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Sumario

Originales

Revisiones

Revista Andaluza de
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Volum 15 Number 1 March 2022

Contents

Original Articles

Review Articles

Revista Andaluza de
Medicina del Deporte

Volume 15 Número 1 Março 2022

Conteúdo

Artigos Originais

Artigos de Revisão

Rev Andal Med Deporte. 2022; **15(1):** *1-5*

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Original

Indicadores técnicos de desempenho para comparação de equipes de sucesso e não sucesso na Bundesliga

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INFORMAÇÃO SOBRE O ARTIGO: Recebido a 4 de agosto de 2020, a 24 de agosto de 2020, *online* a 25 de agosto de 2020.

RESUMO

Objetivo: Este estudo propôs comparar e identificar variáveis técnicas capazes de diferenciar as equipes de melhor desempenho das demais equipes que disputaram a Bundesliga nas últimas cinco temporadas.
Método: Foram coletados dados de nove variáveis técnicas de 1530 jogos da Bundesliga entre as temporadas 2014-15 e 2018-19 através do site público "whoscored.com". As equipes presentes na tabela da Bundesliga nas últimas cinco temporadas foram divididas em grupos de três. Após a coleta, utilizou-se o teste de Shapiro-Wilk para a determinação da distribuição dessas variáveis. Para os dados cuja distribuição é normal foi utilizado o teste T de amostras independente e para os dados cuja distribuição não foi normal, utilizou-se o teste de Mann-Whitney.
Resultado: Os resultados mostraram que as equipes do Grupo 1 apresentaram melhores índices nas variáveis chute de dentro da área, chute de fora da área, passe para setor de meio, passe para setor de ataque e desarme pelo tempo de posse de bola adversária.
Conclusão: O estudo se mostrou satisfatório pois cumpriu com seu objetivo ao identificar variáveis técnicas que discriminam equipes vencedoras das outras equipes, além de proporcionar aos treinadores informações para definir objetivos para equipe e jogadores nas sessões de treinamento.
Palavras-chave: Futebol, Análise discriminante, Análise desempenho.

Indicadores de rendimiento técnico para comparar equipos exitosos y no exitosos en la Bundesliga

RESUMEN

Objetivo: Este estudio propuso comparar e identificar variables técnicas capaces de diferenciar los equipos con mejor desempeño de los demás equipos que compitieron en la Bundesliga en las últimas cinco temporadas.
Método: Fueron recogidos datos sobre nueve variables técnicas de 1530 partidos de la Bundesliga entre las temporadas 2014-15 y 2018-19 a través del sitio Web público "whoscored.com". Los equipos presentes en la tabla de la Bundesliga en las últimas cinco temporadas se dividieron en grupos de tres. A continuación se utilizó usó la prueba de Shapiro-Wilk para determinar la distribución de estas variables. Para los datos cuya distribución es normal, se utilizó la prueba T de muestras independientes y para los datos cuya distribución no fue normal, se utilizó la prueba de Mann-Whitney.
Resultado: Los resultados mostraron que los equipos del Grupo 1 tuvieron mejores índices en las variables remate desde dentro del área, remate desde fuera del área, pase al sector medio, pase al sector de ataque y desarme por el tiempo de posesión del balón del oponente.
Conclusión: El estudio demostró ser satisfactorio porque cumplió su objetivo mediante la identificación de variables técnicas que discriminan a los equipos ganadores de otros equipos, además de proporcionar a los entrenadores información para definir objetivos para el equipo y los jugadores en las sesiones de entrenamiento.
Palabras clave: Fútbol, Análisis discriminante, Análisis rendimiento.

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Technical performance indicators for comparing successful and unsuccessful teams in the Bundesliga

ABSTRACT

Objective: The aim of the current study is to compare and identify specific technical indicators that discriminate the successful and unsuccessful team that played in the Bundesliga in the last five seasons.
Method: Data of nine technical variables of 1530 games in Bundesliga between the seasons 2014-15 and 2018-19 were collected through the public website "whoscored.com". The teams that played in the Bundesliga in the last five seasons were divided in groups of three. The Shapiro-Wil Test was used to determine the distribution of these variables. For data whose distribution is normal, the T test of independent samples was used and for data whose distribution was not normal, the Mann-Whitney test was used.
Results: The results showed the teams on Group 1 had better ratio in variables such Six Yard Box Shot, Out of Box Shot, Passes to Midfield Area, Passes to Attacking Area, Tackles related to Opponent's Possession Time.
Conclusion: In conclusion, this study presents values finding technical indicators that discriminate successful and unsuccessful team that can be used by coaches to design individual and group strategies in training sessions.
Keywords: Soccer, Discriminant analysis, Performance analysis.

Introdução

A análise da performance no futebol está em constante evolução, consequência do aumento dos detalhes das informações obtidas através de sistemas de rastreio computadorizados, que permitem registar o desempenho físico, técnico e tático das equipes em competições[1]. Segundo Zhou et al.[2], a evolução dos indicadores de performance em seguidos anos é uma oportunidade de reconhecer o desenvolvimento dos jogos de futebol.

Para Castellano et al.[3], a análise de dados de jogos é usada nos esportes com um dos processos mais importantes que permite ao treinador coletar informações objetivas que podem ser usadas no treinamento e desenvolvimento da performance da equipe. Lago e Dellal[4], apontam que a principal razão de analisar a desempenho de sua própria equipe é para identificar as forças que podem ser futuramente desenvolvidas e as fraquezas que devem ser melhoradas.

De fato, as pesquisas de análise de desempenho têm concentrado amplamente nos principais indicadores de sucesso, incluindo padrões de posse de bola e passes, estruturas de equipe e probabilidade de vitória[5], prevendo desempenhos futuros bem sucedidos ou caracterizando diferenças entre equipes ou competições[6]. Esses indicadores podem ser avaliados e considerados para projetar resultados esportivos das equipes em um campeonato. Lago et al[7] descobriu que as variáveis: total de finalizações, finalizações no alvo, cruzamentos, cruzamentos contra, posse de bola e local da partida tiveram um maior poder discriminatório entre equipes vencedoras e perdedoras em relação a partidas disputadas na Liga Espanhola. Castellano, Casamichana e Lago[3] também descobriram que as variáveis: total de finalizações, finalizações no alvo e posse de bola tiveram maior poder discriminatório em relação a partidas disputadas em três Copas do Mundo (2002, 2006 e 2010).

Além disso, indicadores de sucesso são utilizados para determinar o estilo de jogo de uma equipe. Hewitt et al[8] diz que, constantemente, as equipes de futebol são relacionadas ao seu estilo de jogo tanto quanto são relacionadas aos seus resultados esportivos. Para McLean et al[9], estilo de jogo é uma determinação de comportamentos de equipes de futebol dentro do campo de jogo em diferentes momentos da partida, que visa alcançar o melhor resultado desportivo. Já Hewitt et al[8], define o estilo de jogo como um padrão de características demonstradas por uma equipe nos cincos momentos do jogo: (1) Momento Ofensivo, (2) Transição do Ataque para a Defesa, (3) Momento Defensivo, (4) Transição da Defesa para o Ataque e (5) Bolas Paradas.

De acordo com Hewitt et al[8], mensurar e definir estilos de jogo podem permitir treinadores, cientistas esportivos, mídia e espectadores a entenderem de modo mais claro o jogo. A identificação e compreensão do estilo ou padrões de jogo das equipes podem ter outras implicações práticas, por exemplo, ao recrutar jogadores que são capazes de jogar de acordo com o estilo da equipe[10]. Além disso, a quantificação de estilos de jogos permitirá análises mais detalhadas sobre os tipos de metodologias de treinamento e avaliação do treinamento em comparação com estratégias e táticas no ambiente de competição[8].

Desta forma, este estudo tem como objetivo comparar e identificar variáveis técnicas que diferenciem as equipes de melhor desempenho das demais equipes que disputaram a Bundesliga nas últimas seis temporadas.

Método

Como cenário de aplicação deste estudo, foram coletados dados de cinco temporadas da Bundesliga (campeonato nacional alemão), totalizando 1530 jogos, entre 2014/15 e 2018/19.

Foram coletadas nove variáveis técnicas, sendo as mesmas compostas por: chutes de dentro da área, chutes de fora da área, passe para o setor de defesa, passe para o setor de meio, passe para o setor de ataque, desarme pelo tempo de posse de bola adversária, interceptação pelo tempo de posse de bola adversária, bloqueio pelo tempo de posse de bola adversária e defesas do goleiro pelos gols sofridos. Para a coleta de dados foi utilizado o site www.whoscored.com.

Para a realização do estudo, foi utilizado o site público "whoscored.com" para a coleta de dados, cujo recurso é a OPTA Sportsdata Company[11].

Liu et al[12] verificaram a confiabilidade do sistema de rastreamento (OPTA Client System) utilizado na coleta de estatísticas em partidas de futebol, e apresentaram um concordância muito boa para os eventos de equipes codificados por operadores independentes que usam este sistema (os valores de Kappa ponderados foram de 0,92 e 0,94)[11].

Para organização dos grupos de estudos, as equipes presentes nas tabelas da Bundesliga nas últimas cinco temporadas foram divididas em grupos de três equipes, do seguinte modo: 1º ao 3º, 4º ao 6º, 7º ao 9º, 10º ao 12º, 13º ao 15º, 16º ao 18º colocado. Em sequência, o primeiro grupo (1º ao 3º colocado) foi comparado com os demais, sempre par a par.

Para análise estatística foi utilizado o teste de Shapiro-Wilk para determinação da distribuição das variáveis. O teste T de amostras independentes para dados cuja a distribuição foi normal. Para os dados cuja distribuição não foi normal, utilizou-se o teste de Mann-Whitney.

Resultados

Esta seção contempla a apresentação dos resultados estatísticos descritos acima. Desta forma, se observará o entendimento da distribuição dos dados, a apresentação das médias de cada grupo descrito e sua diferença estatística nos respectivos testes caso haja.

A partir da realização do tratamento estatístico descrito acima, observou-se que no teste de Shapiro-Wilk para determinação da distribuição, as variáveis Chute de Fora da Área, Passe para o Setor de Defesa e Interceptação pelo tempo de posse de bola adversária apresentaram distribuição normal, sendo assim utilizados o Teste T de amostras independentes. Já para as demais variáveis, utilizou-se o teste de Mann-Whitney para o comparativo entre os grupos descritos.

Na Figura 1 são apresentados os dados de média das ações relacionadas a finalização, ou seja, chute dentro da área e chute fora da área, dos seis grupos. Nota-se que na variável chute de dentro da área, há valores maiores nos grupos da parte de cima da tabela da competição e um decréscimo no valor médio conforme a equipe vai se aproximando do último grupo presente neste estudo. Esta variável ainda apresentou diferença estatística entre o Grupo 1 e todos os demais grupos. Já com a variável chute de fora da área, apenas em relação ao Grupo 6 houve diferença estatística.

Na Figura 2 são apresentados os resultados das médias dos passes realizados para cada setor analisado neste estudo. Nota-se que o Grupo 1 apresenta a maior média nos três tipos de passes analisados. Ainda neste sentido, nos passes para o setor de meio e para o setor de ataque há diferença estatística com todos os demais grupos analisados. Já os passes para o setor de defesa apresentam diferença estatística significante com os grupos 3, 4, 5 e 6.

Já a Figura 3 estão contidos os resultados das médias das variáveis relacionadas ao momento defensivo. Nota-se que a variável que mais apresentou diferença estatística dentre o Grupo 1 e os demais grupos foi o desarme pelo tempo de posse de bola adversária, sendo o mesmo diferente em relação aos grupos 3, 4, 5 e 6.

Discussão

Este artigo tem como objetivo comparar e identificar variáveis técnicas de performance no futebol, que permitem discriminar equipes vencedoras e perdedoras nas últimas cinco temporadas da Bundesliga. Os resultados do presente estudo identificaram que as equipes vencedoras realizaram mais chutes de dentro da área, chutes de fora da área, passe para o setor do meio, passe para o setor de ataque e desarme pelo tempo de posse de bola adversária. Estes dados corroboram com um estudo de Anon et al.[13] que aponta a importância da finalização, da posse de bola e de critérios defensivos para caracterização e sucesso das equipes.

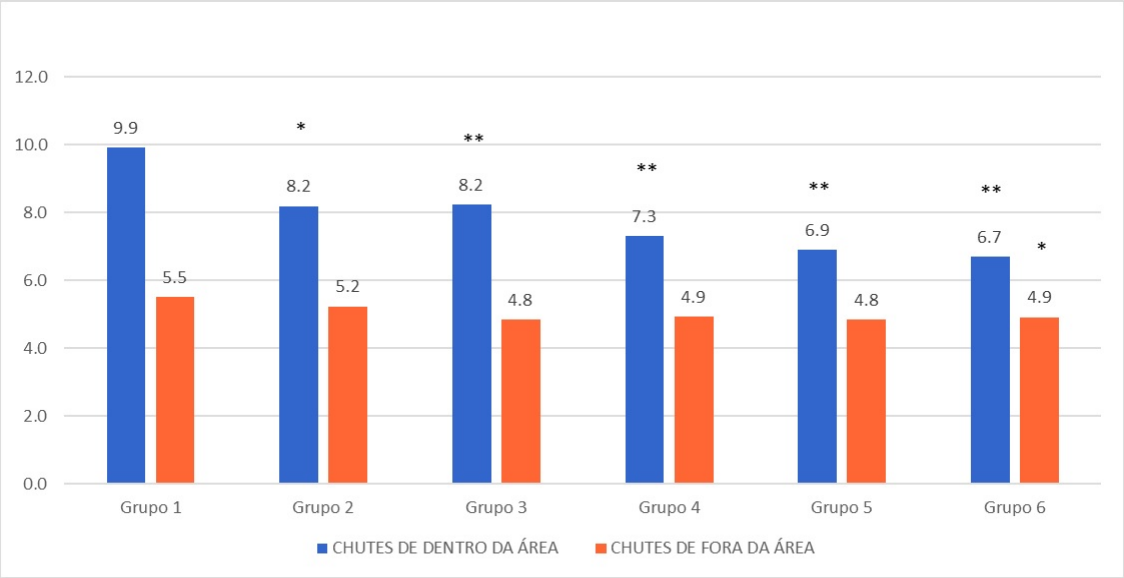

Figura 1. Média das Ações de Finalização nas cinco temporadas da Bundesliga por grupo. *: p<0.05; **: p<0.01.

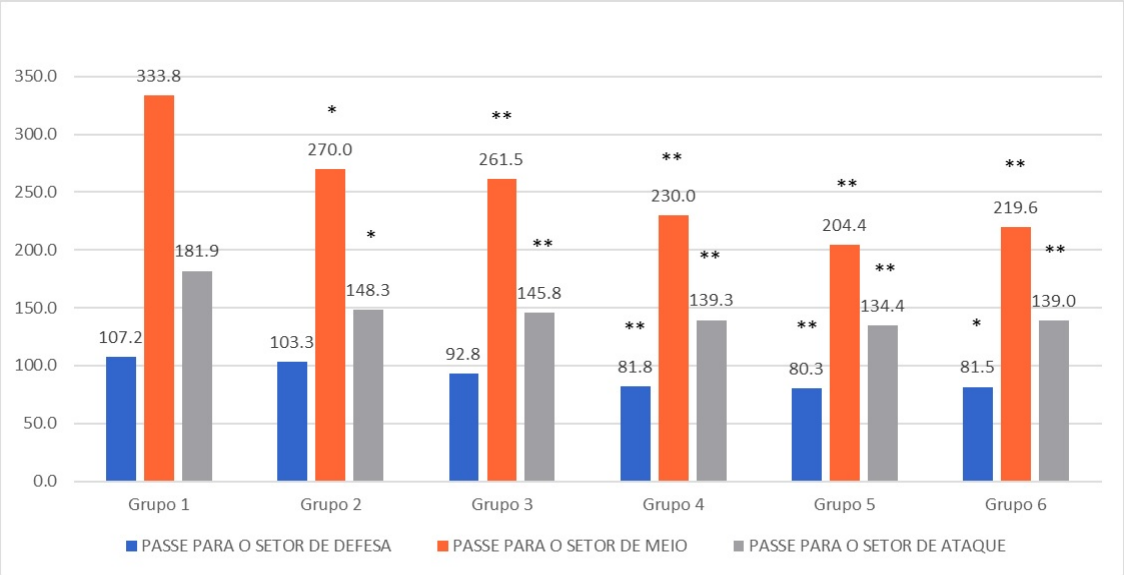

Figura 2. Média das Ações de Passes para os setores nas cinco temporadas da Bundesliga por grupo. *: p<0.05; **: p<0.01.

