue oxygen consumption	This study was the only one that assessed this variable post running.
Priego et al.[8] 2015	Carbon dioxide during running	This study was the only one that assessed these variables during running.
	Oxygen pulse during running	
Rennerfelt et al.[9] 2019	Serum myoglobin	This study reported results in median and interquartile ranges.
	Blood pressure during and post running	This study was the only one that assessed this variable during and post running.
Rider et al.[10] 2014	Heart rate post running	This study presented different time point assessment.
	Lactate threshold during running.	This study was the only one that assessed this variable during running.
Vercruyssen et al.[11] 2014	Heart rate during running	This study reported results in median and interquartile ranges.
	Blood lactate	
Zaleski et al.[12] 2019	Hematocrit measurement	This study was the only one that assessed this variable post running.

Supplementary file 7

Table 1

Summary of unpooled data.

1a Summary of unpooled data for physiological outcomes

Trial (author, year)	Outcome	Intervention	Comparator	SMD, 95% CI	
				During running	**Post-running**
Ali et al.[1] 2011	Blood lactate	Compression socks	Placebo		0.40 (-1.82, 2,62)
Berry et al.[2] 1987	VO2 max	Compression socks	Not wearing socks	0.10 (-0.41, 0.61)	-1.45 (-3.39, 0.49)
Priego et al.[3] 2015	% of maximal VO2	Compression socks	Placebo		0.00 (-511, 5.11)
	Pulmonary ventilation	Compression socks	Placebo	-0.40 (-13.45, 12.65)	
	Ventilatory efficiency	Compression socks	Placebo	0.10 (-4.01, 4.21)	
Kerhervé et al.[4] 2017	VO2 max	Compression socks	Regular sleeves		-0.30 (-3.73, 3.13)

SMD, standardised mean difference; *CI*, confidence interval; VO2 max: maximal oxygen consumption

1b Summary of unpooled data for running performance outcomes

Trial	Outcome	Intervention	Comparator	SMD, 95% CI
				Post-running
Ali et al.[1] 2011	Total running time	Compression socks	Placebo	-0.05 (-0.70, 0.61)
Berry et al.[2] 1987	Time to exhaustion	Compression socks	Not wearing socks	0.06 (-1.07, 1.19)

SMD, standardised mean difference; *CI*, confidence interval

1c Summary of unpooled data for perceptual outcomes

Trial	Outcome	Intervention	Comparator	SMD, 95% CI		
				During running	**Post-running**	**24h Post-running**
Allaert et al.[5] 2011	Muscle Fatigue	Compression socks	Regular socks		-0.56 (-0.99, -0.13)	
Ali et al.[1] 2011	Perceived exertion	Compression socks	Placebo	0.00 (-0.80, 0.80)		
	Arousal-activation			0.10 (-0.62, 0.82)		
	Pleasure or displeasure			0.40 (-1.38, 2.18)		
	Perception of comfort			0.42 (-0.39, 1.24)		
Brophy-Williams et al.[6] 2017	Muscle fatigue	Compression socks	Regular socks		-0.23 (-1.03, 0.57)	
Dos Santos Ferreira et al.[7] 2021	Pleasure or displeasure	Compression socks	Regular socks	0.02 (-2.04, 2.08)		
	Arousal-activation			0.00 (-0.81, 0.81)		
Kerhervé et al.[4] 2017	Calf muscle soreness	Compression socks	Regular sleeves		-0.25 (-1.00, 0.49)	
	Calf muscle soreness 24h post-running					-0.06 (-0.80, 0.68)
	Calf muscle fatigue	Calf compression sleeves	Regular socks		0.20 (-0.55, 0.94)	
	Tigh muscle fatigue				-0.45 (-1.20, 0.30)	
Treseler et al.[8] 2016	Calf muscle soreness	Compression socks	Regular socks		-0.53 (-1.18, 0.12)	
	Calf muscle soreness					-0.14 (-0.78, 0.49)

	24h post-running	
	Perception of comfort	-0.21 (-0.84, 0.43)

SMD, standardised mean difference; *CI*, confidence interval

Data ineligible for pooling

For physiological outcomes, data from four trials were ineligible for pooling[1–4]. Two trials[1,3] compared regular socks with a placebo, one trial[4] compared with regular sleeves, and one trial[2] compared with not wearing socks. In general, wearing compression socks does not differ from the control condition for blood lactate concentration[1], VO2 max[2,4], and % of maximal VO2[3] post-running, as well as for VO2 max[2], pulmonary ventilation, and ventilatory efficiency[3] during running. In terms of running performance outcomes, two trials[1,2] evaluated the effects of wearing compression socks: one compared their use with a placebo[1], and another with not wearing socks[2]. There were no benefits of wearing compression socks on total running time[1] or time to exhaustion[2] compared to control conditions. For perceptual outcomes, six trials[1,4–8] were ineligible for pooling, while five trials[4–8] compared compression socks with regular socks, and one trial[4] also compared them with regular sleeves, only one trial[1] compared compression socks with placebo socks. Overall, only one trial[5] observed that wearing compression socks benefits the perception of muscle fatigue post-running.

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Supplementary file 8

Subgroup analysis of running on a treadmill - Perceived exertion outcome

Study or Subgroup	Compression socks Mean	SD	Total	Regular socks Mean	SD	Total	Weight	Std. Mean Difference IV, Random, 95% CI
Brophy-Williams et al. 2019	18.45	0.99	12	18.35	1.11	12	7.3%	0.09 [-0.71, 0.89]
Chang et al. 2022	13.7	2.2	20	14.3	2.2	20	10.2%	-0.27 [-0.89, 0.36]
Dos Santos Ferreira et al. 2021	6.4	1.2	10	6.2	1.4	10	6.4%	0.15 [-0.73, 1.02]
Lucas-Cuevas et al. 2017	14.7	1.2	36	14.2	1.4	36	13.8%	0.38 [-0.09, 0.85]
Ménétrier et al. 2011	4.7	0.4	14	4.3	0.2	14	7.1%	1.23 [0.41, 2.05]
Miyamoto et al. 2015	13.9	2.1	15	14.4	2.1	15	8.5%	-0.23 [-0.95, 0.49]
Moreno-Pérez et al. 2020	9.9	0.3	16	10	0.1	16	8.8%	-0.44 [-1.14, 0.27]
Priego Quesada et al. 2015	14.6	3.2	44	14	2.9	44	15.1%	0.19 [-0.22, 0.61]
Rider et al. 2014	19	0.9	10	19.5	0.5	10	6.1%	-0.66 [-1.56, 0.25]
Rivas et al. 2017	16.18	2	13	16.2	2.4	13	7.8%	-0.01 [-0.78, 0.76]
Varela-Sanz et al. 2011	6.72	1.22	16	6.69	0.96	16	8.9%	0.03 [-0.67, 0.72]
Total (95% CI)			**206**			**206**	**100.0%**	**0.06 [-0.20, 0.32]**

Heterogeneity: Tau² = 0.07; Chi² = 16.07, df = 10 (P = 0.10); I² = 38%
Test for overall effect: Z = 0.47 (P = 0.64)

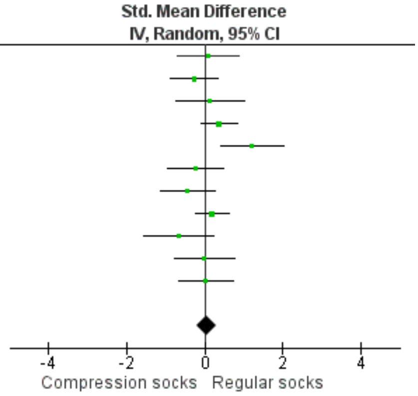

Figure 1. Pooled data for subgroup analysis of running on a treadmill. (SD, standard deviation; IV, inverse variance; Std., standard mean difference).

Supplementary table 1

Table 1. Characteristics of included trials

Author, year	Trial design	Population	Sample characteristics	Intervention / Control	Pressure range (mmhg)	Study protocol	Type of outcomes
Ali et al.[1] 2011	Crossover trial	Well-trained competitive runners	n = 12 M/F = 75%/25% Age = 33 ± 10 BMI = NR	Compression socks / Placebo	32 - 12	Five 10-km time trials were on an artificial surface outdoor 400-m track	Physiological, performance and perceptual
Allaert et al.[2] 2011	Parallel trial	Marathon runners	n = 86 M/F = 69%/31% Age = IG: 42.9 ± 8 / CG: 43.1 ± 8.7 BMI = IG: 24.2 ± 6.5± / CG: 23.0 ± 1.7	Compression socks / Regular socks	21 - 18	Marathon	Physiological
Areces et al.[3] 2015	Parallel trial	Marathon runners	n = 34 M/F = 88%/12% Age = IG: 41.2 ± 8.9 / CG: 42.7 ± 7.8 BMI = NR	Compression socks / Regular socks	25 - 20	Marathon	Physiological, performance and perceptual
Berry et al.[4] 1987	Crossover trial	College students	n = 6 M/F: 100%/0% Age: 22.5 ± 5.4 BMI: NR	Compression socks / No socks	18 - 8	Exercise test on a motor driven treadmill until the subject reached exhaustion.	Physiological and performance

Bieuzen et al.[5] 2014	Crossover trial	Highly trained male runners	n = 11 M/F: 100%/0% Age: 34.7 ± 9.8 BMI: NR	Calf compression sleeves / Regular socks	25	Simulated trail race	Physiological, performance and perceptual
Bovenschen et al.[6] 2013	Parallel trial	Trained recreational runners	n = 13 M/F = 46%/54% Age: 40.5 ± 15.8 BMI = NR	Compression socks / Regular socks	35 - 25	10-km Running Track	Physiological
Brophy-Williams et al.[7] 2019	Crossover trial	Well-trained runners	n = 12 M/F = 100%/0% Age = 30.5 ± 8.1 BMI: NR	Compression socks / Regular socks	37 (4) - 23 (4)	Maximal 5 km time trial on the treadmill	Physiological, performance and perceptual
Chang et al.[8] 2022	Crossover trial	Well-trained half-marathon runners	n = 20 M/F = 50%/50% Age = 38.6 ± 11.3 BMI = NR	Compression socks / Regular socks	22 - 18	3 sets of 7km running trials on a treadmill	Physiological, performance and perceptual
Dos Santos Ferreira et al.[9] 2021	Crossover trial	Recreational runners	n = 10 M/F = 100% Age = 31.5 ± 9.7 BMI = 22.4 ± 1.9	Compression socks / Regular socks	32 - 23	Speed-incremented maximum treadmill test	Physiological and perceptual
Geldenhuys et al.[10] 2019	Parallel trial	Ultramarathon runners	n = 41 M/F = 71%/29% Age = IG: 34 ± 4.8 / CG: 34 ± 6.4 BMI = IG: 24.3* (18.0; 28.8) †† / CG: 23.8* (20.8; 29.0) ††	Compression socks / Regular socks	NR	56km Ultramarathon	Performance

Castilho Junior et al.[11] 2018	Crossover trial	Healthy amateur runners	n = 10 M/F = 40%/60% Age = 40.30 ± 65.03 BMI = 21.88 ± 2.11	Calf compression sleeves / Regular socks	30 - 20	10 km run on a treadmill at an inclination of 1%	Physiological
Kemmler et al.[12] 2009	Crossover trial	moderately trained men runners	n = 21 M/F = 100%/0% Age = 39.3 ± 10.7 BMI = NR	Compression socks / Regular socks	24 – 20	Stepwise speed-incremented treadmill test to voluntary maximum termination.	Physiological and performance
Kerhervé et al.[13] 2017	Crossover trial	Healthy trained runners	n = 14 M/F = 100%/0% Age = 21.7 ± 3.0 BMI = 22.2 (1.6)	Calf compression sleeves / Calf regular sleeves	23 (2)	24-km flat terrain and hilly terrain running	Physiological and performance
Lucas-Cuevas et al.[14] 2017	Crossover trial	Healthy runners	n = 36 M/F = 60%/40% Age = M: 28.14 ± 4.46 / F: 29.17 ± 3.8 BMI = NR	Compression socks / Regular socks	24 - 21	20-min run on a treadmill at 75% of their maximal aerobic speed	Perceptual
Lucas-Cuevas et al.[15] 2015	Crossover trial	Recreational runners	n = 40 M/F = 50%/50% Age = 28.4 ± 5.9 BMI = NR	Compression socks / Placebo	24 - 21	30-min run on a treadmill at 80% of their maximal aerobic speed	Perceptual

Ménétrier et al.[16] 2011	Crossover trial	Young men moderately trained in endurance	n = 14 M/F = 100%/0% Age = 21.9 ± 0.7 BMI = NR	Calf compression sleeves / Regular socks	27 - 15	Running time to exhaustion	Physiological and perceptual
Miyamoto et al.[17] 2015	Crossover trial	Recreationally active young men	n = 15 M/F = 100%/0% Age = 25.2 ± 2.6 BMI= NR	Compression socks / Regular socks	27 - 10	30-min running test on a treadmill	Perceptual
Moreno-Pérez et al.[18] 2020	Crossover trial	Well-trained athletes	n = 16 M/F = 87%/13% Age = 33.2 ± 7.2 BMI = 21.11 ± 1.46	Compression socks / Regular socks	20 - 15	The protocol started with a gradient of 1% at a speed of 10 km h^{-1}, with increments of 0.3 km h^{-1} every 30 s until the maximum exhaustion	Physiological, performance and perceptual
Priego et al.[19] 2015	Crossover trial	Recreational runners	n = 20 M/F = 67%/33% Age = 28.1 ± 5.4 BMI = 22.7 ± 1.8	Compression socks / Placebo	24 - 21	30-min run on a treadmill at 80% of their maximal aerobic speed	Physiological and perceptual

Priego Quesada et al.[20] 2015	Crossover trial	Runners	n = 44 M/F = 66%/34% Age = 29.3 ± 5.8 BMI = NR	Compression socks / Regular socks	25 -10	20-min run at 75% of their maximal aerobic speed	Physiological, and perceptual
Rennerfelt et al.[21] 2019	Crossover trial	Healthy runners	n = 20 M/F = 50%/50% Age = 27* (22 – 35)† BMI = 22* (17-26)†	Compression socks / Regular socks	25	10-km treadmill run	Physiological
Rider et al.[22] 2014	Crossover trial	Division III cross-country runners	n = 10 M/F = 70%/30% Age = M: 21.0 (1.3) / F: 18.7 (0.6) BMI = M: 23.0 (2.7) / F: 21.4 (0.3)	Compression socks / Regular socks	20 - 5	Discontinuous ramped treadmill protocol	Physiological and performance
Rivas et al.[23] 2017	Crossover trial	Collegiate cross-country student-athletes endurance-trained	n = 13 M/F = 77%/23% Age = 20.9 ± 2.5 BMI = NR	Compression socks / Regular socks	15 - 9	Incremental graded exercise test to exhaustion	Physiological and perceptual
Stickford et al.[24] 2015	Crossover trial	Highly trained men	n = 16 M/F = 100%/0% Age = 22.4 ± 3.0 BMI = NR	Calf compression sleeves / Regular socks	20 - 15	Constant submaximal speeds on a motorized treadmill	Physiological

Treseler et al.[25] 2016	Crossover trial	Women physically active	n = 19 M/F = 0%/100% Age = 20 ± 1 BMI = 22 ± 2	Compression socks / Regular socks	21 – 12.5	5-km time trial on an outdoor course	Physiological, performance and perceptual
Varela-Sanz et al.[26] 2011	Crossover trial	Well-trained runners	n = 16 M/F = 81%/19% Age = M: 35.41 (6.61) / F: 32.00 (4.58) BMI = NR	Compression socks / Regular socks	22 - 15	4 consecutive trials of 6 minutes at a recent half-marathon pace on the treadmill at a gradient of 1% to correct for the air resistance effect	Physiological and perceived exertion
Vercruyssen et al.[27] 2014	Crossover trial	Trained runners	n = 11 M/F = 100%/0% Age = 34.7 ± 9.8 BMI = NR	Compression socks / Regular socks	18	15.6 km trail-running	Physiological, performance and perceptual outcomes.
Zaleski et al.[28] 2019	Parallel Trial	Marathoners	n = 20 M/F = 50%/50% Age = IG: 36.9 ± 8.4 / CG: 35.5 ± 8.0 BMI = IG: 23.9 ± 4.3 / CG: 23.0 ± 2.1	Compression socks / Regular socks	25 - 19	Marathon	Physiological and performance

Abbreviations: NR, not reported; CG, control group; IG, intervention group; M, male; F, female; BMI, body mass index.
Age, and BMI reported as mean and standard deviations unless indicated.
† range; †† interquartile range; *median.