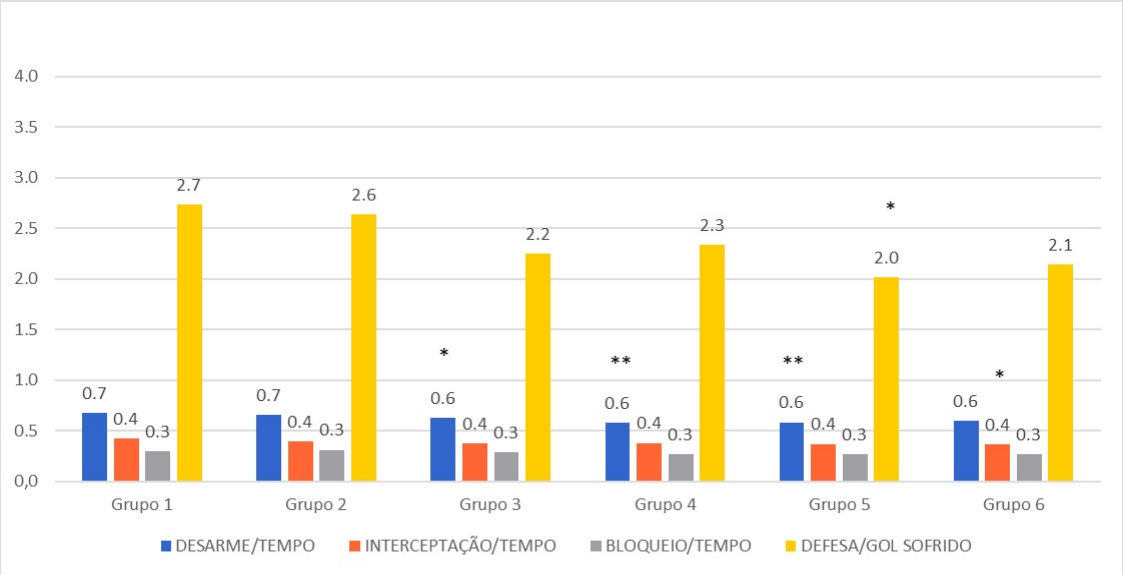

Figura 3. Média das Ações no momento defensivo nas 5 temporadas da Bundesliga por grupo. *: p<0.05; **: p<0.01.

A Figura 1 mostra que as equipes do Grupo1 obtiveram uma média de finalizações de dentro e de fora área maior do que os outros grupos, e apresenta estas várias como determinantes para discriminar o sucesso das equipes. Lago-Peñas et al.[14] complementa este estudo ao apontar que equipe de maior sucesso também apresentaram mais finalizações no alvo do que equipes perdedoras e com maior número de empates na Liga dos Campeões nas temporadas 2007-08, 2008-09 e 2009-10. Já Shafizadeh et al.[15] aponta que a precisão nas finalizações exerce influência no sucesso de uma equipe ao avaliar a conquista da Eurocopa 2002 pela Seleção da Espanha, que apresentou alto índice nesta variável.

Os setores alvos de passe também se apresentaram como variáveis capazes de influenciar no resultado final do jogo e do campeonato, como mostra a Figura 2. Observamos que os índices apresentados pelo Grupo1 em relação à média de passes para zona de meio (333.8) e para zona de ataques (181.9) principalmente, foram muito superiores quando comparados aos outros grupos. Esses resultados corroboram um estudo proposto por Rein et al16, que sugere que a eficiência do passe em relação a mudança de espaço no terço de ataque do campo, bem como a relação de número de jogadores ultrapassados, fornece uma medida válida para investigar o desempenho no jogo de futebol. Os resultados do presente estudo levantam a hipótese de que a média de finalizações está relacionada ao setor de atuação de passes das equipes, como mostra um estudo de Hughes e Franks[17] que uniram estas variáveis, e mostraram que há diferenças significativas entre times de maior e menor sucesso em converter posse de bola em finalizações no alvo, com as equipes de maior sucesso obtendo melhores resultados. Entretanto, o os resultados obtidos não consideram outras variáveis, como nível técnico e econômico das equipes. Casal et al.[18] detectou diferenças significativas na frequência em áreas de ocupação por times de sucesso, que tendem a ocupar na maior parte das vezes o setor meio-ofensivo, enquanto os times de menor sucesso tendem a ocupar o setor meio-defensivo. Para consolidar estes dados, seria interessante se estudos futuros mostrassem uma relação entre posse de bola e zonas de passes com equipes de nível técnico similares. Para Sánchez-Flores et al[19] o nível de competitividade é um fator chave na incerteza do resultado e, por consequência, no interesse que a modalidade esportiva provoca nos diferentes protagonistas (praticantes, torcedores, diretores, patrocinadores e mídias de comunicação. A competitividade tem um claro componente multidimensional, mas sem dúvida, no caso do esporte, se manifesta na igualdade ou desigualdade das equipes competidoras.

Em relação ao desarme, a Figura 3 mostrou que somente a variável média de desarme pelo tempo de posse de bola adversária foi superior no Grupo 1 em relação aos demais, o que pode ser explicado pelo estilo de jogo apresentado pelas equipes. Añon et al.[20] em um estudo sobre a Copa do Mundo de 2010, que a Espanha, eventual campeã do torneio, apresentou superioridade nas ações de bola recuperada e pressão. Esse dado indica que a seleção espanhola tende a iniciar a construção de seu ataque através da bola recuperada, precedida por pressão, que pode assim tomar uma ação de forma eficaz, como um passe ou remate ao adversário. Añon et al.[21] revela uma propensão para as ações ofensivas serem precedidas de um tipo de recuperação, isto é, a bola recuperada pode ser entendida como uma leitura de jogo eficaz para cortar uma determinada linha de passe do adversário e assim tomar uma ação de forma eficaz, podendo ele ser um passe ou ao remate do adversário, ocupando o espaço correto e num timing adequado. Normalmente, após as Copas do Mundo, os times de sucesso tendem a impor um estilo de treinamento de concepções de jogo que serão referências para outras equipes que buscam aumentar seu desempenho[3]. Para complementar, Maleki et al.[22] afirma que treinadores acreditam que métodos e estratégias de recuperação da posse de bola como conectores da fase defensiva, transição e fase ofensiva são os aspectos mais desenvolvidos do futebol atual.

Compreende-se que os indicadores técnicos avaliados que obtiveram maior significância podem apresentar um modo de como as equipes do Grupo1 entendem o jogo e impõem o seu estilo durante a partida, e permite assim caracterizar um estilo de jogo que permite uma relação mais estreita com o sucesso de desempenho no campeonato.

Com base nos dados apresentados, conclui-se que este estudo atingiu seu objetivo, pois identificou indicadores técnicos de desempenho que se apresentam como determinantes para discriminar equipes vencedoras e perdedoras durante uma competição como: chutes de dentro da área, chutes de fora da área, passe para o setor de meio, passe para o setor de ataque e desarme pelo tempo de posse bola adversário.

Desta forma, os treinadores podem usar os resultados obtidos no estudo para estabelecer objetivos para jogadores e equipes em sessões de treino e jogos, avaliar características da equipe adversária e assim ser capaz de minimizar as variáveis de maior influência no resultado da partida.

Autoria. Todos os autores contribuíram intelectualmente no desenvolvimento do trabalho, assumiram a responsabilidade do conteúdo e, da mesma forma, concordam com a versão final do artigo. **Financiamento.** Coordenação de Aperfeiçoamento de Pessoal de Nível Superior –CAPES. **Agradecimentos.** Os autores agradecem o apoio da Coordenação de Aperfeiçoamento de Pessoal de Nível Superior – CAPES, do Programa de Pós-Graduação em Educação Física da Universidade Federal de Viçosa, em especial ao Núcleo de Pesquisa e Estudos em Futebol, coordenado pelo Prof. Dr. Israel Teoldo da Costa. **Conflito de interesses.** Os autores declaram não haver conflito de interesses. **Origem e revisão.** Não foi encomendada, a revisão foi externa e por pares. **Responsabilidades Éticas.** *Proteção de pessoas e animais:* Os autores declaram que os procedimentos seguidos estão de acordo com os padrões éticos da Associação Médica Mundial e da Declaração de Helsinque. *Confidencialidade:* Os autores declaram que seguiram os protocolos estabelecidos por seus respectivos centros para acessar os dados das histórias clínicas, a fim de realizar este tipo de publicação e realizar uma investigação / divulgação para a comunidade. *Privacidade:* Os autores declaram que nenhum dado que identifique o paciente aparece neste artigo.

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Original

The 180/20 intermittent athletic test: A new intermittent track test to assess the maximal aerobic speed in middle-distance runners

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ABSTRACT

Objective: The training of middle-distance runners is based on intermittent exercises. However, no study has proposed intermittent test to assess endurance performance for middle-distance athletes. The aims of the present study are 1) to develop a new specific testing for middle-distance runners entitled the 180/20 intermittent athletic test and to examine the validity of this test as compared to a standard continuous test 2) to check whether the maximal aerobic speed obtained from the180/20intermittent athletic test is related to the 800-m performance.
Methods: Nineteen male middle-distance runners (age: 21.3 ± 2.2 years, height: 1.75 ± 0.04 m, and body mass: 68.8 ± 3.8 kg) performed in a random order three field-tests: a standard test, the 180/20intermittent athletic test and 800-m time-trial. The new test consisted of repeated 180m distance runs interspersed with 20m of active recovery performed until exhaustion. The speed is increased by 0.5 $km.h^{-1}$ every 200 m.
Results: The results of this study showed the maximal aerobic speed achieved during the new test was significantly correlated to the maximal aerobic speed determined from a standard test (r=0.82, p<0.05) with low agreement limits (-1.69–1.48$km.h^{-1}$) without systematic bias (-0.10$km.h^{-1}$).The maximal aerobic speed in new test was better correlated to the 800-m running performance than the maximal aerobic speed achieved during a standard test(r=-0.78 and r=-0.66, respectively).
Conclusions: The 180/20intermittent athletic testis a valid test for scheduling intermittent training sessions in middle-distance runners.
Keywords: Intermittent exercise; Maximal aerobic speed; Field test; Time trial; Running performance.

El test atlético intermitente 180/20: Una nueva prueba de pista intermitente para evaluar la velocidad aeróbica máxima en los corredores de media distancia

RESUMEN

Objetivo: El entrenamiento de los corredores de media distancia se basa en ejercicios intermitentes. Sin embargo, ningún estudio ha propuesto pruebas intermitentes para evaluar el rendimiento de resistencia para atletas de media distancia. Los objetivos del presente estudio son 1) desarrollar una nueva prueba específica para corredores de media distancia denominada prueba atlética intermitente 180/20 y examinar la validez de esta prueba en comparación con una prueba continua estándar 2) verificar si el máximo la velocidad aeróbica obtenida de la prueba atlética intermitente 180/20 está relacionada con el rendimiento de 800 m.
Método: Diecinueve corredores de media distancia masculinos (edad: 21,3 ± 2,2 años, altura: 1,75 ± 0,04 m y masa corporal: 68,8 ± 3,8 kg) realizaron en orden aleatorio tres pruebas de campo: una prueba estándar, la prueba intermitente 180/20 prueba atlética y contrarreloj de 800 m. La nueva prueba consistió en recorridos repetidos de 180 m intercalados con 20 m de recuperación activa realizados hasta el agotamiento. La velocidad se incrementa en 0,5 km.h-1 cada 200 m.
Resultados: Los resultados de este estudio mostraron que la velocidad aeróbica máxima alcanzada durante el nuevo test se correlacionó significativamente con la velocidad aeróbica máxima determinada a partir de un test estándar (r=0,82, p<0,05) con límites de concordancia bajos (-1,69–1,48 km. h-1) sin sesgo sistemático (-0,10 km.h-1). La velocidad aeróbica máxima en la nueva prueba se correlacionó mejor con el rendimiento de carrera de 800 m que la velocidad aeróbica máxima alcanzada durante una prueba estándar (r = -0,78 y r=-0,66, respectivamente).
Conclusiones: El test atlético intermitente 180/20 es un test válido para la programación de entrenamientos intermitentes en corredores de media distancia.
Palabras clave: Ejercicio intermitente; Velocidad aeróbica máxima; Test de campo; Contrarreloj; Rendimiento de carrera.

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O teste atlético intermitente 180/20: Um novo teste intermitente de pista para avaliar a velocidade aeróbia máxima nos corredores de meia distância

RESUMO

Objetivo: O treinamento de corredores de meio-fundo é baseado em exercícios intermitentes. No entanto, nenhum estudo propôs teste intermitente para avaliar o desempenho de resistência para atletas de meia-distância. Os objetivos do presente estudo são 1) desenvolver um novo teste específico para corredores de meio-fundo intitulado teste atlético intermitente 180/20 e examinar a validade deste teste em comparação com um teste contínuo padrão 2) verificar se o a velocidade aeróbia obtida no teste atlético intermitente de 180/20 está relacionada ao desempenho de 800 m.

Métodos: Dezenove corredores de meio-fundo do sexo masculino (idade: 21,3 ± 2,2 anos, estatura: 1,75 ± 0,04 m e massa corporal: 68,8 ± 3,8 kg) realizaram em ordem aleatória três testes de campo: um teste padrão, o teste intermitente 180/20 teste atlético e contra-relógio de 800 m. O novo teste consistiu em corridas repetidas de 180m intercaladas com 20m de recuperação ativa realizada até a exaustão. A velocidade é aumentada em 0,5 km.h-1 a cada 200 m.

Resultados: Os resultados deste estudo mostraram que a velocidade aeróbia máxima alcançada durante o novo teste foi significativamente correlacionada com a velocidade aeróbica máxima determinada a partir de um teste padrão (r=0,82, p<0,05) com limites de concordância baixos (-1,69–1,48km. h-1) sem viés sistemático (-0,10km.h-1). A velocidade aeróbica máxima em novo teste foi melhor correlacionada com o desempenho de corrida de 800 m do que a velocidade aeróbia máxima alcançada durante um teste padrão (r=-0,78 e r=-0,66, respectivamente).

Conclusões: O teste atlético intermitente 180/20 é um teste válido para o agendamento de sessões de treinamento intermitente em corredores de meio-fundo.

Palavras-chave: Exercício intermitente; Velocidade aeróbica máxima; Teste de campo; Contra-relógio; Desempenho de corrida.

Introduction

The maximal aerobic speed (MAS) is a crucial factor for predicting the performance of middle-distance[1] and long-distance running.[2] It is well established that MAS is a great tool for coaches to prescribe adequate training loads.[3–4]However, although several valid and reliable incremental field tests have been developed to determine MAS, these tests do not always consider the specificity of the different sports disciplines and the evolution of training methods.

Various tests have been proposed to determine MAS during laboratory or field testing.[3] The VAM-EVAL test (VAM-T)[4] is one of the most frequently used tests to determine MAS. The test protocol starts at a speed of 8.5 km·h^{-1} and increases by 0.5 km·h^{-1} every minute until exhaustion. This test was proposed for aerobic metabolism(i.e., metabolism with preponderance of the oxidative phosphorylation pathway) evaluation during running[5] and rely on a prolonged continuous bout of running. However, this effort is radically different from that done during daily training in middle-distance runners.

Indeed, while middle- and long-distance running performance is continuous in nature, it is well known that runners, and especially middle-distance runners, practice mainly fast intermittent exercises involving a major contribution from anaerobic energy sources[6] compared with long-distance runners who practice more continuous exercise of lower intensity to develop aerobic capacity.[7] Nevertheless, the evaluation of the MAS is done practically using often the same type of tests (continuous incremental tests) in both middle- and long-distance runners. It is however necessary that the type of muscle work performed during the test should be well related to both the runner's performance and the type of exercise performed during training.[8] It would thus be more appropriate that the MAS determination test rely on the actual efforts (i.e., short intermittent exercises) produced by middle-distance runners, since it can be used as a reference for intermittent training.

On the other hand, in the past 2 decades, a particular attention was paid to incremental intermittent testing to determine aerobic metabolism performance, but mainly in team sports.[8–11]These tests are often composed of shuttle runs, with changes of direction. However, this type of testing appears somewhat inappropriate for middle-distance athletes who perform straight-line running during the competitions (i.e. without direction change) and practice intermittent running in theirs training sessions. To our knowledge, no intermittent straight-line running test to assess especially aerobic metabolism performance in middle-distance runners has been proposed.

Therefore, the aims of the present study were: 1) to develop a new specific testing entitled the 180/20 intermittent athletic test ($180/20_{IAT}$) for middle-distance runners, and to examine the validity of this test, 2) to check that the MAS obtained from the $180/20_{IAT}$ is related to the 800-m performance.

We hypothesize that the $180/20_{IAT}$ is valid and that the relationships between the MAS and the 800-m performance time will be stronger than the one obtained from the VAM-T.

Method

Subject

Nineteen male middle-distance runners, regularly active (5 times/week) participated in the study. The age, height, body mass, body mass index (BMI) and years of training were 21.3±2.2 years, 1.75±0.04 m, 68.8±3.8kg, 22.3±0.9 kg/m^2 and 6.1 ± 1.7 years, respectively. All have been training in middle-distance running regularly for more than 4 years and were accustomed to intermittent exercises as part of their training. All subjects were notified of the research procedures and gave their written consent. The protocol was approved by ethics committee of the Institute of Sports and Physical Education and was performed according to the Helsinki Declaration.

Procedures

All the subjects were evaluated on three occasions on a 400 m tartan running track at least 72 hours apart and in a random order. Day 1: the VAM-T; day 4: the $180/20_{IAT}$. To assess the relationship with performance during both tests, a 800-m time-trial performed on the 8th day was reflective of an athlete's current aerobic fitness. The tests were performed at the same hour of day after eating and under similar experimental conditions (18-20°C, 1.3-1.5 m.s^{-1} runway wind speed measured by a weather station: PCE-AM81, PCE Instruments®, Strasbourg, France). All subjects were advised to refrain from smoking, caffeinated drinks and high-intensity exercise during the 48 hours prior to testing. Heart rate peak (HRpeak) was monitored telemetrically every 5s throughout the test (Polar S610i, Polar® Electro Oy, Kempele, Finland). Three minutes after each test, fingertip blood samples were collected in

order to measure blood lactate [La] by the Lactate Pro LT-1710 (Arkray®, Kyoto, Japan). These two parameters were used as exhaustion criteria.