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Manuscrito Em Andamento

NOTA SOBRE MANUSCRITOS PARA SUBMISSÃO

Este arquivo contém manuscrito(s) a ser(em) submetido(s) para publicação para revisão por pares interna. O conteúdo possui uma formatação preliminar considerando as instruções para os autores do periódico-alvo. A divulgação do(s) manuscrito(s) neste documento antes da revisão por pares permite a leitura e discussão sobre as descobertas imediatamente. Entretanto, o(s) manuscrito(s) deste documento não foram finalizados pelos autores; podem conter erros; relatar informações que ainda não foram aceitas ou endossadas de qualquer forma pela comunidade científica; e figuras e tabelas poderão ser revisadas antes da publicação do manuscrito em sua forma final. Qualquer menção ao conteúdo deste(s) manuscrito(s) deve considerar essas informações ao discutir os achados deste trabalho.

2.2 Effect of wearing a compression sock during running on delayed onset muscle soreness in distance runners: Protocol for a randomised, sham-controlled, crossover trial

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Abstract

Background: Running is the most popular physical activity worldwide. Although running provides many health benefits, it is often associated with injuries and symptoms such as delayed onset muscle soreness. There is still a paucity of interventions that can effectively minimise these symptoms in distance runners.

Aims: Our primary aim is to explore the effect of compression socks during running on delayed onset muscle soreness after running. Our secondary aims are to explore the effects of compression socks during running on perceived recovery, perceived exertion, affective response, and heart rate after running.

Methods: This is a randomised, sham-controlled crossover trial. Forty-four participants will be recruited via social media, running clubs and the running coaches' network of the research team. Participants will be randomised to complete a running protocol under two conditions (compression socks or sham socks). After that, there will be a wash-out period of 7 to 10 days, and participants will repeat the running protocol under the other conditions. Primary outcome: lower limb muscle soreness will be collected, using a 0-100 numerical pain scale, immediately, 24 hours and 48 hours after the running protocol, with 24 hours post-protocol being the primary timepoint. Secondary outcomes: perceived recovery will be collected, using a 0-10 scale immediately, 24 hours and 48 hours after the running protocol. Perceived exertion, affective response, and heart rate will be registered only immediately after the protocol. Between-group differences will be explored using linear mixed models.

Ethics: Approved by the Augusto Motta University Centre Ethics Committee (67709323.1.0000.5235).

Keywords: Runner; Garments; Pain; Stocking; Knee; Sports

Introduction

Running is one of the most popular sports in the world, estimated to be among the three most common leisure-time activities (1). Running has many health benefits, including reduction in mortality risk (2), and body mass reduction (3). Therefore, keeping runners running is the ultimate goal of health professionals and coaches managing these athletes. However, the burden of delayed muscle soreness post-running can affect runners lasting up to seven days (4,5). Consequently, delayed muscle soreness post-running impacts training routine, competition, and social activities.

Immediate and delayed muscle soreness in the lower limbs is highly prevalent in runners (6,7) due to the physical demands of running leading to muscle damage and inflammation (8,9). Several interventions have been explored to minimise immediate and delayed muscle soreness after running, including massage, cryotherapy, and pneumatic compression boots (6,10). However, the effectiveness of these interventions presents conflicting evidence. Massage can reduce delayed muscle soreness, while pneumatic compression boots did not present positive effects (4,6). On the other hand, cryotherapy was thought to reduce delayed muscle soreness after running, but its effect is not clinically relevant (11). Another limitation of these interventions is that they are only employed post-running sessions, which creates many barriers, such as time, costs, and at times, the need to commute to a clinical health setting.

Compression socks are a popular adjunct that have been popular among runners during training and competition as an attempt to reduce muscle soreness without the need for post-running interventions (12,13). Compression socks are thought to facilitate the removal of exercise metabolites and enhance oxygen supply by increasing blood flow, which would potentially reduce muscle soreness and promote muscle recovery (14). However, trials investigating the effect of compression socks on muscle soreness in runners are often of low quality, have a high risk of bias and present conflicting findings. A systematic review suggests runners could benefit from wearing compression socks, but due to the variety of compression garments used and evidence of very low certainty, their findings should be interpreted with caution (12). The effect of compression socks on reducing immediate or delayed muscle soreness in runners is still uncertain, and well-designed trials with a low risk of bias are needed.

Our primary aim is to explore the effect of compression socks during running on delayed onset muscle soreness after running. Our secondary aims are to explore the effects of compression socks during running on perceived recovery, perceived exertion, affective response, and heart rate after running.

Methods

Study design

A randomised, sham-controlled crossover trial will be conducted following the checklist recommendations in Consolidated Standards of Reporting Trials (CONSORT) extension for randomised crossover trials (15) and Standard Protocol Items: Recommendations for Interventional Trials (SPIRIT) (16). The trial has been prospectively registered in the Clinical Trials (number: NCT06225388).

Participants

Participants (women and men) will be recruited via social media, running clubs and the running coaches' network of the research team. When a potential participant indicates interest in participating in the trial, they will complete a form created on the Google Form platform®. This form will include general information about the trial, eligibility criteria and the participant's informed consent form. This trial was approved by the Research Ethics Committee of Augusto Motta University Centre (number: 67709323.1.0000.5235) following the Helsinki Declaration for human research.

Eligibility criteria (17)

Participants will be included if they present all the following inclusion criteria:

- Adults aged between 18 and 50 years old;
- Run consistently in the last six months (at least three times a week and at least 10 kilometres per week);
- Runners who did not run further than 42 kilometres in the last month.

Participants will be excluded if they present one of the following exclusion criteria: - Pregnancy;

- Any lower limbs fracture in the last 12 months;
- History of lower limb arthroplasty or osteotomy, previous venous thrombosis, kidney disease;
- Any running-related injury in the last six months. A running-related injury will be considered the presence of lower limb pain that caused restriction, stoppage of running (distance, speed, duration, or training) for at least seven days or three consecutive scheduled training sessions or the need for a health professional treatment (18).

Setting

This study will be conducted in an outdoor running setting where runners will perform a running protocol, and self-reported outcomes will be obtained via a digital platform.

Randomisation, allocation, and blinding procedures

Participants will be randomised (1:1 allocation) into one of two groups, compression socks (experimental group) or sham (control group). Randomisation will be determined using the "Research Randomizer", an online random number generator available at https://www.randomizer.org/. According to randomisation, participants will be allocated to one of the following treatment sequences: (i) compression socks followed by sham; or (ii) sham followed by compression socks. An independent investigator not involved in the study recruitment, assessment, or data analysis will assign participants to ensure concealed allocation of participants. The investigator will conduct concealed allocation using numbers sequentially ordered in sealed opaque envelopes with a sheet indicating to which intervention group the participant will be designated. The same examiner will open the sealed envelopes after completing the initial assessment, and the participant has completed the consent form. Participants will receive a unique study enrollment number and a plastic bag with a pair of socks corresponding to the planned intervention. Subsequently, participants will execute the proposed running protocol. Investigators who evaluate pre-treatment and post-treatment will not be aware of randomisation and treatment allocation. To ensure unbiased statistical analyses, an investigator without involvement in the recruitment, evaluation and intervention processes will conduct the statistical tests. Participants will only be informed about the study hypotheses at the end of data collection to ensure that treatment expectations will not influence the participants' outcomes. The participants will wear the compression socks independently, and the investigators will provide no information about the possible effects of compression socks during running.

Baseline assessment

Before the start of the first intervention, sociodemographic information will be recorded, such as age, sex, height, body mass, time of running experience (years/months), education level, total running distance covered per week, participation in other sports, previous experience with compression socks, presence of menstrual flow (female participants) and sleep quality. To minimise possible effects related to the data collection, these will be done in the same place and time of day (19). Likewise, the participants will be instructed to use the same pair of shoes for the two running sessions, as well as to maintain routine habits prior and between sessions. Participants will also be advised to avoid taking painkillers and report any medication used throughout the study period. After the running protocol, perceived exertion, heart rate and affective response during the running sessions will be registered.

Compression socks

For the intervention, compression socks will be used, composed of 81% polyamide, 15% elastane and 4% polypropylene (Kendall sports, Kendall, São Paulo, Brazil). The sock offers compression of 20 to 30 mmHg in a decreasing manner with greater pressure at the ankle and less pressure at the knee joint line. Based on the manufacturer's guidelines, the sock size will be determined by measuring the calf and ankle circumference. The sham intervention will be represented by a commercial sock composed of 70% polyamide, 24% cotton and 5% elastodiene without the purpose of providing compression.

Intervention

On the first testing day, the investigator (GFT), a Physiotherapist with >10 years of musculoskeletal rehabilitation experience, will explain the trial procedures to the participants. A pair of socks corresponding to the intervention allocated will be given to the participant, by an investigator who will not participate in the evaluation, in a dark plastic bag to avoid any visual influence. We will adopt strategies to prevent information about the socks from influencing the participants' behaviour: (1) the compression and sham socks will have the same colour, any visual detail and branding will be covered. Words or logos from the compression sock will be covered, so participants are unable to differentiate them. (2) After performing the running protocol, participants will remove their socks and return them to the investigator.

The running protocol will consist of two sessions of interval running on flat terrain. i) Warm-up phase: participants will be instructed to run for 10 minutes with a perception of effort of 20% of their maximum effort (2 out of 10 on the Borg scale).
ii) Effort phase: participants will start 12 blocks composed of 12 sprints of 300 metres between 70% and 80% of their perceived maximum effort (7-8 out of 10 on the Borg scale), 1 minute of rest will be given after each block. Investigators will provide standardized verbal encouragement to keep runners in the proposed perceived effort zone. Participants will be allowed to drink water ad libitum. This protocol is based on a previous study exploring the physiological effect of compression socks in runners (20). The protocol has also been developed with input from 4 experienced runners (2 men and 2 women), 1 running coach (man), and was piloted by 6 runners (5 men and 1 women) to test the feasibility, acceptability, and if it would trigger muscle soreness (pilot data is available in supplementary file X).

One week post the first intervention, the second intervention of the allocation sequence will be provided. The procedures for the running protocol used in the first day will be repeated. The wash-out period of one week between the two interventions was chosen to ensure that the second intervention was conducted without the residual effects of the first intervention. The one-week interval was based on a study that reported pain would return to baseline levels one week after an ultramarathon (4). The level of physical activity between the two interventions will be monitored by a form to ensure similar pre-training conditions during both interventions. Participants will be asked to inform about possible participation in competitions and the training behaviour during the week. The study procedures are outlined in **Figure 1**.

Primary outcome

Lower limb muscle soreness 24 post-running protocol

A visual analogue scale (VAS) will be used to measure the intensity of muscle soreness. This scale ranges from 0 (no pain) to 100 (worst possible pain). This scale has been previously used to assess lower limb pain in runners with excellent intraclass correlation for calf pain (ICC = 0.87) and thigh pain (ICC = 0.88) (21).

Secondary outcomes

Lower limb muscle soreness immediately, and 48 hours post-running protocol.

These outcomes will be collected with a VAS in the same manner as the primary outcome. However, in different time points.

Perceived recovery immediately, 24 hours, and 48 hours post-running protocol.

The Perceived Recovery Status Scales will assess participants' perceived recovery. This scale ranges from 0 (very poorly recovered / extremely tired) to 10 (very well recovered / highly energetic). Values from 0 to 2 indicate "expect declined performance", values from 4 to 6 indicate "expect similar performance", and values from 8 to 10 represent "expect improved performance". Values 3 and 7 are considered transitional conditions. The value 3 means that it is not clear that the participants will be able to maintain their performance, and the value 7 means the participants are not fully recovered (22).

Perceived exertion

The Borg Rating of Perceived Exertion (Borg RPE 6-20) will be used assess how hard and strenuous the running protocol was. This scale ranges from 6 (no exertion at all) to 20 (maximal exertion) (23). This scale presented excellent intraclass correlation with ICC values ranging from 0.95 to 0.97 (24).

Affective response

The Feeling Scale is a bipolar scale that measures the affective response (pleasure/displeasure) related to exercise. This scale ranges from + 5 (very good) to − 5 (very bad). Zero is considered neutral; positive values represent pleasure, and negative values represent displeasure (25).

Heart rate

The average heart rate in beats per minute (bpm) will be monitored through a smartwatch (Amazfit Bip 3 pro).

Data regarding muscle pain and perceived recovery 24 hours and 48 hours after the protocol will be obtained through an electronic form sent by telephone message or email.

Potential confounders

Sleep quality: Sleep quality will be assessed through item 6 of the Pittsburgh Sleep Quality Index (26,27).

Data collection and management

Participant characteristics will be collected immediately before randomisation. An investigator will scan the original data as image files and send them to the study database. Data integrity will be regularly checked for omissions and errors by double entering with automated checks in the Microsoft Excel spreadsheet (Microsoft Corporation) performed by an investigator. Discrepancies will be explored and resolved by checking the original data.

A unique trial number will identify participants to ensure confidentiality, and confidentiality of the data collected. The paper-form data will be stored in locked filing cabinets at the Postgraduate Program in Rehabilitation Sciences. Data will only be accessible to the research team. All statistical analyses will be performed using each participant's unique number, and the investigator will be blinded to the group. Individual participants' data will not be shared to preserve confidentiality.

Statistical analysis

Sample size calculation

The sample size calculation was carried out a priori in the statistical program G* Power software version 3.1 (Heinrich-Heine-Universitat, Dusseldorf, Germany). A mean difference of 1.5 on the numeric pain rating scale was estimated (4) from the analysis of variance test for repeated measures (ANOVA repeated measures) group x time interaction. The parameters were based on a study where runners allocated to the control group had a mean pain of 4.1 and a standard deviation of 1.9 after a simulated running test (28). Considering a statistical power of 80% and an alpha of 0.05, a sample size of 40 participants was estimated. To account for a 10% dropout, we will recruit extra 4 participants, totalling 44 participants.

Data analysis

The collected data will be stored in a spreadsheet (Excel Microsoft Corporation). The reasons will be reported if any data is missing during the study. Demographic and clinical data will be reported as mean and standard deviation for continuous and categorical variables in absolute values and percentages. We will check the assumption of negligible carryover effects by summing the values measured at the end of both periods for the primary outcome and comparing the two sequences using an unpaired t-test. The distribution of continuous variables will be analysed using the Shapiro-Wilk test. Analyses of the primary and secondary outcomes variables will be undertaken using linear mixed models, with treatment and time included as fixed effects and within-person correlation modelled as a random effect. Adjusted mean differences will be tested at baseline, immediately, 24 hours and 48 hours after the study protocol. Multiple comparisons will be performed using the Tukey test with p values adjusted using the Holm procedure two-sided p values of less than 0.05 will be considered to indicate statistical evidence of significance. The mean difference for the primary and secondary outcomes will be reported as a mean difference and 95% confidence interval. All the confounding variables will be assessed separately and included as random effects. Statistical analyses will be performed using the JASP program version 0.16.4 (Netherlands).

Subgroup analyses

We are planning to have an even distribution between women and men in our study. A sub-group analysis by gender is planned.

Plans for communicating important protocol amendments to relevant parties.

Important protocol changes, such as changes to eligibility criteria, outcomes, or analyses, will be communicated to all parties involved (e.g., Research Ethics Committee, researchers, participants, and journal of publication). Participants will also be asked to provide feedback on any changes to the protocol.