VAM-EVAL test (VAM-T)

The VAM-T is a modified version of the University of Montreal Track (UM-TT).[12] The only relevant difference between the two tests is the distance between the cones placed along the 400 m track (i.e., 50m for UM-TT vs. 20m for VAM-T), thus allowing to adjust the speed between the cones to the sound signals, which makes the VAM-T easier to conduct to young athletes. The VAM-T is commonly used, which consisted to follow race speed controlled by audio beeps on a prerecorded file. Cones were placed every 20m along the track as a reference. The speed at the first stage was set at 8.5 km.h^{-1} and increases by 0.5 km.h^{-1} every minute until exhaustion. Participants had to reach cones on each beep and adjusted their running speed. The test ended when the subject was no longer capable of following the imposed speed. The MAS (abbreviated: MAS_{VAM-T}) corresponds to the speed at the last completed stage.[4] The reliability of VAM-T has already been studied [CV was 3.5 % (90 % confidence limits: 3.0;4.1)].[13]

The 180/20 Intermittent Athletic Test($180/20_{IAT}$)

The $180/20_{IAT}$ is a track running test adapted to the training mode of the middle distance runners (intermittent exercises), without changes of direction and which can be used as a training session. The test consisted of repeated short 180m distance runs interspersed with 20m active recovery periods performed until exhaustion (180/20). It takes place on a 400m athletics track (180/20 = 200 × 2 = 400m). The speed is imposed by an audio beep designed at the $180/20_{IAT}$. The latter issues "beep" at regular intervals. At each beep, the athlete should be at one of the cones placed on the track every 20 m. The test starts at a speed of 8 km.h^{-1}. The speed is increased by 0.5 km.h^{-1} every 200m, which corresponds to the successful overcoming of a level. Subjects were instructed to reach as many stages as possible and incomplete stage is not considered. The test stopped when the subject was at least 3m behind the appropriate cone at the moment of the audio signal on 2 consecutive times. The MAS (abbreviated: $MAS_{180/20IAT}$) corresponds to the speed reached at the last completed stage.

800 m time trial

Participants completed a 800m time trial on a 400 m tartan outdoor track, at least 72 hours following the $180/20_{IAT}$. Subjects completed a 20 min warm-up in the following sequence: 10 min run, 5 m stretching and a 5 min up-tempo run. Participants were asked to run the distance in the shortest possible time and wore the same kind of garments (running shoes, lightweight t-shirts and light shorts). The time in seconds was collected after exercise.

Statistical analysis

The results are presented as mean ± standard deviation (SD). The assumption of normality was verified with the Shapiro-Wilk test. As data were normally distributed, parametric tests were used. In order to test the validity of $180/20_{IAT}$, the MAS and other characteristics (i.e., HRpeak and [La]) between both tests (VAM-T vs $180/20_{IAT}$) were compared from Student´s t-test for paired sample. Moreover, the relationships between MAS_{VAM-T} and $MAS_{180/20IAT}$was examined from Bravais and Pearson test, and quantified using Pearson correlation coefficient (r) and confidence intervals (95% CI). The correlation coefficients were interpreted in accordance with the thresholds proposed by Hopkins[14]:r<0.1, trivial; 0.1≤ r<0.3, small; 0.3≤ r<0.5, moderate; 0.5≤ r<0.7, large; 0.7≤r<0.9, very large; and 0.9≤ r<1, almost perfect. Furthermore, Bland and Altman plots were used to determine the bias and limits of agreement between MAS_{VAM-T} and $MAS_{180/20IAT}$.The relationship between 800-m running performance and MAS during each test has been examined from Bravais and Pearson test, and quantified using Pearson correlation coefficient. The level of statistical significance was set at p< 0.05. All statistical analyses were performed using SPSS for Windows 23.0 (SPSS Inc., IBM, Chicago, USA).

Results

A significant difference was found between the distance travelled during $180/20_{IAT}$ and VAM-T (Table 1). However, a significant correlation was observed between the distance covered during both tests (p = 0.01, r = 0.71, likely very large).

No significant differences were found between MAS_{VAM-T} and $MAS_{180/20IAT}$. Moreover, no significant difference was noted for HRpeak and [La] between the VAM-T and $180/20_{IAT}$ (Table 1). MAS (p< 0.01, r= 0.82, CI 95%: 0.41–0.87, likely very large), HRpeak (p=0.02, r= 0.50, CI 95%: 0.04–0.67, likely moderate) and [La] (p<0.01, r= 0.72, CI 95%: 0.34–1.00, likely very large) between both tests were significantly correlated.

Figure 2A shows the linear regression between MAS_{VAM-T} and $MAS_{180/20IAT}$, whereas Figure 2B presents the Bland and Altman plot of MAS obtained during both tests. Systematic bias (-0.10km.h^{-1}) and limits of agreement (-1.69–1.48 km.h^{-1}) are low.

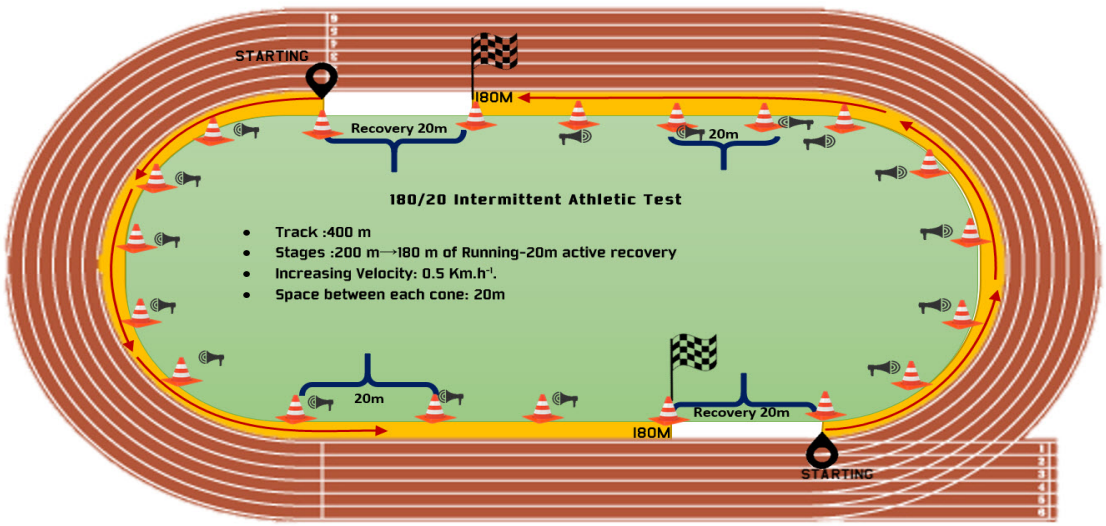

Figure 1. Material organization of the 180/20 intermittent athletic test

Table 1. Physiological characteristics and the performance realized during both tests.

Variables	VAM-T	$180/20_{IAT}$	*p*
MAS ($km.h^{-1}$)	19.1 ± 1.1	19.2 ± 1.4	0.57
HRpeak (bpm)	191.3 ± 2,2	191.8 ± 3.1	0.42
[La] ($mmol.L^{-1}$)	11.3 ± 0.6	11.5 ± 0.7	0.08
Distance traveled (m)	5253 ± 705	4168 ± 520	

p: p value; MAS: maximal aerobic speed; HRpeak: the heart rate peak; [La] : blood lactate concentration; 180/20IAT : 180/20 intermittent athletic test; VAM-T: VAM-EVAL test. *Significant difference ($p < 0.05$).

The average time for the 800 m time trial was 125 ± 6s (range: 112–135s) which corresponds to a velocity of 23 $km.h^{-1}$. The velocity represented 119.3 ± 6.0% (range: 108–133%) of the first $MAS_{180/20IAT}$, and 119.8 ± 5.5% (range: 108–129%) of MAS_{VAM-T}. Significant relationships were found between 800-m performance and $MAS_{180/20IAT}$ and MAS_{VAM-T}. Pearson's correlation showed a very large negative (r = -0.78, p < 0.01) relationship between 800-m performance and $MAS_{180/20IAT}$ (Figure 3A), and large negative relationship (r = -0.66, p < 0.01) between 800-m performance and MAS_{VAM-T}. (Figure 3B).

Discussion

The aims of the present study were to develop and examine the validity of a new intermittent running test named the $180/20_{IAT}$, as well as to analyze the relationship between $MAS_{180/20IAT}$ and the 800-m performance in middle-distance runners.

The major finding of the present study is that the MAS achieved in the$180/20_{IAT}$ is significantly associated with MAS measured on traditional track test (VAM-T), and the maximal variables derived from both tests are non-significantly different. In addition, the results showed that the $180/20_{IAT}$ was strongly correlated with performance on 800-m.

In the present study, we observed that the $180/20_{IAT}$ elicits similar MAS, HRpeak, and [La] to a classic graded continuous field test (VMA-T). VMA-T was carried out with the aim of obtaining a measure of MAS,[4] which we used as a reference in this study. Moreover, MAS obtained during both tests were significantly correlated (r= 0.82, p<0.05), with very large correlation coefficient. These results are consistent with those of other studies comparing VMA-T with Yo-Yo intermittent recovery test,[15,16] or yet recently with treadmill intermittent protocol.[17] Therefore, the validity of the $180/20_{IAT}$ to determine MAS seems similar or even better than that of other tests already validated. This result is moreover largely confirmed by our low 95% interval of agreements.

It should be noted, however, that the increments in speed were different for the two tests (0.5 $km.h^{-1}$ per 1 min stage in the VAM-T, 0.5 $km.h^{-1}$per 200m stage in the $180/20_{IAT}$). For the $180/20_{IAT}$, the total distance of 200m for each stage (180m run with a short rest of 20m to allow an adaptation of the speed) was chosen because middle-distance runners use short intermittent exercises (from a distance of about 200m) as part of their training.[6] In addition, this

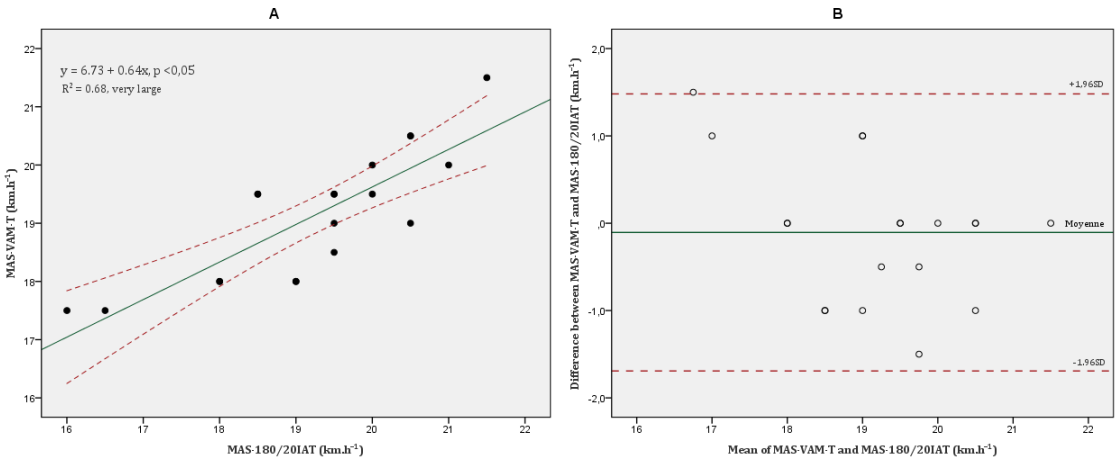

Figure 2. (A) Relationship between the maximal aerobic speed obtained from the VAM-EVAL test and the maximal aerobic speed obtained from the 180/20 intermittent athletic test. **(B)** Bland-Altman plot of the maximal aerobic speed obtained from the VAM-EVAL versus the maximal aerobic speed achieved during the 180/20 intermittent athletic test.

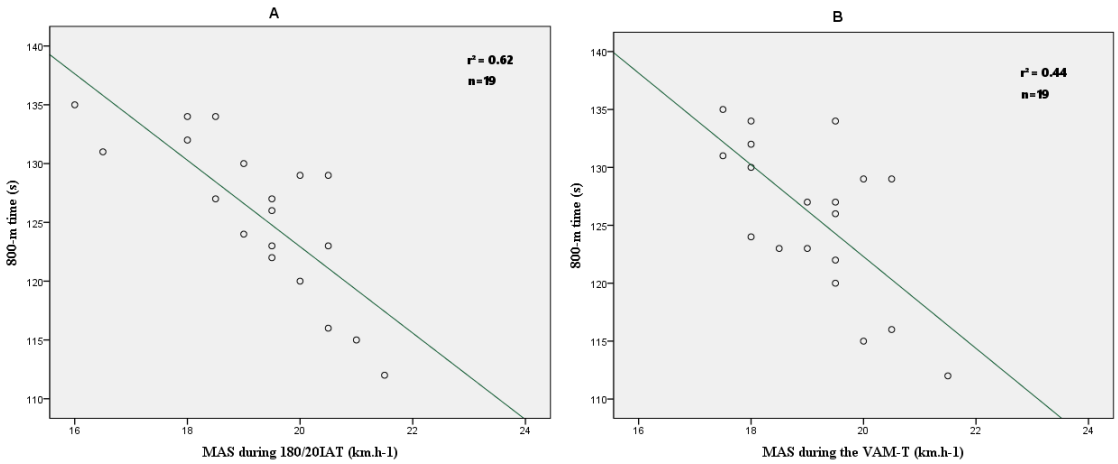

Figure 3. (A) Relationship between 800-m performance and MAS180/20IAT. (B) Relationship between 800-m performance and MASVAM-T.

distance for each stage (200m) has also been chosen because it been demonstrated that performance over a distance of 200m can be used to predict performance on 800m in middle-distance runners.[6] The results of the current study showed a similar MAS between an incremental continuous test commonly used (VAM-T) and a new incremental test with short intermittent exercise (which is supposed to be better meet the intermittent nature of the middle running distance discipline). These results confirm those found recently by Benhammou et al.[18] Moreover, MAS during both tests were significantly correlated, and low systematic bias (-0.10km.h^{-1}) and limits of agreement (-1.69–1.48 km.h^{-1}) were noted. In other words, MAS is non-significantly underestimated by -0.5%, and among 100 new runners, 95 athletes would have at worst a MAS underestimated (not significantly) by -8.8% or overestimated (not significantly) by +7.7%.

According to the present data, the 180/20$_{IAT}$ was correlated with the other indicators of maximal capacity of aerobic metabolism. The results showed that the 180/20$_{IAT}$ produced values of HRpeak and [La] comparable with those of VAM-T. These results are in agreement with values obtained by other authors[5,15]comparing intermittent protocols to other continuous incremental field exercises. The homogeneity of the HRpeak and [La] values at the end of the tests allowed to confirm maximal exertion at the end of the 180/20$_{IAT}$ and the major contribution of anaerobic metabolism, when an athlete reaches her/his MAS. Supporting this idea, previous studies reported a major anaerobic participation during intermittent exercise.[19,20] As maximal oxygen uptake (VO_2max) is considered to be the best indicator of maximal capacity of aerobic metabolism and that VO_2max is routinely evaluated during incremental exercise tests,[21,22] the future studies could compare VO_2max between continuous test and 180/20$_{IAT}$.

Previously, several studies have demonstrated a strong relationship between middle-distance performance and the MAS.[23,24] Indeed, Ingham et al.[23] have previously observed large relationship between MAS measured on treadmill during incremental intermittent running test and 800-m running performance in 15 male 800-m runners (r= 0.53), and 16 female 800-m runners (r= 0.82). The current study confirms this because MAS determined from the VAM-T was significantly related to 800-m performance time (r= -0.66 considered as large, p<0.01).However, a better significant correlation between 800-m running performance and MAS achieved during 180/20$_{IAT}$ was noted (r= -0.78 considered as very large, p<0.01). So, MAS achieved during 180/20$_{IAT}$is a better predictor of 800-m performance than MAS obtained from the VAM-T. These results may be considered as a consequence of the intermittent form of 180/20$_{IAT}$which simulates daily training of middle-distance runners.

In conclusion, the results of the current study showed that 180/20$_{IAT}$may be considered as a valid test to assess the MAS in middle-distance runners. Moreover, the MAS obtained during this filed test was significantly correlated to the 800-m running performance. Consequently, the 180/20$_{IAT}$appears as an interesting and practical alternative to a classic incremental continuous tests and seems as accurate for determine a reference velocity for intermittent training prescription in middle-distance athletes. Given the interest of the MAS determination in middle-distance runners, further researches examining the effect of training program including short intermittent exercises on the MAS$_{180/20IAT}$ are to be conducted in order to evaluate the sensibility of 180/20$_{IAT}$.

This study has some limitations that should be noted. The number of samples was relatively small. In addition, no women have performed this test. The need for familiarization with the sound signals to adjust running pace. A comparison with other MAS determination protocols is also recommended. Despite the very good correlations, perfect agreement and low bias observed in this investigation, future studies should replicate this research but using a portable gas analyzer in the field.

Practical applications

Evaluation of the MAS is essential for middle-distance runners and coaches, but they have to choose the specific test. The current study showed that athletes and coaches can use the 180/20$_{IAT}$ because it lead to a particular MAS that takes into account various qualities solicited during intermittent training of middle-distance runners, i.e., aerobic metabolism performance, and the ability to recover between intermittent exercises. Moreover, the 180/20$_{IAT}$ were very largely correlated with the 800-m running performance suggesting that it could therefore be a very helpful tool to individualize a reference velocity for intermittent training in middle-distance athletes.