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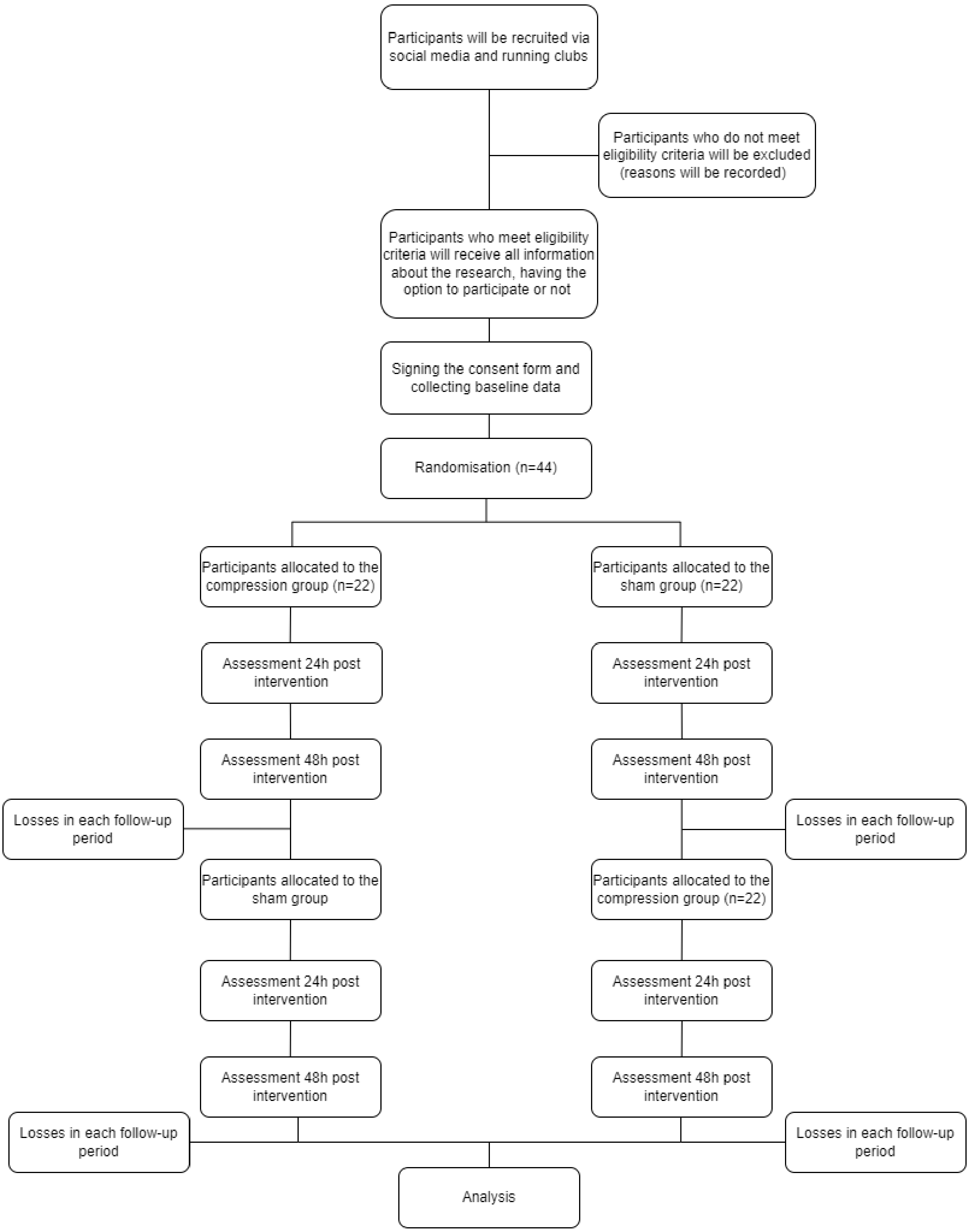
Figure 1 – Study procedures



Manuscritos Publicados

3.1 Artigo Publicado no Doutorado – Autor Principal.

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1. **Telles, Gustavo Felicio**; Coelho, Vanessa Knust; Gomes, Bruno Senos; Alexandre, Dângelo José de Andrade; Corrêa, Leticia Amaral Nogueira, Leandro Alberto Calazans. **Pain and disability were related to Y-balance test but not with proprioception acuity and single-leg triple-hop test in patients with patellofemoral pain: A cross-sectional study.** O foi publicado no *Journal of Bodywork & Movement Therapies*, volume 38, páginas 42-46, 2024.

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Pain and disability were related to Y-balance test but not with proprioception acuity and single-leg triple-hop test in patients with patellofemoral pain: A cross-sectional study

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ABSTRACT

Introduction: Patellofemoral pain is a common complaint between physically active subjects. Patients with patellofemoral pain present limitations to performing daily activities. Pain could alter proprioceptive acuity and lead to movement impairment. The aim of this study was to investigate the relationship of pain and disability with proprioception acuity and physical performance in patients with patellofemoral pain. Methods: Forty-eight patients with patellofemoral pain [age 31.15 (5.91) years; 30 (62.50%) males] were recruited. Data collected included pain intensity, pain duration, disability, joint position sense (JPS) test at 20° and 60° of knee flexion, and physical performance tests (Single-Leg Triple-Hop Test and Y- Balance Test). Spearman's rank correlation coefficient (r_s) and 95% confidence intervals (CI) were computed to assess the relationship between the variables.
Results: Pain intensity was correlated with Y-Balance Test posteromedial component ($r_s = -0.32$, 95%CI = −0.55 to −0.03, p = 0.029) and the composite score ($r_s = -0.35$, 95%CI = −0.58, −0.07, p = 0.015). Pain duration was correlated with Y-Balance Test posterolateral component ($r_s = -0.23$, 95% CI = −0.53 to −0.01, p = 0.047). Disability was correlated with Y-Balance Test posteromedial component ($r_s = 0.41$, 95% CI = 0.14 to 0.62, p = 0.004). Pain and disability were not correlated with JPS and the Single-Leg Triple-Hop Test.
Conclusion: Pain and disability were related to Y-Balance Test but not to proprioceptive acuity and Single-Leg Triple-Hop Test in patients with patellofemoral pain.

1. Introduction

Patellofemoral pain (PFP) is a musculoskeletal disorder that has received considerable attention due to its prevalence. PFP affects approximately 23% of the general population (Smith et al., 2018). Patients with PFP usually present pain in the anterior aspect of the knee during weight-bearing activities (Barton et al., 2021; Crossley et al., 2016). PFP commonly affects physically active people, including adolescents, runners, and militaries (Kakouris et al., 2021; Neal et al., 2019). Likewise, PFP can precede knee osteoarthritis and lead to disability (Crossley et al., 2016; Thomas et al., 2010). Although there is no consensus about the origin of PFP (Lankhorst; Bierma-Zeinstra; Van Middelkoop, 2012; Neal et al., 2019), identifying factors associated with PFP would benefit clinical practice.

Risk factors for patellofemoral pain have been investigated. These factors are related to biomechanics (dynamic knee valgus and foot protonation), strength (quadriceps and hip abductors) (Neal et al., 2019), anthropometric (sex, and body mass index), and proprioception (Lankhorst; Bierma-Zeinstra; Van Middelkoop, 2013). Proprioception is the body's capacity to detect joint movement and position through information from muscles and joint mechanoreceptors (Gandevia; Refshauge; Collins, 2002). Because maltracking and damage of the

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patellofemoral joint could be presented in PFP, knee proprioception has been investigated in patients with PFP (Guney et al., 2016; Naseri; Pourkazemi, 2012). Even though pain may play a role in knee proprioception, it is unknown whether pain is related to proprioception and physical performance in patients with PFP.

Although there is a rationale for impaired proprioception in patients with PFP, the current literature is controversial. Conflicting results were found when proprioception between patients and healthy subjects was investigated (Baker et al., 2002; Coelho et al., 2021; Rhode et al., 2021; Yosmaoglu et al., 2013). Although proprioception is assessed through weight-bearing and non-weight-bearing tests, these tests usually do not represent functional movements (Guney et al., 2016). Moreover, higher pain intensity was reported during jumping, landing, and lunge tasks (Herrington, 2014; Nunes; Barton; Viadanna Serrão, 2019). Conversely, there was no difference in pain intensity during a dynamic balance test between patients with patellofemoral pain and asymptomatic controls (Aminaka; Gribble, 2008; Goto; Aminaka; Gribble, 2018). Investigating whether pain is related to proprioception and physical performance tests could elucidate this issue.

Despite pain and functional limitation being markedly aspects of PFP, it is unclear if different pain levels and functional limitations are related to proprioception and functional limitation. Therefore, the current study aimed to analyse the relationship of pain and disability with proprioception acuity and physical performance in patients with PFP. We hypothesised that higher levels of pain intensity and disability would be related to diminished proprioception acuity and physical performance in patients with PFP.

2. Methods

2.1. Design

This is a cross-sectional study conducted and reported following the consensus from the International Patellofemoral Research Network to improve the REPORTing of quantitative PatelloFemoral Pain studies (Barton et al., 2021) and the requirements of Strengthening the Reporting of Observational Studies in Epidemiology (STROBE). We used data from a previous study by our group Coelho et al., 2021, which was approved by an Institutional Review Board (CAAE: 65274017.3.0000.5256). Patients' informed consent was obtained. In brief, the previous study was a matched case-control study designed to compare the proprioceptive function of the knee and two physical performance tests between patients with PFP and controls matched for several characteristics, including physical activity level. The sample size of 96 patients was calculated, counting 48 patients with PFP.

2.2. Study participants

Patients from a Physical Functional Rehabilitation Service were recruited. The inclusion criteria for patients with PFP were: (1) age between 18 and 45 years old; (2) unilateral knee pain with pain intensity between 3 and 9 on the numerical pain rating scale; (3) insidious onset of pain symptoms; (4) retropatellar or peripatellar pain during at least two of the following functional activities: stair ambulation, running, riding, kneeling, squatting, isometric contracting of the quadriceps and palpation of the medial and/or lateral patellar facet. Exclusion criteria were: (1) lower limb surgery within six months before the study; (2) presence of low back pain or any lower limb injury; (3) concurrent psychological or psychiatric treatment; (4) previous patellar dislocation; or (5) pregnancy. (6) bilateral knee pain (7) chronic musculoskeletal disorders (i.e., fibromyalgia, rheumatoid arthritis, widespread chronic pain) due to the possible presence of the central sensitization mechanism (Woolf, 2011). The period of recruitment was between April and August 2017.

2.3. Procedures

Demographic characteristics (age and sex), health status data (weight, height, exercise level, and previous treatment), pain characteristics (pain duration and severity), and physical examination information were obtained by a questionnaire. Pain intensity and knee disability due to PFP were acquired through the numerical pain rating scale and Kujala Scoring Questionnaire, respectively. The exercise level was calculated as the product of the duration and frequency of moderate-intensity aerobic exercise (in minutes per week). An examiner carried out the proprioceptive assessment with an isokinetic dynamometer, and another examiner conducted the physical performance tests (single-leg triple-hop test and Y-Balance Test). The physical performance tests were carried out bilaterally, but only the affected side of the patients with PFP was used for the current analysis. The patients took 5 min of rest between the tests. The whole procedure was performed on the same day. All examiners had at least 12 years of clinical experience in knee rehabilitation.

2.4. Knee proprioception assessment

Proprioception was assessed by joint position sense (JPS) with an isokinetic dynamometer (Biodex 4 Multi-joint System Pro, 850–000; New York, USA) during active knee extension. To eliminate visual and auditory input, patients wore a mask and headphones. Ninety degrees of knee flexion was the start position, and the target positions were 20° and 60° of knee extension (Guney et al., 2016).

First, the patients had their knees passively moved to the target positions as a reference. Five trials were completed by each participant for each target position, followed by 1-min rest intervals. Values from the last three attempts were averaged to determine the absolute angular accuracy. The absolute difference between the target and the participant's final positions was used to calculate the absolute error.

2.5. Single-leg triple-hop test

Before the physical performance test assessment, the patients made a 3-min general warm-up on a stationary bike. Patients stood on their affected limbs with the toes positioned at the initial point. The final score was the distance from the initial point to where the patients touched the ground after completing three consecutive forward hops. The patients were instructed to stand on one foot and hop as far as possible. Upper limb swing was allowed, and individuals had three trials before testing. The test was repeated if the contralateral limb touched the floor or extra hops were observed. Patients wore self-selected footwear and received no verbal stimuli during the test. Maximum distance was recorded, and the relative distance was calculated using the following equation: (maximum reached distance/leg length * 3) *100. This test showed an excellent intra-rater reliability [ICC2,2: 0.96 (95% CI: 0.95 to 0.98)]. A detailed description of the procedures was reported previously (Coelho et al., 2021).

2.6. Y-balance test

The Y-Balance Test measures the lower extremity dynamic balance. During the test, patients stood on the affected lower limb and were asked to reach three directions (anterior, posterolateral, and posteromedial) with the non-stance foot. (Powden; Dodds; Gabriel, 2019). Patients kept their hands on their hips and pushed a board using the nonstance foot. The test was repeated if the participant touched the floor before returning to the starting position, moved the support foot, or kicked the indicator plate forward (Bulow et al., 2019). The patients executed the test in the following order: anterior, posteromedial, and posterolateral. The maximum distance was recorded in centimetres and normalized using the participant's leg length, the distance from the anterior superior iliac spine (ASIS) to the medial malleolus (Bulow et al., 2019). We calculated the relative score (maximum reached distance/limb length * 100) and the composite score (sum of the three reach directions/three times the limb length * 100). Excellent intra-rater reliability was reported for the Y-Balance Test (Powden; Dodds; Gabriel, 2019).

2.7. Statistical analysis

Double entry techniques (entering the same data in two separate spreadsheets) were adopted to avoid data insert errors. Patients' characteristics were presented as means (standard deviations) for continuous variables with normal distribution, median (interquartile range) for non-normal distribution and absolute (percentages) for categorical variables. The Shapiro-Wilk test verified the data distribution for each outcome variable (pain, proprioceptive acuity, physical performance tests). Since most of the data were not normally distributed, Spearman's rank correlation coefficient (rho) and 95% confidence intervals (CI) were computed to assess the relationship between the variables. The correlation coefficient was classified as weak (below 0.3), moderate (between 0.3 and 0.7), and strong (above 0.7) (Hinkle; Wiersma; Jurs, 2003). The significance level was set at 0.05. The data were analysed using JASP software (version 0.16, Netherlands).

3. Results

The first screening selected eighty-three patients with PFP, and thirty-five were excluded for having bilateral knee pain, previous knee injury or surgery (Fig. 1). The procedures were completed without adverse events.

Patients included had a mean of 31.15 (5.91) years old, 30 (62.50%) were male, body mass index of 25.26 (3.56) kg/m^2, and a mean exercise level of 310.42 (255.89) minutes per week. Patients showed a median pain intensity of 3.50 (3.00–4.00) at the initial screening and a median pain duration of 24.00 (8.00–48.00) months. The mean self-reported disability was 76.08% (9.18).

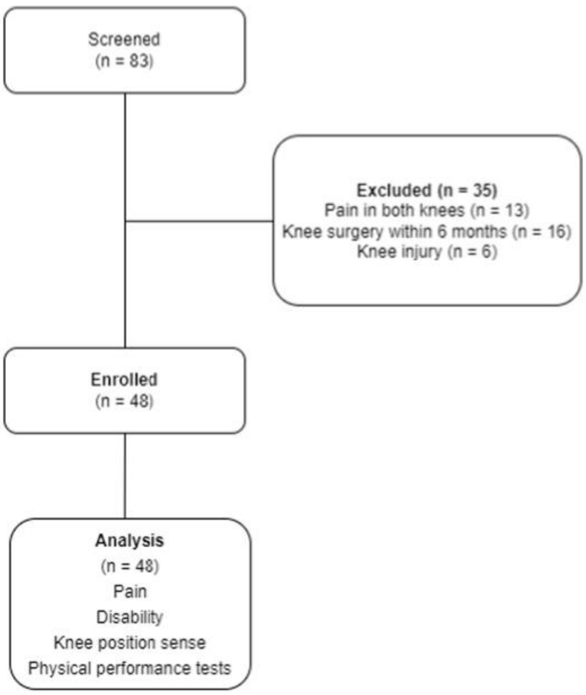

Fig. 1. Flowchart of the study procedure.

The median absolute error of the knee proprioception acuity at 60° and 20° were 4.70 (2.60–7.65) degrees and 3.90 (1.35–5.50) degrees, respectively. The mean relative distance reached on the single-leg triple hop test was 156.49% (33.83). The median distance reached on component anterior, posteromedial, and posterolateral, and the composite score of the Y-Balance Test were 59.20% (54.22–63.85), 95.62% (90.27–101.11), 99.71% (92.98–105.76) and 84.42% (80.30–89.18), respectively.

Pain intensity at the screening was correlated with Y-Balance Test posteromedial component (rs = −0.32, 95% CI = −0.55 to −0.03, p = 0.029) and the composite score (rs = −0.35, 95% CI = −0.58, −0.07, p = 0.015). Pain duration was correlated with Y-Balance Test posterolateral component (rs = −0.23, 95% CI = −0.53 to −0.01, p = 0.047). Disability was correlated with Y-Balance Test posteromedial component (rs = 0.41, 95% CI = 0.14 to 0.62, p = 0.004). Pain and disability were not correlated with the anterior component of the Y-Balance Test. Pain was not correlated with proprioceptive acuity and the Single-Leg Triple-Hop Test. Self-reported disability was not significantly correlated with proprioceptive acuity and Single-Leg Triple-Hop Test. The correlation coefficients with a 95% confidence interval are presented in Table 1.

4. Discussion

This study investigated the relationship between self-reported pain and knee disability with proprioceptive acuity and lower limb physical performance in patients with PFP. Pain and knee disability were correlated with dynamic balance. On the other hand, pain characteristics and knee disability were not correlated with proprioceptive acuity and the Single-Leg Triple-Hop Test. Our findings suggest that higher pain intensity and greater knee disability are associated with poor dynamic balance in patients with PFP.

This is the first study that investigated the association of pain and disability with proprioception (measured using an isokinetic dynamometer). Patients were assessed through standard physical performance tests to ensure they reproduced daily activities. On the other hand, our findings must be considered with caution since only military personnel were included. Moreover, physically active patients with PFP were included. It seems a physical activity routine could improve proprioceptive acuity (Venâncio et al., 2016). This study cohort may not represent people with PFP since most of the patients were men, and PFP is more prevalent in women (Glaviano et al., 2015). Moreover, as a

Table 1
Correlation coefficients between pain and function, joint position sense and physical performance tests.