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Original

Acute effects of swimming aerobic exercise on contractility and intracellular calcium handling in isolated right ventricular cardiomyocytes

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ABSTRACT

Objectives: The acute adjustments on the contractile function and the intracellular calcium (Ca^{2+}) handling in the cardiomyocytes of the right ventricle (RV) after an acute aerobic exercise session are not known. Our aim was to investigate the acute responses of the contractile function and the intracellular Ca^{2+} handling in isolated RV cardiomyocytes after a swimming exercise session.
Methods: Ten-week-old female *Wistar* rats were randomly allocated into two groups: control (C; n = 5) and exercise (Ex; n = 7). It was performed a swimming exercise session for 30 minutes. with an overload of 4% relative to the body weight attached to the tail. The rats were sacrificed after the exercise session for the analysis of the RV contractile function parameters and the intracellular Ca^{2+} handling by the isolated cardiomyocyte technique.
Results: Body and heart weights, as well as sarcomere length were similar between the groups. Also, it was not observed differences between the groups for RV cardiomyocyte contractile parameters. However, the systolic and diastolic intracellular Ca^{2+} concentration was significantly lower in the Ex group compared to C with maintenance of Ca^{2+} amplitude.
Conclusion: An acute swimming aerobic exercise session promotes cardiomyocyte contractility maintenance even with systolic and diastolic intracellular Ca^{2+} concentration reduced in the RV cardiomyocytes, reflecting an improvement in the intracellular Ca^{2+} handling.
Keywords: Acute exercise; Cardiomyocyte; Calcium handling; Right ventricle.

Efectos agudos del ejercicio de natación aeróbica sobre la contractilidad y el manejo del calcio intracelular en cardiomiocitos aislados del ventrículo derecho

RESUMEN

Objetivos: se desconocen los ajustes agudos de la función contráctil y el manejo del calcio (Ca^{2+}) intracelular en los cardiomiocitos del ventrículo derecho (VD) tras una sesión de ejercicio aeróbico agudo. Nuestro objetivo fue investigar las respuestas agudas de la función contráctil y el manejo del Ca^{2+} intracelular en cardiomiocitos aislados del VD después de una sesión de ejercicio de natación.
Métodos: se asignaron al azar ratas Wistar hembra de diez semanas de edad en dos grupos: control (C; n = 5) y ejercicio (Ex; n = 7). Se realizó una sesión de ejercicios de natación durante 30 minutos con una sobrecarga del 4% con respecto al peso corporal adherido a la cola. Las ratas fueron sacrificadas después de la sesión de ejercicio para el análisis de los parámetros de la función contráctil del VD y el manejo del Ca^{2+} intracelular mediante la técnica de cardiomiocitos aislados.
Resultados: los pesos corporales y cardíacos, así como la longitud del sarcómero, fueron similares entre los grupos. Además, no se observaron diferencias entre los grupos para los parámetros contráctiles de los cardiomiocitos del VD. Sin embargo, la concentración de Ca^{2+} intracelular sistólica y diastólica fue significativamente menor en el grupo Ex en comparación con C con el mantenimiento de la amplitud de Ca^{2+}.
Conclusión: Una sesión de ejercicio aeróbico de natación aguda promueve el mantenimiento de la contractilidad de los cardiomiocitos incluso con una concentración de Ca^{2+} intracelular sistólica y diastólica reducida en los cardiomiocitos del VD, lo que refleja una mejora en el manejo del Ca^{2+} intracelular.
Palabras clave: Ejercicio agudo; Cardiomiocito; Manejo de calcio; Ventrículo derecho.

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Efeitos agudos do exercício aeróbio de natação na contratilidade e no transiente de cálcio intracelular em cardiomiócitos isolados do ventrículo direito

RESUMO

Objetivo: os ajustes agudos na função contrátil e no transiente do cálcio (Ca^{2+}) intracelular nos cardiomiócitos do ventrículo direito (VD) após uma sessão aguda de exercício aeróbio não são conhecidos. Desta forma objetivo foi investigar as respostas agudas da função contrátil e do no transiente Ca^{2+} intracelular em cardiomiócitos do VD isolados após uma sessão de exercício de natação.
Métodos: Ratas Wistar com dez semanas de idade foram alocadas aleatoriamente em dois grupos: controle (C; n = 5) e exercício (Ex; n = 7). Foi realizada uma sessão de exercícios de natação por 30 minutos com uma sobrecarga de 4% em relação ao peso corporal preso à cauda. Os ratos foram sacrificados após a sessão de exercícios para análise dos parâmetros da função contrátil do VD e do transiente Ca^{2+} intracelular pela técnica de cardiomiócitos isolados.
Resultados: Os pesos corporais e cardíacos, bem como o comprimento do sarcômero foram semelhantes entre os grupos. Além disso, não foram observadas diferenças entre os grupos para os parâmetros contráteis dos cardiomiócitos do VD. No entanto, a concentração de Ca^{2+} intracelular sistólica e diastólica foi significativamente menor no grupo Ex em comparação com C com manutenção da amplitude de Ca^{2+}. *Conclusão:* Uma sessão aguda de exercício aeróbio de natação promove a manutenção da contratilidade dos cardiomiócitos mesmo com a concentração intracelular de Ca^{2+} sistólica e diastólica reduzida nos cardiomiócitos do VD, refletindo uma melhora no manuseio do Ca^{2+} intracelular.
Palavras chaves: Exercicio agudo; Cadiomiocito; Transiente de cálcio; Ventrículo direito

Introduction

The acute and chronic cardiac physiological effects of aerobic exercise training (AET), mainly in the structure and function of the left ventricle (LV), are widely recognized.[1-4] The long-term cardiac adaptations to AET includes the increase in ventricular ejection and filling capacities, physiological hypertrophy and reduced heart rate,[3,4] the enhanced ability of cardiomyocytes to contract and stretch;[5-7] and in the right ventricle (RV), the increase in mass and in the capacity to accommodate blood.[2,7,8]

Although it has been well established that the cardiac effects of AET in the mechanical function of cardiomyocytes results from adaptations of successive individual sessions, the acute impacts of this practice in the right ventricle (RV) are not fully understood.[4,9,10] It is known that the exercise acutely generates a cardiac overload in both ventricles, with a magnitude determined mainly by the type, intensity, and volume of the exercise.[2,8] Therefore, during exercise the LV and RV are simultaneously subjected to work overload at different degrees,[5,6,11,12] which occurs in the RV as a result of increased afterload, where the increase in the atrial pressure and limited pulmonary vascular reserve capacity leads to an increase in the pulmonary vascular and end-diastolic RV pressure.[11]

Interestingly, clinical[12-14] and experimental studies[15] have shown some negative outcomes with regard to the vigorous exercise training on the RV, including dysfunction and arrhythmias,[12-15] as well as myocardial fibrosis,[15] whereas, low-intensity exercise training seems to be unable to promote functional changes in RV cardiomyocytes.[5] However, there are few studies which highlight the acute responses of the RV cardiomyocytes to exercise.[5,11] In a previous study, it was observed that a single session of exhaustive exercise impairs the calcium handling and the mechanical function of RV cardiomyocytes,[11] nonetheless, the evaluation of these parameters after an acute aerobic exercise was not evidenced.

Therefore, the aim of this study was to investigate the contractile function and calcium handling responses after an acute swimming aerobic exercise session in cardiomyocytes isolated from RV. Our hypothesis is that the acute aerobic exercise improves the contractile function and the intracellular calcium handling in the cardiomyocytes from the RV, contributing to the understanding of the acute impact of the aerobic exercise on the right side of the heart.

Methods

Animals

Ten-week-old female *Wistar* rats (n= 12) were housed in collective cages (*4 animals per cage*), in a climate-controlled environment with a 12 h light/dark cycle and free access to food and water. All experiments were conducted according to the Guide for the Care and Use of Laboratory Animals (NIH, USA) and were approved by the University Ethics Committee for the Use of Animals under protocol number 20/2015.

Experimental protocol

The rats were randomly distributed into two groups: control (C; n= 5) and exercise (Ex; n= 7). The Ex group was submitted to a swimming exercise session, according to the protocol described below. The C group was not subjected to the exercise session; however, the rats were placed in shallow water for the same time and frequency as the Ex group.

Acute swimming exercise protocol

The exercise protocol was performed in an apparatus adapted for rats which is cylindrical in shape, with a depth of 45 cm and the water temperature was maintained between 30±1º C. Forty-eight hours before the exercise session the rats were acclimatized to the water environment in shallow water for 30 minutes. The swimming aerobic exercise was performed in a single session for 30 minutes. Araújo et al., 2009[16] found the maximum lactate steady state at an overload of 5% relative to the body weight in swimming female rats. Therefore, to ensure that all of the animals were practicing the exercise with the predominance of the aerobic sources, we chose to perform the swimming exercise with an overload of 4% relative to the body weight. After the exercise session, the animals were dried with absorbent tissue and a hairdryer.

Cardiomyocyte preparation

One hour after the exercise session or resting in the water (group C), the rats were euthanized by anesthetic overdose using ketamine and xylazine (250 mg/kg and 50 mg/kg, i.p., respectively); The hearts were quickly removed by median thoracotomy and mounted in a Langendorff system adapted to perform the retrograde perfusion by the aorta. Firstly, the hearts were perfused with Solution A (NaCl 120 mM, KCl 5.4 mM, $MgSO_4$ 1.2 mM, NaH_2PO_4 1.0 mM, $NaHCO_3$ 20 mM, Glucose 5.6 mM; pH 7.4) for approximately 3 to 5 minutes, followed by Solution B (Solution A plus 1 mg/mL collagenase, 1 mg/50mL protease; pH 7.4) for approximately 3 to 5 minutes and Solution C (Solution A plus 0.5 M $CaCl_2$, 1 mg/mL collagenase, 1 mg/50mL protease; pH 7.4) for 20 minutes. All of the solutions were oxygenated and equilibrated with 5% CO_2 and 95% O_2, and heated at 37.5°C in a coronary perfusion system. The coronary flow was maintained constant at 10 mL/min. by a peristaltic pump (Gilson, Middleton,

WI, USA). After digestion, the heart was dissected and the RV was cut into small pieces (2–3 mm^3) in Solution C at room temperature. The cells were then dissociated, resuspended and filtered. After 10 minutes, the supernatant was removed, and the pellet was washed every 10 minutes with Solutions A, B, and C, respectively.

Cardiomyocyte contractility

Briefly, isolated cells were placed in an experimental chamber with a glass coverslip base mounted on the stage of an inverted microscope (IonOptix, Milton, MA, USA), using an edge detection system with a 40x objective lens (Nikon Eclipse – TS100, USA). Cells were immersed in Tyrode's solution containing 1.8 mM $CaCl_2$ and field stimulated at 1Hz (20 V, 5 ms duration square pulses). Cell shortening in response to electrical stimulation was measured with a video-edge detection system at a 240Hz frame rate (Ionwizard, IonOptix, Milton, MA, USA) and the contractile parameters were evaluated. In addition, the sarcomere length was recorded and later analyzed using the Ion Wizard Software (IonOptix, Milton, MA, USA). Cell shortening (expressed as a percentage of resting cell length), maximal velocities of shortening and relaxation, and times to 50% shortening and 50% decay were measured in 15-20 cells per animal.

Intracellular Ca^{2+} measurements

Myocytes were loaded with 1 µM Fura2-acetoxymethyl (Fura2-AM) ester (Molecular Probes, Eugene, OR, USA) for 10 minutes at room temperature, washed with Tyrode solution and allowed to rest for an additional 10 minutes for the de-esterification of the dye. Subsequently, the cardiomyocytes were stimulated at 1Hz (Myopacer 100, IonOptix Inc., Milton, MA, USA) and fluorescence images were obtained using excitation at wavelengths from 340 to 380 nm using a Hyper Switch system (IonOptix Inc., Milton, MA, USA). Background-corrected Fura2-AM ratios reflected intracellular Ca^{2+} concentrations detected at approximately 510 nm. The Ca^{2+} transient amplitude was reported as F/F0, where F is the maximal fluorescence intensity average measured at the peak of $[Ca^{2+}]i$ transients, and F0 is the baseline fluorescence intensity measured at the diastolic phase of $[Ca^{2+}]i$ transients. Systolic and diastolic intracellular Ca^{2+}, time to peak Ca^{2+} and the time to 50% Ca^{2+} decay were also analyzed.

Statistical analysis

Data were reported as the mean ± standard error of the mean (SEM) and submitted to the Kolmogorov-Smirnov test to determine adherence to normality. The comparisons between groups were performed by the unpaired Student's t-test for independent samples. The level of significance was set at $p< 0.05$.

Results

General characteristics

The general characteristics of animals are shown in Table 1. The results indicate no statistical difference for the body and heart weight, the heart weights corrected by the body weight and the sarcomere length between the C and Ex groups ($p> 0.05$).

Table 1. General characteristics of experimental groups.

Parameters	C (n =5)	Ex (n =7)	*P-value*
Body weight (g)	200 ± 2.5	215 ± 6	0.07
Heart weight (mg)	965 ± 50	1123 ± 66	0.11
HW/BW (mg/g)	4.82 ± 0.21	5.27 ± 4.29	0.42
Sarcomere length (µm)	1.64 ± 0.02	1.69 ± 0.01	0.04

Data are expressed as the Mean ± SEM. C: Control group; Ex: Exercise group; BW: Body weight; HW: Heart weight. Unpaired Student's t-test for independent samples.

RV Cardiomyocyte contractile properties

Figure 1 shows the parameters related to the contractile function of cardiomyocytes isolated from the RV after electrical stimulation with 1Hz. It was not observed statistical differences between the groups in all of the parameters evaluated after an acute swimming aerobic exercise session ($p> 0.05$).

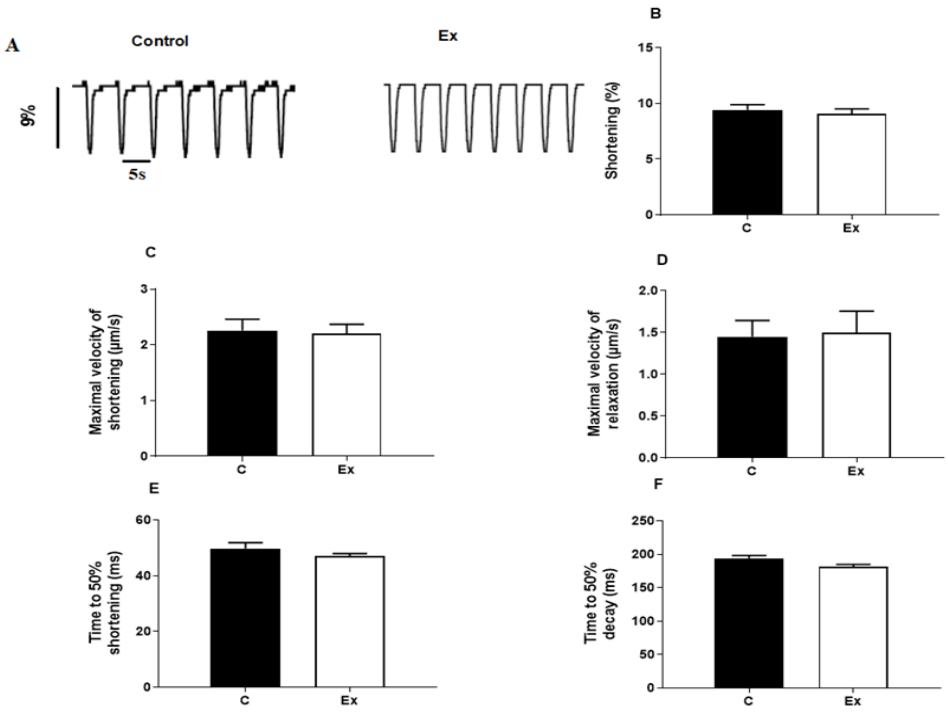

Figure 1. Contractile function of the right ventricle cardiomyocytes from control (C; n = 5; cells = 20) and exercise rats (Ex; n = 7; cells = 34). A) Representative contraction traces obtained from the cardiomyocytes of rats. Data are expressed as the mean ± SEM. Unpaired Student´s t test.

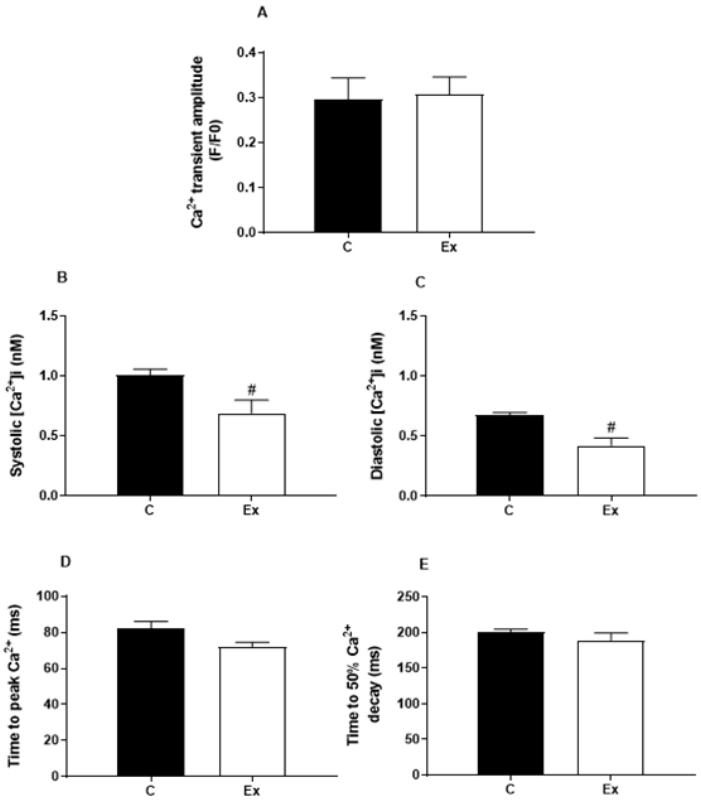

Figure 2. Cardiomyocyte calcium (Ca^{2+}) handling from control (C; n = 5; cells = 20) and exercise rats (Ex; n= 7; cells = 34). Data are expressed as the mean ± SEM. Unpaired Student´s t test. # p< 0.05 *vs.* C group.