	Pain intensity at the screening	Pain duration (months)	Kujala score
	r_s(95%CI)	r_s(95%CI)	r_s(95%CI)
JPS			
20° target angle	−0.26 (−0.51, 0.03)	0.12 (−0.17, 0.39)	−0.10 (−0.37, 0.20)
60° target angle	0.07 (−0.22, 0.35)	0.03 (−0.26, 0.31)	0.14 (−0.15, 0.41)
SLTHT (m)	0.05 (−0.24, 0.33)	0.11 (−0.19, 0.38)	0.19 (−0.10, 0.45)
Y-BT (%)			
Anterior	−0.24 (−0.49, 0.05)	−0.14 (−0.41, 0.15)	−0.18 (−0.44, 0.11)
Posterolateral	−0.22 (−0.48, 0.07)	−0.23* (−0.53, −0.01)	0.22 (−0.07, 0.47)
Posteromedial	−0.32* (−0.55, −0.03)	−0.13 (−0.40, 0.16)	0.41* (0.14, 0.62)
Composite score	−0.35* (−0.58, −0.07)	−0.24 (−0.49, 0.05)	0.27 (−0.02, 0.51)

Note: Values represented as correlation coefficient and confidence intervals. Abbreviations: CI, confidence intervals. JPS, joint position sense. SLTHT, Single-Leg Triple-Hop Test. m, metres. Y-BT, Y-Balance Test. %, relative distance. *$p < 0.05$.

secondary analysis, this sample size could not be satisfactory for reaching significant results.

Pain and disability may affect dynamic balance. Moreover, this finding needs to be interpreted with caution. The significant correlations involved the posteromedial and posterolateral components and the composite score of the Y-Balance Test. Likewise, the anterior component is more meaningful for injury prediction. (Smith; Chimera; Warren, 2015). Our findings suggest pain and disability did not influence the Single-Leg Triple-Hop Test performance. These controversial findings can be explained because physical performance tests assess different constructs (Hamilton et al., 2008; Powden; Dodds; Gabriel, 2019). While the Y-Balance Test mainly involves neuromuscular control and range of motion (Bulow et al., 2019), the Single-Leg Triple-Hop Test assess strength (Reid et al., 2007).

Although the present study's findings suggest a relationship between pain and dynamic balance, pain may not affect physical performance. According to a recent systematic review, there is limited evidence that pain level is higher during functional tasks in patients with patellofemoral pain (Glaviano; Bazett-Jones; Boling, 2022). Similar results were found when different functional tests were included. Pain and self-reported disability were not correlated to the 6-min step test (Zamboti et al., 2021). Since findings in the literature comparing physical performance between patients with patellofemoral pain and controls are conflicting (Coelho et al., 2021; Priore et al., 2019), investigating the influence of pain on physical performance is important for future research.

The lack of association between pain and JPS observed in the present study corroborates the findings of previous studies (Baker et al., 2002; Yosmaoglu et al., 2013). Also, there was no correlation between pain level and JPS during weight-bearing and non-weight-bearing assessments (Baker et al., 2002). On the other hand, one study found a weak correlation between proprioception and self-reported disability (Yosmaoglu et al., 2013). Although it has been advocated that PFP could contribute to proprioception deficit (Guney et al., 2016), we did not observe a link between pain and JPS.

The current study's findings showed that the use of the JPS to evaluate proprioception in patients with PFP did not provide relevant data since it was not related to pain and disability. Other mechanisms could affect movement performance instead of pain and self-reported disability. Clinicians are encouraged to assess lower limb strength due to the remarkable impairment in patients with PFP (Guney et al., 2016; Hazneci et al., 2005). The sample of our study was physically active. Thus, it could influence the functional test performance rather than the presence of pain or decreased JPS. Hence, we suggest that future studies examine the effects of pain on proprioception and physical performance tests in a general population sample.

5. Conclusion

Pain and disability were related to the Y-Balance Test but not to proprioceptive acuity and the Single-Leg Triple-Hop Test in patients with PFP.

Author contributions

Dângelo José de Andrade Alexandre: Software, Methodology, Formal analysis, Conceptualization. Bruno Senos Gomes: Writing – review & editing, Writing – original draft, Visualization, Resources, Project administration, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. Leticia Amaral Corrêa: Writing – review & editing, Writing – original draft, Visualization, Methodology, Formal analysis. Leandro Alberto Calazans Nogueira: Writing – review & editing, Writing – original draft, Visualization, Supervision, Resources, Project administration, Methodology, Formal analysis, Conceptualization. Vanessa Knust Coelho: Writing – review & editing, Writing – original draft, Visualization, Resources, Project administration, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. Gustavo Telles: Writing – review & editing, Writing – original draft, Visualization, Resources, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization

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Ethics approval

This study was approved by an Institutional Review Board (CAAE:65274017.3.0000.5256)

Patient consent statement

Patients' informed consent was obtained.

Data availability

The data that support the findings of this study are available from the corresponding author upon reasonable request.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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3.2 Produção Relacionada ao Período de Doutorado-Sanduíche

2023

1. Silva, Danilo De Oliveira; Johnston, Richard T R; Mentiplay, Benjamin F; Haberfield, Melissa J; Culvenor, Adam G; Bruder, Andrea M; Semciw, Adam I; Girdwood, Michael; Pappalardo, Paula J; Briggs, Connie; West, Thomas J; P Hill, Joshua; Patterson, Brooke E; Barton, Christian J; Sritharan, Prasanna; Alexander, James L; Carey, David L; Schache, Anthony G; Souza, Richard B; Pedoia, Valentina; Oei, Edwin H; Warden, Stuart J; **Telles, Gustavo F**; King, Matthew G; Hedger, Michael P; Hulett, Mark; Crossley, Kay M. **Trajectory of knee health in runners with and without heightened osteoarthritis risk: the TRAIL prospective cohort study protocol**. O artigo foi publicado no *BMJ Open*, volume 13, páginas 1-10, 2023.

3.3 Artigos Publicados no Doutorado – Contribuições

2023

1. Camilo Zumbi Rafagnin, Arthur de Sá Ferreira, **Gustavo Felicio Telles**, Thiago Lemos, Dângelo José de Andrade Alexandre, Leandro Alberto Calazans Nogueira. Anterior component of Y-Balance test is correlated to ankle dorsiflexion range of motion in futsal players: a cross-sectional study O artigo foi publicado no *Physiotherapy Reasearch International*, volume 13, páginas 1-7, 2023.

2. Pabst, Sônia; Mainenti, Miriam Raquel Meira; Lemos, Thiago; Corrêa, Leticia Amaral; Silva, Julio Guilherme; **Telles, Gustavo Felicio**; Nogueira, Leandro Alberto Calazans. **Efeito da manipulação da articulação sacroilíaca no controle postural em idosos com dor lombar: ensaio clínico de braço único.** O artigo foi publicado na *Revista brasileira de osteopatia e terapia manual*, volume 13, páginas 5-12, 2023.

2022

3. Corrêa, Leticia Amaral; Bittencourt, Juliana Valentim; Pagnez, Maria Alice Mainenti; Mathieson, Stephanie; Saragiotto, Bruno Tirotti; **Telles, Gustavo Felicio**; Filho, Ney Meziat; Nogueira, Leandro Alberto Calazans. **Neural management plus advice to stay active on clinical measures and sciatic neurodynamic for patients with chronic sciatica: Study protocol for a controlled randomised clinical trial.** O artigo foi publicado na *Plos One*, páginas 2-15, 2022.

4. Bezerra, Mariana Alonso Monteiro; Corrêa, Leticia Amaral; **Telles, Gustavo Felicio**; Nogueira, Leandro Alberto Calazans **Exergaming plus conventional treatment for Anterior Cruciate Ligament reconstruction – Case Report.** O artigo foi publicado na revista *Clinical Case Reports International*, volume 6, páginas 1-4, 2022.

2021

5. Coelho, Vanessa Knust; Gomes, Bruno Senos Queiroz; Lopes, Thiago Jambo Alves; Corrêa, Leticia Amaral; **Telles, Gustavo Felicio**; Nogueira, Leandro Alberto Calazans. **Knee proprioceptive function and physical performance of patients with patellofemoral pain: A matched case-control study.** O artigo foi publicado no jornal *The Knee,* volume 33, páginas 49-57, 2021.