Figure 2 shows the RV cardiomyocytes loaded with the Ca^{2+} indicator Fura2-AM after electrical stimulation with 1Hz. In Figure 2A, the Ca^{2+} transient amplitude (F/F0) was not different between the groups. As visualized in Figs. 2B and C, the cardiomyocytes from the Ex group exhibited a lower systolic and diastolic intracellular Ca^{2+} concentration compared with the C group (p< 0.05). The time to peak Ca^{2+} and Time to 50% Ca^{2+} decay (Figure 2C and D, respectively), it was not observed statistical differences between the groups.

Discussion

The aim of the current study was to analyze the contractile function and Ca^{2+} handling responses of RV cardiomyocytes after an acute swimming aerobic exercise session. Our study highlights the acute impact promoted by the aerobic exercise on the RV cardiomyocytes, which is important for the understanding of its magnitude on the main functional component of the right heart.

Acute and chronic adaptations to exercise have been extensively studied in the LV in healthy individuals,[1,3,4,17-19] whereas attention to the RV is undervalued.[2,5,7,8] The majority of the studies addressing the effects of exercise on the RV involves athletes,[2,12-14] and little scientific evidence in this field came from experimental studies with healthy animals.[5,11,15] Such studies would be important because of the impossibility to extrapolate the findings from the LV to the RV since there are substantial differences in embryology, morphology, perfusion, workload, and downstream vascular beds between the chambers.[2]

During AE, it is known that a higher relative change in RV wall stress occurs in comparison with the LV,[11,12,14] and the interventricular septum, which comprises myocardial fibers from both the LV and RV, appears to be particularly susceptible to fatigue following isolated events and periods of training.[14] In this regard, the literature shows that both acute[11,12] and chronic[12-15] exhaustive exercise, characteristic in the training of high-performance athletes, may lead to RV dysfunction and arrhythmia,[12-15] as well as myocardial fibrosis,[15] in addition to the impaired functioning of cardiomyocytes.[11]

Moreover, different exercise intensities led to distinct cardiovascular changes after exercise,[21] thus, more vigorous activities generate greater post-exercise cardiac work in order to promote the return of the individual to the rest condition. However, studies with cardiac cell isolation more accurately reflect the exercise-induced adjustments, specifically on cardiomyocytes, and not the impact on the whole cardiovascular system.

Experimental studies indicate that one of the major mechanisms related to improvements of the mechanical function of cardiomyocytes by exercise is Ca^{2+} handling, the main regulator of cardiac excitation-contraction coupling (ECC).[17,18,22] As such, the positive chronic adaptations on contractile and relaxation capacities of cardiomyocytes observed in chronic exercised individuals may be explained in part by the increased Ca^{2+} handling amplitude, the faster increase, and decay of intracellular Ca^{2+} handling and myofilament sensitivity.[23,24,25] In our study, the acute swimming exercise in rats neither increased Ca^{2+} transient amplitude nor improved the Ca^{2+} increase and decay velocities in the RV cardiomyocytes. Studies which evaluated the acute effects of exercise on this issue in RV are sparse and the majority of the literature has studied the effects of high-intensity and exhaustive exercise protocols on these parameters. In accordance, Delgado et al.[26] observed that a single exhaustive exercise session in trained and untrained rats did not change the activity of regulatory proteins of Ca^{2+} handling in the homogenate of cardiac tissue 24- and 48-hours post-exercise, however, the cardiac contractility was not measured in this study. On the other hand, Ljones et al.[11], after assessing the acute impact of an exhaustive aerobic exercise

session on the Ca^{2+} handling and its regulatory proteins in RV cardiomyocytes of untrained rats observed a reduction in Ca^{2+} transient amplitude and an increase in the time to 50% decay and diastolic Ca^{2+} removal. Therefore, since the force of contraction is mainly regulated by the amplitude and duration of intracellular Ca^{2+} handling, the absence of alterations in these parameters with our acute swimming aerobic protocol can be considered a positive result which demonstrates the maintenance of the RV cardiomyocyte function after exercise.

In this sense, a major finding of our study shows that the acute aerobic exercise induces an adjustment in the Ca^{2+} handling mechanism, causing a significant reduction of the systolic and diastolic intracellular Ca^{2+} concentration with the maintenance of Ca^{2+} amplitude and the contractile function of the RV cardiomyocytes. This result is important because it reflects an improvement in the intracellular Ca^{2+} reuptake mechanism.

Important bullets may be present such, few studies examining differential the acute responses of contractile function and calcium handling in isolated right ventricular (RV) cardiomyocytes after a physical exercise session. Understanding of acute impact from an exercise session on right side of heart and the magnitude of post-exercise response in RV cardiomyocytes to this activity is very important to the area. Finally, the effects of exercise may differ on RV based on the protocol employed.

Althought the measurement of the contractile behavior of single cardiomyocytes has made a significant contribution to our understanding of the physiology and pathophysiology of the myocardium some limitations should be mentionated in the present study. First, the techcnique of isolated cells do not permit full understood of ventricular performance, due the complex geometry of heart the mechanical performance of cadiac chambers is regulated not onlu by factors directly dependent of contractile state o myofibrils. Second, its study evaluated the cardiomyocyte contractility of right ventricule after 30 minutes by aerobic single session, in this way more studies should be conducted to clary the role of exercise type, the interdependency of volume and intensity and chronic adaptations. Third, the study did not investigate the activity and protein expression of calcium handling regulatory proteins known to affect the myocardial contraction and relaxation. In addition, the current study did not evaluate the blood samples with measures of lactate or other biological stress markers, which could indicate the actually workload performed during exercise.

In the current study promotes cardiomyocyte contractility maintenance even with systolic and diastolic intracellular Ca^{2+} concentration reduced in the RV cardiomyocytes, reflecting an improvement in the intracellular Ca^{2+} handling. Our findings confirm that exercise performed with a low to moderate intensity can be interesting for the health of RV cardiomyocytes and possibly to the RV function. These results reinforce the premise that the practice of moderate exercise training may be an important strategy for the maintenance of cardiac contractility.

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Original

The effect of static passive stretching on a bench press, in one maximum repetition test performance, is independent of the level of flexibility

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ABSTRACT

Objective: The aim of this study was to investigate at different levels of flexibility the influence of static passive stretching on bench press one maximum repetition test.
Method: Eleven men (26.09 ± 4.2 years, 81.69 ± 13.94 kg, 1.70 ± 0.05 m) were evaluated in flexibility using Flexitest and goniometry test classified according to their flexibility levels (small and upper middle levels) and joint range of motion (deficit levels), as well as performed the one maximum repetition test in the following experimental protocols: without previous stretching and with stretching 10, 20 and 60 seconds before the test.
Results: The results indicate that 64% demonstrated a low level of flexibility and 36% with a higher average level. In both, there was no significant difference in load: A0s (72.43 ± 21.10Kg vs 66.25 ± 19.02Kg); A10s (72.29 ± 20.25Kg vs 67.25 ± 20.35Kg); A20s (73.43 ± 20.78Kg vs 67.75 ± 18.23Kg) and A60s (73.29 ± 19.35Kg vs 68 ± 19.25Kg). ANOVA for repeated measures showed that no significantly different the maximum strength between groups the protocols of static passive stretching tested.
Conclusion: It was concluded that passive static stretching times lower than 60 seconds, in accordance with the current recommendations, do not interfere in the neuromuscular performance of men in the one maximum repetition test, in the bench press independent of their level of flexibility.
Keywords: Muscle Stretching Exercises; Resistance Training; Range of Motion; Articular.

El efecto del estiramiento pasivo estático en la prensa de banco, en el rendimiento del test de una repetición máxima, es independiente del nivel de flexibilidad

RESUMEN

Objetivo: El objetivo de este estudio fue investigar, a diferentes niveles de flexibilidad, la influencia del estiramiento pasivo estático en el test de una repetición máxima de la prensa de banca.
Método: la flexibilidad de once hombres (26.09 ± 4.2 años, 81.69 ± 13.94 kg, 1.70 ± 0.05 m) fue evaluada usando la prueba de *Flexitest* y goniometría y clasificada de acuerdo a sus niveles de flexibilidad (niveles bajo y medio superior) y rango de movimiento articular (niveles de déficit), además de realizar la prueba una repetición máxima con los siguientes protocolos experimentales: sin estiramiento previo y con estiramiento 10, 20 y 60 segundos antes de la prueba.
Resultados: Los resultados indican que el 64% demostrado un bajo nivel de flexibilidad y el 36% con un nivel promedio más alto. En ambos, no hubo diferencia significativa en la carga: A0s (72.43 ± 21.10Kg vs 66.25 ± 19.02Kg); A10s (72.29 ± 20.25Kg vs 67.25 ± 20.35Kg); A20s (73.43 ± 20.78Kg vs 67.75 ± 18.23Kg) y A60s (73.29 ± 19.35Kg vs 68 ± 19.25Kg). El test ANOVA, para medidas repetidas, no mostró diferencias significativas en la fuerza máxima entre los grupos, con los diferentes protocolos de estiramiento pasivo estático testados.
Conclusión: se concluyó que los tiempos de estiramiento estático pasivo inferiores a 60 segundos, de acuerdo con las recomendaciones actuales, no interfieren en el rendimiento neuromuscular de la prensa de banca de los hombres, en la prueba de una repetición máxima, independientemente de su nivel de flexibilidad.
Palabras clave: Ejercicios de Estiramiento Muscular; Entrenamiento Fuerza; Rango de Movimiento; Articular.

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O efeito do alongamento estático passivo, no supino no teste de uma repetição máxima, é independente do nível de flexibilidade

RESUMO

Objetivo: O objetivo deste estudo foi investigar em diferentes níveis de flexibilidade a influência do alongamento estático passivo no supino no teste de uma repetição máxima.
Método: Onze homens (26.09 ± 4.2 anos, 81.69 ± 13.94 kg, 1.70 ± 0.05 m) foram avaliados quanto à flexibilidade usando o Flexiteste e a goniometria classificados de acordo com seus níveis de flexibilidade (níveis médio e baixo) e amplitude de movimento articular (níveis de déficit), bem como realizou o teste de uma repetição máxima nos seguintes protocolos experimentais: sem alongamento prévio e com alongamento 10, 20 e 60 segundos antes do teste.
Resultados: Os resultados indicam que 64% demonstraram um baixo nível de flexibilidade e 36% com um nível médio mais alto. Em ambos, não houve diferença significativa na carga: A0s (72.43 ± 21.10Kg vs 66.25 ± 19.02Kg); A10s (72.29 ± 20.25 kg vs 67.25 ± 20.35 kg); A20s (73.43 ± 20.78 kg vs 67.75 ± 18.23 kg) e A60s (73.29 ± 19.35 kg vs 68 ± 19.25 kg). A ANOVA para medidas repetidas mostrou que não houve diferença significativa entre a força máxima entre os grupos e os protocolos de alongamento estático passivo testados.
Conclusão: Concluiu-se que tempos de alongamento estático passivo inferiores a 60 segundos, de acordo com as recomendações atuais, não interferem no desempenho neuromuscular dos homens no teste de uma repetição máxima, no supino independente do seu nível de flexibilidade.
Palavras-chave: Exercícios de Alongamento Muscular; Treinamento de Resistência; Amplitude de Movimento; Articular.

Introduction

Different heating techniques are used in the resistance training routine as a preparatory procedure to potentiate the development of maximum loads,[1] among them: specific heating with movements similar to the main; Muscular stretching exercises and aerobic exercise.[2]

Muscle stretching exercises are often used in the warm-up routine in a resistance training session to increase amplitude and improve athletic performance.[3] Although stretching be frequently used and the focus of numerous scientific investigations[4,5] there is still no consensus on its potential interference in the generation of force, once the possibilities of duration and intensity of the applied stimuli present different combinations.[6]

In general, in the scientific literature, it is observed that investigations with passive stretches with durations longer than 30 seconds interfere with muscle properties, reducing strength generation, while those below this time seem to exhibit opposite behavior.[7] Some authors observed a decrease in strength when muscle stretching was performed before resistance exercise, as decreases in muscle strength and power were observed. Static muscle stretches lasting up to 60 seconds can be used in pre-exercise routines without risk of significant reductions in performance of force-dependent tasks.[8]

Therefore, Souza and Penoni,[9] already stated that the decrease in strength and power induced by muscle stretching is attributed to the deterioration of the neurological response, as well as changes in the muscle-tendon unit (UMT). The authors also state that loose elastic components in series and in parallel can cause an electromechanical delay, delaying the period between the cross bridges in the myofilament, in addition to the tension exerted by UMT in the skeletal system.

However, in these investigations the level of flexibility or joint range of motion was not considered for the effect that stretching has on strength. In this regard, is important to clarify the use of this technique during a resistance training session, enabling professionals involved in the prescription of this type of training to be more critical in the preparation of the exercises training programs.

The aim of this study was to investigate at different levels of flexibility the influence of static passive stretching on bench press on test of a 1 maximum repetition (1-RM).

Method

Eleven sport sciences male students healthy (age 26.09 ± 4.2 years, body mass 81.69 ± 13.94 kg, height 1.70 ± 0.05 m) were recruited for this study for convenience. They regularly practiced recreational resistance training for the past six months, at least three times a week, lasting 60 minutes per session; previous bench press experience. For this, these individuals declared that they did not present musculoskeletal injuries that could affect the performance of the test, in addition to not using anabolic steroid medications or substances that could interfere with the generation of muscle strength at the time of the research. The study was approved by the local ethics committee (2.028.925) of the State University of Ceará.

First, an anamnesis was applied to collect data related to the participants and anthropometric evaluation with measures of height, weight,[10] for characterization of samples and classification of shoulder flexibility levels through the application of Goniometry[11] (medial and lateral rotation) through the goniometer pendular (Sanny®) and Flexitest[12] (shoulder extension and abduction; posterior shoulder extension; posterior adduction from the 180º abduction in the shoulder). The subjects performed two familiarization sessions on the bench press to ensure an adequate technique during the experimental protocols.

After, the participants performed the 1-RM tests following the recommendations of the Protocol described by Heyward,[13] to verify the maximum strength capacity achieved in the horizontal bench press exercise in the guided machine (Jones model Freedom Strength Training System®). The execution begins with the participant in dorsal decubitus, with the hip joints and knees flexed, parallel lower limbs and feet supported. The positioning of the hands in the bar was standardized according to the performance of the eccentric phase, angle of 90º formed between the arm and forearm, with arm parallel to the ground. The grip was performed with the thumb underneath the bar. In the eccentric phase, the initial position was from extended elbows and horizontal flexion of shoulders to form an angle of 90º between the arm and forearm with flexion of the elbows. To finalize the movement, the horizontal flexion of the shoulders and the complete extension of the elbows were considered.[14]

The intervention conditions were without stretching (A0) and with stretching, in the period of 10 seconds (A10), 20 seconds (A20) and 60 seconds (A60) before the 1-RM test. The passive and static stretching was performed with horizontal shoulder abduction until the maximum articular amplitude of the movement limited by the pain threshold, maintaining this position during the determined times.

To minimize interferences, each participant was randomly submitted to tests on the intervention days, which an interval of 72 hours. During the test stages, all study participants were instructed not to perform any type of exercise involving the joints and musculature required in the tests.

Descriptive data are presented as means, standard deviation and relative frequency. The normal distribution of the data was confirmed by the Shapiro-Wilk test ($p<0.05$). After, to verify the difference between the loads found in the force protocols, were used two-way repeated measures ANOVA confirmed by the

Bonferroni test. For data analysis the program used was the Statistical Package for the Social Sciences (SPSS) version 17.0.

Results

The mean and standard deviation values found in Flexiteste and Goniometry were similar, considering their evaluation components, as shown in Table 1.

Table 1. Mean values, standard deviations, minimum and maximum for the variables related to the flexibility of the evaluated.

Flexiteste	Mean ± SD	Minimum	Maximum
Posterior Shoulder Abduction	1.36 ± 0.81	0	3
Shoulder Horizontal Abduction	1.45 ± 0.93	0	3
Shoulder extension	1.82 ± 0.87	1	3
Flexiindex (summation)	4.64 ± 2.34	2	8
Goniometry (Glenohumeral Mobility)	Mean ± SD	Minimum	Maximum
Right Medial rotation (internal)	59.82° ± 17.07	20°	85°
Left Medial rotation (internal)	62.45° ± 18.45	20°	95°
Right Lateral rotation (external)	73.18° ± 22.83	30°	100°
Left Lateral rotation (external)	72.73° ± 22.18	30°	90°

Source: Own authorship. SD: standard deviations.

The results of maximum muscle strength achieved in the 1-RM tests was not influenced by the stretching times studied, that is, the loads (kg) recorded in the 1-RM tests of groups A0s, A10s, A20s and A60s remained unchanged independent of the individual's level of flexibility, as shown in Table 2.

Discussion

Based on these data, the main conclusion of our study is that performing a passive stretching of 60 seconds or less, with horizontal shoulder abduction movement in the warm-up before the horizontal bench press, does not interfere with the maximum dynamic strength performance.

In this study, the low stretching volumes tested did not significantly interfere with the strength performance in the horizontal bench press in recreationally trained youngsters. Even in individuals with low flexibility, passive acute stretching did not change strength levels.

These results reinforce the body of evidence that reinforce a dose response effect between the amount of stretching employed and its effects on strength,[15] in which static stretching routines with reduced volumes (e.g., 2x30s; 3x15s; 6x10s) has been shown to have no negative effect on the strength of the horizontal bench press and may sharply increase the range of motion of the shoulder girdle.[16-18] However, routines with high stretching volume (e.g., 16min) have a greater deleterious effect on the performance of the dynamic strength of upper members of young men.[17] This tendency is also observed in the lower members, with the high intensity and short duration static stretching protocol decreasing the peak strength.[20]

Although the stretching volume has been shown to interfere differently in performance, controversies are pointed out in the literature about the effect of static stretching on strength performance. Simic, Sarabon and Markovic,[21] in a meta-analysis review, showed a likely negative effect of static stretching lasting 46 to 90sec per muscle group on maximal strength (about 5.6%), with greater impact on isometric strength than in the dynamics.

Neural and structural factors related to the involved muscle group, high volume and strong intensity of stretching exercises have been discussed by De Souza and Penoni,[9] Ebadi and Çetin[22] to understand the possible causes of loss of strength after stretching. It is appointed that neural mechanisms (central fatigue) would be involved in the reduction of muscle strength when it is preceded by long-lasting static stretching. When there is a decrease in performance in routines with shorter duration, this seems to be related to structural factors, such as the reduction in the passive stiffness of the muscle-tendon unit.[9,24]

The characteristics of the stretching exercise used in this study with low volume (only one series; times less than or equal to 60seg) and moderate intensity (pain threshold) may explain the non-influence of previous stretching on strength. It can be assumed that even in individuals with less muscular flexibility and probably greater passive stiffness, the volumes used did not cause a reduction in the stiffness of the muscle-tendon unit and, consequently, of its specific tension, not compromising the capacity to generate force.

The absence of changes in performance in the studied times (A0s, A10s, A20s, A60s) can also be attributed to the amount of muscles involved in stretching and strength exercises, as in the study by Gonçalves et al.[25] and Lopes et al.[26] when performing shoulder abduction movement in the extensive static stretching protocol, they also did not identify interference in the performance of the repetitions and loads of presses in the bench press. The same authors report that possible changes in synergic muscles potentiate the mechanical action of the triceps brachii, compensating for a possible strength deficit caused by the reduction of motor unit recruitment in the horizontal shoulder abductors.

It is highlighted that there are numerous possibilities of prescribing volume and intensity of stretching exercises in the heating routines related to muscular strength performance. Further investigations on the subject with stretching protocols involving different muscle groups and different types of stretching (dynamic, active, proprioceptive neuromuscular facilitation) are necessary and relevant to the scientific field as they may broaden and clarify the influence of stretching on muscle strength performance in low volumes contributing to planning and prescription of exercises.

Table 2. Load values (kg) after each stretching period (0sec, 10sec, 20sec and 60sec), sorted by flexibility level in both tests used.

Flexiteste	n (%)	Load (Kg)			
		A0s	A10s	A20s	A60s
Small level	7 (64%)	72.43 ± 21.10	72.29 ± 20.25	73.43 ± 20.78	73.29 ± 19.35
Upper Middle Level	4 (36%)	66.25 ± 19.02	67.25 ± 20.35	67.75 ± 18.23	68 ± 19.25
Goniometry (Glenohumeral Mobility)	n (%)	A0s	A10s	A20s	A60s
Right Medial rotation (internal)					
Deficit > 10%	10 (91%)	71.20 ± 20.39	71.30 ± 20.24	72.30 ± 19.92	72.30 ± 19.24
Deficit < 10%	1 (9%)	60 ± 0	62 ± 0	62 ± 0	62 ± 0
Left Medial rotation (internal)					
Deficit > 10%	10 (91%)	69.10 ± 20.35	69.50 ± 20.18	70.50 ± 19.96	70.50 ± 19.28
Deficit < 10%	1 (9%)	81 ± 0	80 ± 0	80 ± 0	80 ± 0
Right Lateral rotation (external)					
Deficit > 10%	6 (55%)	75.92 ± 19.20	76.50 ± 18.20	77.67 ± 18.57	76.33 ± 17.77
Deficit < 10%	5 (45%)	63.30 ± 19.85	63.20 ± 20.18	63.80 ± 18.85	65.40 ± 19.51
Left Lateral rotation (external)					
Deficit > 10%	5 (45%)	69.60 ± 25.14	70 ± 24.29	71.60 ± 25.12	71 ± 23.19
Deficit < 10%	6 (55%)	70.67 ± 16.27	70.83 ± 16.76	71.17 ± 15.13	71.67 ± 15.97

A0s: no stretching period; A10s: after 10 seconds of stretching; A20s: after 20 seconds of stretching; A60s: after 60 seconds of stretching. Source: Own authorship.

The study has some limitations that must be considered. The sample this study was small and include only young men, the results being specific to this public. For greater reliability of the results, the sample size and power must be considered. In addition, the individual's difficulty in remaining in the research stands out, because, although the size and power of the sample can be calculated, the individuals initially recruited were unable to complete the stages of the study, especially the four experimental strength conditions and stretching. Another limitation was not to measure the range of motion of the participants after applying static stretching, which restricts the verification of the stretching effect.

The practical implications of this study indicate that the maximum performance of dynamic strength in the bench press of the recreational practitioner will not be interfered with when performing passive static stretching for up to 60 seconds, even if his levels of shoulder flexibility are not optimal.

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Original

The effect of static passive stretching on a bench press, in one maximum repetition test performance, is independent of the level of flexibility

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ABSTRACT

Objective: The aim of this study was to investigate at different levels of flexibility the influence of static passive stretching on bench press one maximum repetition test.
Method: Eleven men (26.09 ± 4.2 years, 81.69 ± 13.94 kg, 1.70 ± 0.05 m) were evaluated in flexibility using Flexitest and goniometry test classified according to their flexibility levels (small and upper middle levels) and joint range of motion (deficit levels), as well as performed the one maximum repetition test in the following experimental protocols: without previous stretching and with stretching 10, 20 and 60 seconds before the test.
Results: The results indicate that 64% demonstrated a low level of flexibility and 36% with a higher average level. In both, there was no significant difference in load: A0s (72.43 ± 21.10Kg vs 66.25 ± 19.02Kg); A10s (72.29 ± 20.25Kg vs 67.25 ± 20.35Kg); A20s (73.43 ± 20.78Kg vs 67.75 ± 18.23Kg) and A60s (73.29 ± 19.35Kg vs 68 ± 19.25Kg). ANOVA for repeated measures showed that no significantly different the maximum strength between groups the protocols of static passive stretching tested.
Conclusion: It was concluded that passive static stretching times lower than 60 seconds, in accordance with the current recommendations, do not interfere in the neuromuscular performance of men in the one maximum repetition test, in the bench press independent of their level of flexibility.
Keywords: Muscle Stretching Exercises; Resistance Training; Range of Motion; Articular.

El efecto del estiramiento pasivo estático en la prensa de banco, en el rendimiento del test de una repetición máxima, es independiente del nivel de flexibilidad

RESUMEN

Objetivo: El objetivo de este estudio fue investigar, a diferentes niveles de flexibilidad, la influencia del estiramiento pasivo estático en el test de una repetición máxima de la prensa de banca.
Método: la flexibilidad de once hombres (26.09 ± 4.2 años, 81.69 ± 13.94 kg, 1.70 ± 0.05 m) fue evaluada usando la prueba de *Flexitest* y goniometría y clasificada de acuerdo a sus niveles de flexibilidad (niveles bajo y medio superior) y rango de movimiento articular (niveles de déficit), además de realizar la prueba una repetición máxima con los siguientes protocolos experimentales: sin estiramiento previo y con estiramiento 10, 20 y 60 segundos antes de la prueba.
Resultados: Los resultados indican que el 64% demostrado un bajo nivel de flexibilidad y el 36% con un nivel promedio más alto. En ambos, no hubo diferencia significativa en la carga: A0s (72.43 ± 21.10Kg vs 66.25 ± 19.02Kg); A10s (72.29 ± 20.25Kg vs 67.25 ± 20.35Kg); A20s (73.43 ± 20.78Kg vs 67.75 ± 18.23Kg) y A60s (73.29 ± 19.35Kg vs 68 ± 19.25Kg). El test ANOVA, para medidas repetidas, no mostró diferencias significativas en la fuerza máxima entre los grupos, con los diferentes protocolos de estiramiento pasivo estático testados.
Conclusión: se concluyó que los tiempos de estiramiento estático pasivo inferiores a 60 segundos, de acuerdo con las recomendaciones actuales, no interfieren en el rendimiento neuromuscular de la prensa de banca de los hombres, en la prueba de una repetición máxima, independientemente de su nivel de flexibilidad.
Palabras clave: Ejercicios de Estiramiento Muscular; Entrenamiento Fuerza; Rango de Movimiento; Articular.

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O efeito do alongamento estático passivo, no supino no teste de uma repetição máxima, é independente do nível de flexibilidade

RESUMO

Objetivo: O objetivo deste estudo foi investigar em diferentes níveis de flexibilidade a influência do alongamento estático passivo no supino no teste de uma repetição máxima.
Método: Onze homens (26.09 ± 4.2 anos, 81.69 ± 13.94 kg, 1.70 ± 0.05 m) foram avaliados quanto à flexibilidade usando o Flexiteste e a goniometria classificados de acordo com seus níveis de flexibilidade (níveis médio e baixo) e amplitude de movimento articular (níveis de déficit), bem como realizou o teste de uma repetição máxima nos seguintes protocolos experimentais: sem alongamento prévio e com alongamento 10, 20 e 60 segundos antes do teste.
Resultados: Os resultados indicam que 64% demonstraram um baixo nível de flexibilidade e 36% com um nível médio mais alto. Em ambos, não houve diferença significativa na carga: A0s (72.43 ± 21.10Kg vs 66.25 ± 19.02Kg); A10s (72.29 ± 20.25 kg vs 67.25 ± 20.35 kg); A20s (73.43 ± 20.78 kg vs 67.75 ± 18.23 kg) e A60s (73.29 ± 19.35 kg vs 68 ± 19.25 kg). A ANOVA para medidas repetidas mostrou que não houve diferença significativa entre a força máxima entre os grupos e os protocolos de alongamento estático passivo testados.
Conclusão: Concluiu-se que tempos de alongamento estático passivo inferiores a 60 segundos, de acordo com as recomendações atuais, não interferem no desempenho neuromuscular dos homens no teste de uma repetição máxima, no supino independente do seu nível de flexibilidade.
Palavras-chave: Exercícios de Alongamento Muscular; Treinamento de Resistência; Amplitude de Movimento; Articular.

Introduction

Different heating techniques are used in the resistance training routine as a preparatory procedure to potentiate the development of maximum loads,[1] among them: specific heating with movements similar to the main; Muscular stretching exercises and aerobic exercise.[2]

Muscle stretching exercises are often used in the warm-up routine in a resistance training session to increase amplitude and improve athletic performance.[3] Although stretching be frequently used and the focus of numerous scientific investigations[4,5] there is still no consensus on its potential interference in the generation of force, once the possibilities of duration and intensity of the applied stimuli present different combinations.[6]

In general, in the scientific literature, it is observed that investigations with passive stretches with durations longer than 30 seconds interfere with muscle properties, reducing strength generation, while those below this time seem to exhibit opposite behavior.[7] Some authors observed a decrease in strength when muscle stretching was performed before resistance exercise, as decreases in muscle strength and power were observed. Static muscle stretches lasting up to 60 seconds can be used in pre-exercise routines without risk of significant reductions in performance of force-dependent tasks.[8]

Therefore, Souza and Penoni,[9] already stated that the decrease in strength and power induced by muscle stretching is attributed to the deterioration of the neurological response, as well as changes in the muscle-tendon unit (UMT). The authors also state that loose elastic components in series and in parallel can cause an electromechanical delay, delaying the period between the cross bridges in the myofilament, in addition to the tension exerted by UMT in the skeletal system.

However, in these investigations the level of flexibility or joint range of motion was not considered for the effect that stretching has on strength. In this regard, is important to clarify the use of this technique during a resistance training session, enabling professionals involved in the prescription of this type of training to be more critical in the preparation of the exercises training programs.

The aim of this study was to investigate at different levels of flexibility the influence of static passive stretching on bench press on test of a 1 maximum repetition (1-RM).

Method

Eleven sport sciences male students healthy (age 26.09 ± 4.2 years, body mass 81.69 ± 13.94 kg, height 1.70 ± 0.05 m) were recruited for this study for convenience. They regularly practiced recreational resistance training for the past six months, at least three times a week, lasting 60 minutes per session; previous bench press experience. For this, these individuals declared that they did not present musculoskeletal injuries that could affect the performance of the test, in addition to not using anabolic steroid medications or substances that could interfere with the generation of muscle strength at the time of the research. The study was approved by the local ethics committee (2.028.925) of the State University of Ceará.

First, an anamnesis was applied to collect data related to the participants and anthropometric evaluation with measures of height, weight,[10] for characterization of samples and classification of shoulder flexibility levels through the application of Goniometry[11] (medial and lateral rotation) through the goniometer pendular (Sanny®) and Flexitest[12] (shoulder extension and abduction; posterior shoulder extension; posterior adduction from the 180º abduction in the shoulder). The subjects performed two familiarization sessions on the bench press to ensure an adequate technique during the experimental protocols.

After, the participants performed the 1-RM tests following the recommendations of the Protocol described by Heyward,[13] to verify the maximum strength capacity achieved in the horizontal bench press exercise in the guided machine (Jones model Freedom Strength Training System®). The execution begins with the participant in dorsal decubitus, with the hip joints and knees flexed, parallel lower limbs and feet supported. The positioning of the hands in the bar was standardized according to the performance of the eccentric phase, angle of 90º formed between the arm and forearm, with arm parallel to the ground. The grip was performed with the thumb underneath the bar. In the eccentric phase, the initial position was from extended elbows and horizontal flexion of shoulders to form an angle of 90º between the arm and forearm with flexion of the elbows. To finalize the movement, the horizontal flexion of the shoulders and the complete extension of the elbows were considered.[14]

The intervention conditions were without stretching (A0) and with stretching, in the period of 10 seconds (A10), 20 seconds (A20) and 60 seconds (A60) before the 1-RM test. The passive and static stretching was performed with horizontal shoulder abduction until the maximum articular amplitude of the movement limited by the pain threshold, maintaining this position during the determined times.

To minimize interferences, each participant was randomly submitted to tests on the intervention days, which an interval of 72 hours. During the test stages, all study participants were instructed not to perform any type of exercise involving the joints and musculature required in the tests.

Descriptive data are presented as means, standard deviation and relative frequency. The normal distribution of the data was confirmed by the Shapiro-Wilk test ($p<0.05$). After, to verify the difference between the loads found in the force protocols, were used two-way repeated measures ANOVA confirmed by the

Bonferroni test. For data analysis the program used was the Statistical Package for the Social Sciences (SPSS) version 17.0.

Results

The mean and standard deviation values found in Flexiteste and Goniometry were similar, considering their evaluation components, as shown in Table 1.

Table 1. Mean values, standard deviations, minimum and maximum for the variables related to the flexibility of the evaluated.

Flexiteste	Mean ± SD	Minimum	Maximum
Posterior Shoulder Abduction	1.36 ± 0.81	0	3
Shoulder Horizontal Abduction	1.45 ± 0.93	0	3
Shoulder extension	1.82 ± 0.87	1	3
Flexiindex (summation)	4.64 ± 2.34	2	8
Goniometry (Glenohumeral Mobility)	Mean ± SD	Minimum	Maximum
Right Medial rotation (internal)	59.82° ± 17.07	20°	85°
Left Medial rotation (internal)	62.45° ± 18.45	20°	95°
Right Lateral rotation (external)	73.18° ± 22.83	30°	100°
Left Lateral rotation (external)	72.73° ± 22.18	30°	90°

Source: Own authorship. SD: standard deviations.

The results of maximum muscle strength achieved in the 1-RM tests was not influenced by the stretching times studied, that is, the loads (kg) recorded in the 1-RM tests of groups A0s, A10s, A20s and A60s remained unchanged independent of the individual's level of flexibility, as shown in Table 2.

Discussion

Based on these data, the main conclusion of our study is that performing a passive stretching of 60 seconds or less, with horizontal shoulder abduction movement in the warm-up before the horizontal bench press, does not interfere with the maximum dynamic strength performance.

In this study, the low stretching volumes tested did not significantly interfere with the strength performance in the horizontal bench press in recreationally trained youngsters. Even in individuals with low flexibility, passive acute stretching did not change strength levels.

These results reinforce the body of evidence that reinforce a dose response effect between the amount of stretching employed and its effects on strength,[15] in which static stretching routines with reduced volumes (e.g., 2x30s; 3x15s; 6x10s) has been shown to have no negative effect on the strength of the horizontal bench press and may sharply increase the range of motion of the shoulder girdle.[16-18] However, routines with high stretching volume (e.g., 16min) have a greater deleterious effect on the performance of the dynamic strength of upper members of young men.[17] This tendency is also observed in the lower members, with the high intensity and short duration static stretching protocol decreasing the peak strength.[20]

Although the stretching volume has been shown to interfere differently in performance, controversies are pointed out in the literature about the effect of static stretching on strength performance. Simic, Sarabon and Markovic,[21] in a meta-analysis review, showed a likely negative effect of static stretching lasting 46 to 90sec per muscle group on maximal strength (about 5.6%), with greater impact on isometric strength than in the dynamics.

Neural and structural factors related to the involved muscle group, high volume and strong intensity of stretching exercises have been discussed by De Souza and Penoni,[9] Ebadi and Çetin[22] to understand the possible causes of loss of strength after stretching. It is appointed that neural mechanisms (central fatigue) would be involved in the reduction of muscle strength when it is preceded by long-lasting static stretching. When there is a decrease in performance in routines with shorter duration, this seems to be related to structural factors, such as the reduction in the passive stiffness of the muscle-tendon unit.[9,24]

The characteristics of the stretching exercise used in this study with low volume (only one series; times less than or equal to 60seg) and moderate intensity (pain threshold) may explain the non-influence of previous stretching on strength. It can be assumed that even in individuals with less muscular flexibility and probably greater passive stiffness, the volumes used did not cause a reduction in the stiffness of the muscle-tendon unit and, consequently, of its specific tension, not compromising the capacity to generate force.