6. Junior, Pedro Manoel Pena; Ferreira, Arthur de Sá; Telles, Gustavo; Lemos, Thiago; Nogueira, Leandro Alberto Calazans. **Concurrent validation of the centre of pressure displacement analyzed by baropodometry in patients with chronic non-specific low back pain during functional tasks** O artigo foi publicado no *Journal of Bodywork & Movement Therapies* volume 28, páginas 489-495, 2021.

3.4 Artigo do Mestrado Publicado nos Anos do Doutorado

2022

7. Telles, Gustavo Felicio; Ferreira, Arthur de Sá; Junior, Pedro Manoel Pena; Lemos, Thiago; Bittencourt, Juliana Valentim; Nogueira, Leandro Alberto Calazans. **Concurrent validity of the inertial sensors for assessment of postural sway during quiet standing in patients with chronic low back pain and asymptomatic individuals.** O artigo foi publicado no *Journal of Medical Engineering & Technology*, páginas 354-362, 2022.

Disseminação da Produção

3.5 Participação em eventos

1. Palestra. **Dor e lesão: Até que ponto estão relacionadas no esporte?** Seminário Alto Rendimento no Esporte, Negros na Ciência. Instituto Insporte. Maio 2023.

2. Palestra: **Estratégia de busca de artigos.** PBEflix. Outubro 2023.

3. Palestra: **Desenho de estudos.** PBEflix. Outubro 2023.

4. Palestra. **An overview on current recommendations in management of knee osteoarthritis.** PHYSICAL THERAPY AND OSTEOARTHRITIS. Gulf Medical University. Setembro 2022

3.6 Resumos apresentados em eventos

1. de Souza, Carlos Eduardo Pereira; **Telles, Gustavo Felicio**; Nogueira, Leandro Alberto Calazans. **Associação do controle de volume de treino de corrida, da prática de exercícios resistidos e do desempenho físico de membros inferiores com o histórico de lesões em corredores de rua amadores.** 1º Congresso de Saúde da Unisuam**,** 2023.

2. Marcell Slemau Silveira, **Gustavo Felicio Telles**, Leandro Alberto Calazans Nogueira. **Comparação entre testes de desempenho físico em praticantes de crossfit com e sem síndrome da dor subacromial: um estudo transversal**. 1º Fórum Discente da ABRAPG-FT, 2023.

3**. Gustavo Felicio Telles**, Leandro Alberto Calazans Nogueira, Karime Andrade Mescouto, Danilo De Oliveira Silva. **Crenças e percepções de corredores em relação ao uso de meias de compressão: um estudo qualitativo**. XX Semana Internacional da Pesquisa, 2023.

4. Bittencourt, Juliana Valentim; Corrêa, Leticia Amaral; Pagnez, Maria Alice Mainenti; Rio, Jéssica Pinto Martins do; **Telles, Gustavo Felicio**; Mathieson, Stephanie; Nogueira, Leandro Alberto Calazans. **Efeitos da mobilização neural na função e estrutura nervosa de pacientes com dor neuropática periférica**: uma revisão sistemática com meta-análise. XX Semana Internacional da Pesquisa, 2023.

5. Telles, Gustavo Felicio; de Sá, Arthur Ferreira; Junior, Pedro Manoel Pena; Lemos, Thiago; Bittencourt, Juliana Valentim; Nogueira, Leandro Alberto Calazans. **Validade concorrente de sensores inerciais para análise do balanço postural em pacientes com dor lombar crônica e indivíduos assintomáticos**. XVI Semana de pesquisa extensão, pós-graduação e inovação da UNISUAM, 2020.

3.7 Resumos Publicados em Anais de Eventos

1**. Gustavo Felicio Telles;** Vanessa Knust Coelho; Bruno Senos Gomes; Dângelo José de Andrade Alexandre; Leticia Amaral Corrêa; Leandro Alberto Calazans Nogueira. **A acuidade proprioceptiva não foi relacionada à dor e testes funcionais em pacientes com dor femoropatelar: Um estudo transversal**. Publicado nos anais do XXIII Congresso Brasileiro de Fisioterapia (COBRAF), 2021. Disponível em: https://proceedings.science/cobraf/cobraf-2021/trabalhos/a-acuidade-proprioceptiva-nao-foi-relacionada-a-dor-e-testes-funcionais-em-pacie?lang=pt-br

2. **Gustavo Felicio Telles;** Vanessa Knust Coelho; Bruno Senos Gomes; Thiago Jambo Alves Lopes; Leticia Amaral Corrêa; Leandro Alberto Calazans Nogueira; **A comparação da acuidade proprioceptiva e da funcionalidade da extremidade**

inferior entre indivíduos com dor femoropatelar e controles: estudo caso-controle. Publicado nos anais do XXIII Congresso Brasileiro de Fisioterapia (COBRAF), 2021. Disponível em: https://proceedings.science/cobraf/cobraf-2021/trabalhos/a-comparacao-da-acuidade-proprioceptiva-e-da-funcionalidade-da-extremidade-infer?lang=pt-br

3.8 Aulas ministradas

1. **Princípios da reabilitação musculoesquelética**. Disciplina: Reabilitação musculoesquelética. Julho de 2024

2. **Instrumentos de Medida.** Disciplina: Elaboração de Projetos de Pesquisa na Área de Reabilitação. Outubro de 2023.

3. **Meta-Análise**. Disciplina: Epidemiologia II. Março 2023

4. **Estratégia de busca de artigos**. Disciplina: Elaboração de Projetos de Pesquisa na Área de Reabilitação. Novembro de 2022.

5. **Escrita de introdução de artigos científicos em fisioterapia.** Disciplina: Redação de artigos. Setembro de 2022.

Blog

1. STORIES THAT INSPIRE … WITH GUSTAVO TELLES. BMJ Open Sport & Exercise Medicine, 2022 (https://blogs.bmj.com/bmjopensem/2022/11/22/stories-that-inspire-with-gustavo-telles/)

Produto(s) Técnico-Tecnológico(s)

4.1 Evento organizado

Escrita de Introdução de Artigos em Fisioterapia. Integrafisio. Outubro 2023.

4.2 Curso de formação profissional

2021
Corrêa, Leticia Amaral; Bittencourt, Juliana Valentim; Telles, Gustavo Felicio; Nogueira, Leandro Alberto Calazans. Tratamento fisioterápico dos pacientes com dores ciáticas. 2021. (Curso de curta duração ministrado/Extensão).

4.3 Software/Aplicativo (Programa de computador)

DE SÁ FERREIRA, ARTHUR; NOGUEIRA, LEANDRO ALBERTO CALAZANS; TELLES, GUSTAVO FELICIO; RIO, JÉSSICA PINTO MARTINS DO; PAGNEZ, MARIA ALICE MAINENTI. UsIA | Ultrasound Image Analysy. 2023.

Considerações Finais

O **tópico 2.1** apresentou uma revisão sistemática que explorou os efeitos das meias de compressão, quando utilizadas durante a corrida, em desfechos fisiológicos, de desempenho e auto reportados. Os resultados sugerem que as meias de compressão não apresentaram efeitos sobre os desfechos mencionados quando comparadas às meias convencionais. Contudo, as meias de compressão parecem não prejudicar o desempenho dos corredores. Apesar da ausência de efeitos positivos, a utilização das meias de compressão pode ocorrer devido à preferência dos corredores. Cabe ressaltar que os resultados apresentaram qualidade da evidência de muito baixa a moderada. Este aspecto sugere que os resultados descritos podem ser diferentes quando estudos com metodologias com baixo risco de viés forem conduzidos.

O **tópico 2.2** apresentou um ensaio clínico que está em andamento. Este estudo encontra-se em fase de coleta de dados e espera-se que as meias de compressão apresentem efeitos positivos para a redução da dor muscular em membros inferiores e percepção de recuperação física.

Futuros estudos com metodologia mais criteriosa do que a literatura disponível precisam ser conduzidos. O primeiro ponto a ser considerado é a determinação de um tamanho amostral adequado para que os erros aleatórios sejam minimizados, a amostra seja representativa e resultados sejam precisos. Também se faz necessário a inclusão de procedimentos como randomização dos participantes e inclusão de intervenção placebo para que os possíveis efeitos das meias de compressão sejam explorados com menos influência de fatores como efeito placebo. Devido às várias rotinas de treinos de corrida, o efeito das meias de compressão deve ser investigado em diferentes populações como por exemplo, corredores recreacionais, maratonistas e ultramaratonistas.

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