The absence of changes in performance in the studied times (A0s, A10s, A20s, A60s) can also be attributed to the amount of muscles involved in stretching and strength exercises, as in the study by Gonçalves et al.[25] and Lopes et al.[26] when performing shoulder abduction movement in the extensive static stretching protocol, they also did not identify interference in the performance of the repetitions and loads of presses in the bench press. The same authors report that possible changes in synergic muscles potentiate the mechanical action of the triceps brachii, compensating for a possible strength deficit caused by the reduction of motor unit recruitment in the horizontal shoulder abductors.

It is highlighted that there are numerous possibilities of prescribing volume and intensity of stretching exercises in the heating routines related to muscular strength performance. Further investigations on the subject with stretching protocols involving different muscle groups and different types of stretching (dynamic, active, proprioceptive neuromuscular facilitation) are necessary and relevant to the scientific field as they may broaden and clarify the influence of stretching on muscle strength performance in low volumes contributing to planning and prescription of exercises.

Table 2. Load values (kg) after each stretching period (0sec, 10sec, 20sec and 60sec), sorted by flexibility level in both tests used.

Flexiteste	n (%)	Load (Kg)			
		A0s	A10s	A20s	A60s
Small level	7 (64%)	72.43 ± 21.10	72.29 ± 20.25	73.43 ± 20.78	73.29 ± 19.35
Upper Middle Level	4 (36%)	66.25 ± 19.02	67.25 ± 20.35	67.75 ± 18.23	68 ± 19.25
Goniometry (Glenohumeral Mobility)	n (%)	A0s	A10s	A20s	A60s
Right Medial rotation (internal)					
Deficit > 10%	10 (91%)	71.20 ± 20.39	71.30 ± 20.24	72.30 ± 19.92	72.30 ± 19.24
Deficit < 10%	1 (9%)	60 ± 0	62 ± 0	62 ± 0	62 ± 0
Left Medial rotation (internal)					
Deficit > 10%	10 (91%)	69.10 ± 20.35	69.50 ± 20.18	70.50 ± 19.96	70.50 ± 19.28
Deficit < 10%	1 (9%)	81 ± 0	80 ± 0	80 ± 0	80 ± 0
Right Lateral rotation (external)					
Deficit > 10%	6 (55%)	75.92 ± 19.20	76.50 ± 18.20	77.67 ± 18.57	76.33 ± 17.77
Deficit < 10%	5 (45%)	63.30 ± 19.85	63.20 ± 20.18	63.80 ± 18.85	65.40 ± 19.51
Left Lateral rotation (external)					
Deficit > 10%	5 (45%)	69.60 ± 25.14	70 ± 24.29	71.60 ± 25.12	71 ± 23.19
Deficit < 10%	6 (55%)	70.67 ± 16.27	70.83 ± 16.76	71.17 ± 15.13	71.67 ± 15.97

A0s: no stretching period; A10s: after 10 seconds of stretching; A20s: after 20 seconds of stretching; A60s: after 60 seconds of stretching. Source: Own authorship.

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Original

The effect of a core training program on jump performance in female handball players

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ABSTRACT

Objectives: To analyze the effects of core strength training on jump performance in female handball players.
Methods: This is a randomized controlled trial. A total of 20 female handball players [age = 19.5 (1.4) years, height = 1.65 (0.05) m, body mass= 61.7 (9.3) kg] were recruited and split in: a core training group and a control group. The core training group participated in 8 weeks in-season of a core strength program (2 times/week). Pre- and post-intervention jump height, contact time and reactive strength index were collected during bilateral and unilateral drop vertical jumps. Frontal knee projection angle was measured only at unilateral drop jumps. Statistical significant difference was set at p <0.05.
Results: group x time interactions were statistically significant for bilateral and unilateral jump height and for FKPA (<0.05). Core training group increased the bilateral jump height by 18.8% and showed a statistically significant difference in reactive strength index from pre-intervention [0.07 (0.03)] to post-intervention [0.10 (0.04)]. The core training group also improved the unilateral jump height by 20%, but only at the non-dominant leg. This improvement was accompanied by a statistically significant decrease in the frontal knee projection angle from pre-intervention [13.8 (7.4) degrees]to post-intervention [9.3 (6.1) degrees]. Control group did not obtain significant improvements in any of the assessed variables. There were no significant differences between groups in the baseline (p>0.05).
Conclusion: A core strength training increased jump performance *(drop jump)* in female handball players.
Keywords: Strength; Valgus; Knee; Training; Exercise.

Efecto de un programa de entrenamiento del core en la capacidad de salto de jugadoras de balonmano

RESUMEN

Objetivos: Analizar los efectos del entrenamiento de la fuerza del core sobre el rendimiento del salto en jugadoras de balonmano.
Métodos: Ensayo controlado aleatorio. 20 jugadoras de balonmano [edad = 19.5 (1.4) años, altura = 1.65 (0.05) m, masa corporal = 61.7 (9.3) kg]. Dos grupos: entrenamiento del core y grupo de control. El grupo entrenamiento del core realizó 2 veces por semana (8 semanas) un programa de fortalecimiento específico del core. Fueron registradas pre-post intervención, la altura de salto, el tiempo de contacto, el índice de fuerza reactiva en saltos verticales de caída bilateral y unilateral y el ángulo de proyección frontal de rodilla en saltos con recepción unilateral (p 0.05) <0.05.
Resultados: las interacciones grupo x tiempo fueron estadísticamente significativas para la altura de salto bilateral y unilateral y la FKPA (p<0.05). El grupo de entrenamiento del core aumentó la altura de salto bilateral en un 18.8% y mostró diferencias significativas en el índice de fuerza reactiva desde la preintervención [0.07 (0.03)] hasta la post-intervención [0.10 (0.04)]. Asimismo, mejoró la altura de salto unilateral en un 20%, en la pierna no dominante. Esta mejora se acompañó de una disminución del ángulo de proyección frontal de la rodilla entre el pre [13.8 (7.4) grados] y el post [9.3 (6.1) grados]. El grupo de control no obtuvo mejoras significativas en las variables evaluadas. No hubo diferencias significativas entre los grupos antes de la intervención (p>0.05).
Conclusiones: el fortalecimiento del core ha influido positivamente en el rendimiento del salto (drop jump) en las jugadoras.
Palabras clave: Fuerza; Valgo; Rodilla; Entrenamiento; Ejercicio

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Efeito de um programa do treinamiento do Core na desempenho de saltos em jogadoras de handebol

RESUMO

Objetivos: Analisar os efeitos do treino de força central no desempenho de saltos em jogadores de andebol feminino.
Métodos: Ensaio controlado aleatorizado. 20 jogadoras de andebol [idade = 19,5 anos (1,4), altura = 1,65m (0,05), massa corporal = 61,7kg (9,3)]. Dois grupos: grupo núcleo de formação e grupo de controlo. O grupo de formação principal realizou 2 vezes por semana (8 semanas) um programa específico de reforço do núcleo. Foram registados a intervenção pré-pós, altura do salto, tempo de contacto, índice de força reativa em saltos verticais bilaterais e unilaterais, e ângulo de projeção do joelho frontal em saltos de captura unilaterais ($p < 0.05$).
Resultados: As interações grupo x tempo foram estatisticamente significativas para a altura de salto bilateral e unilateral, e FKPA ($p<0,05$). O grupo de treino principal aumentou a altura do salto bilateral em 18,8% e mostrou diferenças significativas no índice de força reativa desde a pré-intervenção [0,07 (0,03)] até à pós-intervenção [0,10 (0,04)]. Para além disso, a altura do salto unilateral melhorou em 20% na perna não dominante. Esta melhoria foi acompanhada por uma diminuição do ângulo de projecção do joelho frontal entre os pré [13,8 (7,4) graus] e os pós [9,3 (6,1) graus]. O grupo de controlo não teve uma melhoria significativa nas variáveis avaliadas. Não houve diferenças significativas entre os grupos na linha de base ($p>0,05$).
Conclusões: O reforço do núcleo teve um efeito positivo no desempenho dos jogadores no salto de queda.
Palavras-chave: Força, Valgus, Joelho, Treino, Exercício.

Introduction

The core is a functional concept referred to the muscular, osteoarticular and neural structures of the central part of the body. It is suggested that a strong core allows an athlete the full transfer of forces generated with the lower extremities, through the torso, and to the upper extremities and sometimes an implement.[1]

In recent decades, core exercises have been incorporated into strength training routines with the purpose of increasing sports performance and reducing injury incidence. Taskin[2] studied the effect of a core training program on speed, acceleration, vertical jump, and standing long jump in female soccer players and found that the core training group improved their results in all the variables measured. Prieske et al.[3] applied a core strength training in a group of soccer players and found statistical significant improvements only for sprint time and kicking performance, but they did not find it for countermovement jump height. Likewise, improving core stability through strength exercise is common in musculoskeletal injury prevention programs.[4,5]

Among sport performance tests, vertical drop jump is one of the most studied tests since numerous sports activities involve jumps and require appropriate jump landing techniques (i.e. volleyball, basketball, handball…).[6,7] However, studies focused on the effect of core training interventions on vertical jump performance show controversial results.[8] For example, studies performed on soccer,[2,9–11] basketball[12] and volleyball[13] players reported a positive impact of core training on vertical jump performance, while other studies have not recorded an improvement when applying this type of training routines, for example, in soccer,[3] lacrosse[14] and capoeira athletes.[15]

Handball is one of the most popular team sports.[16] It is a sport that requires an extensive number and variety of movements; jumps, settings, accelerations, changes of direction, and passing are the most frequent gestures.[17,18] In addition to technical and tactical skills, anthropometric characteristics as well as physical performance play an important role for success.[19,20]

The jump throw is the most applied throwing technique in team- handball, 73 - 75% of all throws during a competitive team-handball game are jump throws.[21] In order to counteract them, there are two common defense actions: blocking the ball and the players' collaboration with the goalkeeper in order to reduce the opponent's throwing success towards the goal. For both actions the defenders need the vertical jump. Thus, both in attack and defense, jumps with a vertical component acquire relevance in the technical-tactical actions of the game.

Various studies in handball have shown a positive effect of a specific core muscle training on handball players' throws performance.[22,23] For instance, Sasaki et al.[24] applied a core strength training in a group of female basketball players and found that peak knee-valgus moment decreased in the training group compared to the control group during the drop-jump test. Similar results were found by Jeong et al.[25] during a side-step cutting task.

Increased medial knee movement in dynamic actions has been pointed out as one of the risk factors for injury.[26] This increase in the angle in a landing action has to do with the pronation that occurs in the foot, the weakness of the hip abductor musculature, a greater internal rotation of the leg and furthermore, may be conditional to task demand.[27]

Therefore, given the inconsistencies in the literature regarding the effect of core training on vertical jump performance, together with the paucity of scientific studies in the field of team sports such as handball, the purpose of this study was to evaluate the effect of a core training program on bilateral and unilateral vertical drop jump (VDJ) performance in female handball players. We also evaluated the influence of the intervention on frontal knee projection knee angle (FKPA) during unilateral jumps. We hypothesized that players performing the core training will improve unilateral and bilateral VDJ performance variables (height, contact time and reactive strength index) and will decrease FKPA during unilateral landings compared to players who do not perform it.

Methods

Study Design

A randomized control trial was conducted to assess the impact of an 8-week core strength program on jump performance and dynamic knee valgus angle at landing in female handball players. Two teams from a female handball club were recruited and were randomly assigned to either a core training intervention (CTG) or control (CG) group. The allocation sequence was computed generated and one of the teams was assigned to CTG while the other served as control group with group allocation conducted by a research assistant who did not participate in the study. All players from both teams had similar practice and competition schedules throughout the study. The study was carried out in the middle of the soccer competition (February and March).

The CTG group performed the program twice a week as a warm-up before the team's regularly scheduled practices and was implemented by two experienced members of the research team.

Participants on the CG performed their usual warm-up exercises (running, dynamic stretching and ball exercises). Participants were assessed twice, one at baseline and again at the end of the training weeks.

Participants

Two teams, with a total of 20 young female handball players from the Spanish second division participated voluntarily in this study (CTG= 10 participants and CG=8 participants). There were 2 dropouts from the CG (due to injury). Players performed 3 handball sessions per week (1 hour and 30 minutes per session) plus the official weekend game. Inclusion criteria included female players between 18 and 20 years of age, with an organized handball previous experience of 5 up to 10 years, currently participating actively on a handball team and with no previous experience in a core training programme. Exclusion criteria included a prior anterior cruciate ligament (ACL) injury, lower extremity surgery within the past year, a serious lower extremity injury within the past 6 months (defined as an injury requiring more than 4 weeks of absence from participation in handball activity), and prior or current participation in an ACL injury prevention program. We recorded the dominant leg (DL) and non-dominant leg (NDL) in each participant and this information was used for subsequent analyses. The players self-reported their preferred upper limb for throwing a ball as their dominant upper limb and their preferred lower limb for kicking a ball as their dominant lower limb. All the 18 players reported the right upper and lower limb as their DL and their left upper and lower limb as their NDL. The anthropometric and training experience can be seen at Table 1.

Table 1. Anthropometric and sport profiles of the players.

	n	Age (years)	Body Mass (kg)	Height (m)	Practice (years)
CTG	10	19.7 ± 1.5	63.9 ± 10.1	1.68 ± 0.05	11.1 ± 2.0
CG	8	19.2 ± 1.4	59.4 ± 8.2	1.62 ± 0.06	11.4 ± 1.7
TOTAL	18	19.5 ± 1.4	61.7 ± 9.3	1.65 ± 0.05	11.2 ± 1.8

X: mean; SD: Standard deviation; CTG: Core training group; GC: Control group; n.: number of players; kg: kilograms; m:meters. Data are expressed as mean ± SD.

Before testing, institutional review board approval was obtained. Approval for the study was obtained from the Ethics Committee at the corresponding institution. The study was conducted in accordance with the Declaration of Helsinki, good clinical practices, and applicable laws and regulations.

Assessment procedure: Vertical Drop Jump Test

Pre- and post-intervention assessments at the same laboratory consisted on evaluation of the VDJ test performance and measurement of height and weight. Both assessments were performed at similar appointment times to avoid the influence of diurnal variation in test performance.

To conduct the test, the participants should wear short pants to be instrumented with markers to determine the landmarks according to the configuration of previous studies.[28] Markers were attached to: anterior superior iliac spine, patella, center of the ankle, greater trochanter, lateral surface of the thigh, lateral epicondyle of the femur, lateral surface of the leg, lateral malleolus and fifth metatarsus. The same evaluator was responsible for placing the markers to each participant and made sure they were not moved or detached from the skin during the test.

Previous to the test measurements, a standard 10-minute warm-up was performed for all players: 5 min running at a 5 km/h pace, 3 min of hip and leg dynamic stretches and 2 min of submaximal vertical jumps (5 bilateral jumps, and 5 jumps for right and left leg [10 sec rest between jumps]). The warm-up was controlled by an evaluator in order to ensure that the stipulated time and intensity was met. Two days previous to the intervention, a familiarization session was conducted. On test measurements, participants performed 3 drop jumps as specific warm-up to assure the correct performance of the VDJ (one with both legs, one with the right and one with the left). Then, the test was performed including 3 bilateral jumps and 3 unilateral right and left jumps whose order were randomized with 30 seconds rest between repetitions.

The players were instructed to put their arms in jar, hands supported on the hips (without covering the marks and feet barefoot) and drop from a 30 cm height, landing with the two feet on the ground and immediately jumping as high as they could to finally land again on the floor.

The jumps were considered invalid if participants jumped from the box instead of dropping down, if they moved their arms or if they clearly lost balance during the test. Further, in the unilateral test, this was considered invalid when the non-supporting leg touched the ground. When invalid repetition was performed, the participants were allowed to repeat it. The first 3 valid jumps of each type (two legs, right leg and left leg) were selected and included for further analysis.

For the recording of the test, one digital camera (Samsung ST66, Samsung, South Korea) was placed on the frontal plane, on a tripod at 110 cm in height and separated 4 meters from the jump box (30 cm high). The app Kinovea (GPLv2 license) was used to analyze the jump and to obtain the variable FKPA. FKPA was calculated measuring the angle formed by the markers placed at the anterior superior iliac spine, patella and center of the ankle (Figure 1).

Figure 1. Variable FKPA (measured with Kinovea).

Another digital camera (Samsung ST66, Samsung, South Korea) that recorded with a frame rate of 30 frames per second was placed on a sagittal plane at ground floor and separated 2 meters from the landing place. The application My Jump 2 was used to obtain the jump performance variables of jump height (JH), feet contact time (Ct) and the reactive strength index (RSI). JH was calculated from flight time that is the time between the takeoff and ground contact. Feet Ct was calculated as the time between feet first ground contact at landing to feet last ground contact at takeoff. RSI was calculated with the jump height (meters) divided by ground contact time (seconds). This is one metric commonly analyzed from DJ. It identifies an athlete's ability to quickly switch

from an eccentric to a concentric contraction, and how much force the athlete is able to produce in the shortest possible time.

The reliability of the VDJ to analyze biomechanical variables in young athletes is excellent for the sagittal plane (intraclass correlation coefficient [ICC] between sessions > 0.8) and for the frontal plane (ICC between sessions > 0.75).[29]

The validity and reliability of the My Jump 2 app for measuring the reactive strength index (RSI) and drop jump performance has been studied.[30] Near perfect agreement has been found at 20 cm (ICC = 0.95) and at 40 cm (ICC = 0.98), while the validity at 20 cm and 40 cm has been found to be r = 0.94 and r = 0.97, respectively.

Pre- and post-intervention JH, Ct and RSI were collected during bilateral and unilateral drop vertical jumps. FKPA was measured only at unilateral drop jumps.

Core Strength Training

Over the 8-week training period, a total of 16 sessions of 30 minutes each were performed. During the sessions, two trained supervisors helped to control the correct execution of the exercises that were previously explained by one of the researchers.

The criteria to choose the exercises for core strength training were: involvement of multiple muscles and involvement of 3 types of exercises involving the trunk (extension, flexion and rotation) based on the proposal of Boyle.[31] Flexion exercises included: plank, plank moving forward and backward, abdominal wheel and crawling. Extension exercises included: Plank with arm extended, clock plank, isometric press pallof and press pallof. Rotation exercises included: lateral plank, lateral plank plus row with elastic, one leg kneeling woodchopper and both legs kneeling woodchopper. In addition, a specific work of gluteus medium was included, given the fundamental role that plays in core stability.

To establish working time and repetitions, we followed the model of other similar studies.[2] To individualize exercise intensity in the core strength exercises, participants using resistance bands were instructed to do as many repetitions needed in each set until moderate to intense exertion was perceived. The intensity was controlled by the 10-point modified Borg Scale, maintaining an intensity between 7 (moderate) and 8 (intense) for each set of exercises. Players who did not experience fatigue after the established work time for isometric contractions were required to add additional weight to ensure fatigue at the end of the exercise. The familiarization session was used to adjust exercise intensity for all players. Subjects' adherence rates were recorded throughout the study period. None of the participants missed more than 1 session as required to be included in the analysis. The baseline structure of the 8-week core stability and strength-training program is shown in Table 2.

Table 2. Structure of the 8-week core stability and strength training program.

Exercises	Week 1	Week 2
Plank	3x20s	3x25s
Plank with arm extended	3x20s	3x25s
Lateral Plank	3x20s	3x25s
Clamshell lying	3x20 reps	3x25 reps
	Week 3	Week 4
Plank forward and backward	3x20s	3x25s
Clock plank	3x20s	3x25s
Lateral plank + row with elastic	3x20s	3x25s
Clamshell lying	3x20 reps	3x25 reps
	Week 5	Week 6
Ab Wheel	3x20s	3x25s
Isometric press pallof	3x20s	3x25s
Kneeling whoodchopper	3x20s	3x25s
Hip abductions with elastics around knees	3x20 reps	3x25 reps
	Week 7	Week 8
Crawling	3x20s	3x25s
Press Pallof 1	3x20s	3x25s
Kneeling whoodchooper	3x20s	3x25s
Hip abductions with elastics around ankles	3x20 reps	3x25 reps

*Reps: repetitions; s: seconds

Recovery time was 20 s between sets and 60 s between exercises. Some of the exercises performed in the core strength training are shown in Figures 2a, 2b and 2c.

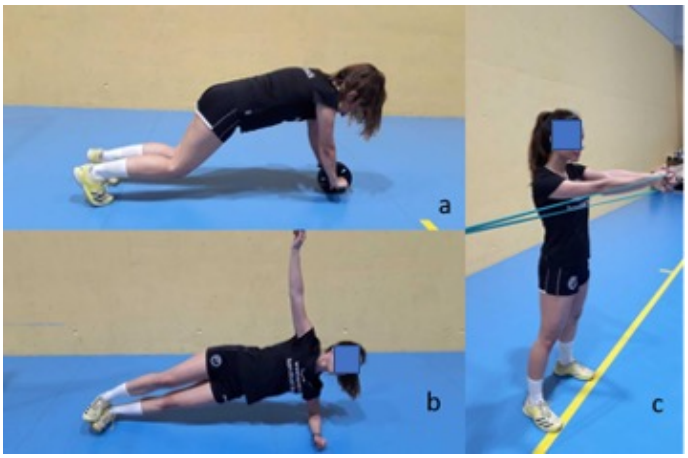

Figure 2. Some of the exercises performed in the core strength training

Statistical analysis

All data analysis was conducted using SPSS version 24 (SPSS Inc., Chicago, IL, USA). Descriptive data are presented as mean and standard deviation (SD). All the dependent variables were measured bilaterally when bilateral jumps were performed and unilaterally, when the jumps were performed on a single leg. The bilateral variables, (i.e. HJ, Ct, RSI and the FKPA) were analyzed using mixed MANOVA with the factors group (CG and CTG) and time (pre, post). Unilateral variables JH, Ct, RSI, and the FKPA were analyzed using another mixed MANOVA with the factors group (CG and CTG), time (pre, post) and laterality (right and left). Significant interactions were followed up with Bonferroni tests. Assumptions of statistical tests such as normal distribution and homoscedasticity of data were checked. The effect sizes for pairwise comparisons were calculated with 95% confidence interval for the difference. The differences between groups in age, height, weight and time of sport experience were checked with the Mann-Whitney U test (as the normality of the data was not assumed). 95% Confidence interval were obtained for the pairwise comparisons. Statistically significant difference was set at $p < 0.05$

Results

No significant baseline differences were found between groups in terms of age, body weight, body height, and years of practice.

There were no significant differences between groups at baseline in any of the variables recorded ($p > 0.05$). Further, there were no significant differences between hemi bodies ($p > 0.05$).

For the bilateral analysis, there was a significant interaction between Group x time for Jump height ($F[1,16]=9.98$, $p<0.05$, $\eta^2=0.38$. However, there were no significant interaction between the factors for RSI and Contact time ($p>0.05$).

For the unilateral, there was a significant interaction between Group x time for Jump height ($F[1,16]=5.07$, $p<0.05$, $\eta^2=0.24$) and FKPA ($F[1,16]=10.91$, $p<0.05$, $\eta^2=0.41$). However, there were no significant interaction between the factors for RSI, and Contact time ($p>0.05$).

Table 3 shows the descriptive results of the variables obtained for the bilateral jump in both CG and CTG. There was a statistically significant improvement in JH and RSI at post-training in the CTG.

Table 3. Descriptive results of the variables obtained for the bilateral jump in both CG and CTG.

		Pre Mean (SD)	Post Mean (SD)	95% CI of the mean difference
Jump Height (m)	CG	18.68 (3.22)	16.20 (5.73)	-0.89 to 5.85
	CTG	18.31 (3.87)	22.56 (3.66)*	-7.27 to -1.24
Contact time (s)	CG	255.75 (48.37)	232.00 (64.92)	-44.84 to 92.34
	CTG	277.80 (71.48)	253.10 (62.92)	-36.65 to 86.05
RSI (N)	CG	0.08 (0.02)	0.07 (0.03)	-0.02 to 0.03
	CTG	0.07 (0.03)	0.10 (0.04)*	-0.05 to -0.01

*: p<0.05 between groups; RSI: Reactive strength index; CG: Control group; CTG: Core training group; m: meters; N: newtons; s: seconds. Pre: Pre-intervention; Post: Post-intervention. CI: 95% confidence interval of the mean difference between pre and post-training.

Table 4 shows the descriptive results of the variables obtained for the unilateral dominant and non-dominant legs in both CG and CTG. The CTG showed a statistically significant improvement in JH and the FKPA for the NDL after the implementation of the core training program.

Discussion

The main contribution of this study shows the importance of applying a core muscle strength training to increase jump performance and knee stability during unilateral jumps in female handball players.

Our results showed an increased in JH and RSI at bilateral jump performance in the CTG, and an increased JH and a decrease in the FKPA at unilateral NDL jump performance. These results confirm our hypothesis, as we hypothesized that improving core strength would improve both bilateral and unilateral VDJ performance variables, and furthermore, would decrease FKPA angle during unilateral VDJ landing.

Our results are in line with other studies in which the authors showed a positive impact of core training on jumping performance in different sports as soccer[2,10,32] and basketball.[12] However, to the best of authors' knowledge, this is the first study analyzing the impact of a core training intervention on jump height. One of the reasons for the positive results found in this study could be related to the fact that increasing core strength increases the ability to control the position and motion of the trunk over the pelvis. As previously mentioned by other authors, an improvement of the neuromuscular function optimizes production, transfer and control of force and motion to the terminal segment in integrated athletic kinetic chain activities.[33] Another potential explanation is that almost all exercises imply hip extensor muscles, in isometric or dynamic contractions. This may be an effective stimulus to increase strength in these muscles, which may induce a positive transfer to jump performance.

Bilateral jumping is an important skill in handball, since actions such as throws over the defenders, pivots and wing player's throws or blocking long distance throws by defenders are very common during a handball game. Regarding bilateral jumping, our results are very similar to those reported by Dupeyron et al.,[34] who found a significant improvement of JH (16.9 %) and a decrease of contact time (– 6.5 %) during hopping after an 8-week hollowing transversus abdominis trunk exercise program in soccer players. According to them, the improvement was due by a 6.5% decrease in contact time and an increase of 8.8% in flight time. In our study, JH was not increased because a decrement of Ct since data did not show statistically significant differences. Maybe the lack of significance could be related to the small sample size (Type II error).

However, Ct is directly related to RSI, which is calculated based on contact time and jump height.[35] We obtained a statistically significant increase in RSI, and according to the literature, smaller angular displacements of the hip, knee and ankle joints are necessary to jump higher following a shorter landing duration.[36] Furthermore, RSI has been correlated to change of direction speed ($r = -0.645$, $P = 0.001$),[9] attacking agility ($r = 0.625$, $P = 0.004$) and defensive agility ($r = 0.731$, $P < 0.001$),[10] making the VDJ a useful performance test to help evaluate athletic tasks.[37,38] The previous mentioned motor actions showed an increase in RSI after applying a core training program in a group of adolescent male soccer players. It was concluded that the improvement of RSI might be attributable to increasing the joint stiffness of the trunk and hip during the VDJ by activating the co-contraction of trunk muscles. Therefore, although we did not measure leg stiffness, we can address that the core training program improved the athlete's ability to quickly switch from an eccentric to a concentric contraction, and to produce a higher force in a shorter time. This finding provides evidence that increasing hip muscle strength via core training should be considered when programming strength exercises to improve performance in handball players.

Apart from bilateral jumping, it was also important to analyze unilateral jumping, especially in the NDL since it is the responsible of the jump throws. The jump throw is the most frequently applied throwing technique in the game of team-handball. In fact, it has been found that 73 - 75% of all throws during the competitive handball games are jump throws.[21] It is important to highlight that handball players like basketball players[39] have as a NDL the leg that corresponds to the contralateral arm performing the throws to facilitate the technical execution of the jumping throw. In our study all participants were right hand and leg dominant. In this line, we obtained an improvement in JH only in the NDL. The NDL in handball players require to perform many jumps where the stretch-shortening cycle is specially addressed and more contact time is required, while the DL will be involved in shorter contact times looking for fast motor actions such as feints or changing direction displacements.[40] These differences in motor skills may explain the differences obtained after the core intervention in the CTG, which only improved the vertical jump on the NDL.

Bilateral jumping differences between DL and NDL have been previously addressed.[41] Most specific motor actions in handball require the NDL being the responsible of leading the throws, passes and the jumping and landing after a jump throw. Without specific instructions other than aiming for maximal vertical jumping height, drop jumps are performed in at least two different ways: (1) fast, that is, with a very short contact time and (2) slower, that is, with somewhat longer contact time on the ground.[42] Our players kept their regular handball training and, as

Table 4. Descriptive results of the variables obtained for the unilateral dominant and non-dominant legs in both CG and CTG.

		Dominant		95% CI of the mean	Non-dominant		95% CI of the mean
		Pre	Post	difference	Pre	Post	difference
Jump Height (m)	CG	9.7 (3.1)	9.1 (3.8)	-2.4 to 3.6	9.2 (3.1)	9.4 (3.0)	-1.9 to 1-5
	CTG	9.8 (2.8)	12.1 (2.5)	-4.9 to 0.4	9.9 (2.4)	12.4 (3.2)*	-4.1 to 0.9
Ct (s)	CG	321.3 (68.0)	248 (74.7)	-9.1 to 155.6	310.4 (38.7)	288.4 (53.9)	-48.7 to 92.74
	CTG	333.8 (92.7)	333.5 (52.8)	-73.3 to 73.9	302.4 (65.8)	316.3 (88.6)	-77-2 to 94.4
RSI (N)	CG	0.03 (0.01)	0.04 (0.02)	-0.1 to 0.1	0.03 (0.01)	0.04 (0.03)	-0.1 to 0.1
	CTG	0.04 (0.01)	0.04 (0.01)	-0.1 to 0.1	0.03 (0.01)	0.04 (0.01)	-0.1 to 0.1
FKPA (º)	CG	10.4 (2.0)	11.5 (6.7)	-6.2 to 3.9	9.2 (6.4)	9.3 (5.4)	-4.5 to 4.2
	CTG	13.4 (7.4)	10.8 (8.6)	-1.9 to 7.1	13.8 (7.4)	9.3 (6.1)*	0.6 to 8.4

*: p<0.05 between groups; Ct: Contact Time; FKPA: Frontal knee projection angle; H: Height; m: meters; sec: seconds; º: degrees; N: Newton's; RSI: Reactive strength index; CG: Control group; CTG: Core training group. Pre: Pre-intervention; Post: Post-intervention. CI: 95% confidence interval of the mean difference between groups in the post-treatment in each lower extremity

suggested by other authors[2,10,32] the combination of core stability/strength training and regular sports training may produce improvement on the vertical jump.

The improvement of the NDL on the JH occurs simultaneously with the lower extremity position at landing reception measured as FKPA only at unilateral jumps. Further, although we did not measure leg FKPA at bilateral jumps, it would have been interesting to compare how the core training program affects this variable.

In the present study, as it occurred with the implementation of a core stability training in high school female athletes,[43] the strengthening of this part of the body reduced FKPA during a VDJ. We obtained a reduction of the FKPA in the DL (mean difference of 4.5º). These reductions were greater than those reported by Brown et al.[44] probably because of two reasons. The first one is that they did not implement a specific gluteus medius strength exercise. As previously mentioned, gluteus medius exercises have been shown to improve knee valgus during dynamic activities and, therefore, reducing knee valgus during landings.[45] The second one would be related to the proper control of the core intervention training since according to their study limitations they may have stemmed from a lack of expertise of the assistant training staff. Therefore, similar to other study on abdominal-bracing maneuver performed during landing,[46] our study provides evidence to recommend the application of a program aimed at improving strength and control in the core area, as it influences vertical jump performance and facilitate motor control of knee movement to positions that increase the risk of injury at landing in female handball players.

One limitation of the study was the absence of measures like muscle activation during tests. Such analyses may provide further insight into the current benefits of core strength training and should be explored in future studies. It would be interesting also to investigate, what specific core training: muscle stability or muscle strength, affect more positively jump performance. Another limitation is that participants in our study were used to perform stability and strength exercises for the core which might have a bigger stimulus compared to people familiarized with this type of exercises, so it could be useful to explore the results of a core intervention in untrained individuals. Finally, core exercises have not been performed on a bipodal standing position (except the press pallof and the lateral side-walk with elastic band), therefore it should be interesting to implement specific core exercises which challenge the core in this specific position.

Despite widespread acceptance that core training impacts on sports performance, further research needs to be performed to examine the impact on jumping performance.

As we hypothesized the implementation of an in-season, 8-week core training program for female handball players resulted in improvements on bilateral and unilateral jump performance. In addition, it has also been shown to improve FKPA during unilateral VDJ in the NDL, which is the most common type of jump in handball.

Future strength training efforts in young women handball players should include specific core exercises, because not only positively contributes to improve jump performance but reduce FKPA, a key issue in lower limb injury prevention.

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Original

Nível de atividade física entre usuários de substâncias psicoativas

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RESUMO

Objetivo: Este estudo verificou o nível de atividade física entre usuários de substâncias psicoativas.
Método: Estudo transversal, realizado nos Centros de Atenção Psicossocial Álcool e Outras Drogas do município de Recife (Brasil). Participaram 160 indivíduos com idade 44.09±12.46 anos. Os participantes foram entrevistados por meio do questionário Global physical active questionnaire. Foi aplicado o teste Qui-quadrado de independência para verificar associação entre nível de atividade física e tipo de substância psicoativa utilizada, nível de instrução, raça/cor, sexo e tipo de moradia sendo aceito um $p<0.05$ como significativo.
Resultados: Os resultados mostraram que 51.9% dos usuários de substâncias psicoativas são fisicamente inativos. Houve associação nos domínios raça/cor da pele ($p=0.039$) e nível de instrução ($p=0.002$) com relação ao nível de atividade física.
Conclusão: A partir destes dados será possível estabelecer os grupos que necessitam de maior apoio para promover estímulo à prática de exercício físico.
Palavras Chaves: Transtornos Relacionados ao Uso de Substâncias, Atividade física, Atenção Saúde.

Nivel de actividad física de los consumidores de sustancias psicoactivas

RESUMEN

Objetivo: En este estudio se comprobó el nivel de actividad física de los consumidores de sustancias psicoactivas.
Método: Se realizó un estudio transversal en los Centros de Alcohol y Otras Drogas Psicoactivas de Recife (Brasil). Participaron 160 personas de 44.09±12.46 años. Se entrevistó a los participantes mediante el cuestionario del *Global physical active questionnaire*. La prueba de chi-cuadrado de independencia se aplicó para verificar la asociación entre el nivel de actividad física y el tipo de sustancia psicoactiva utilizada, el nivel de educación, la raza/color, el sexo y el tipo de vivienda siendo aceptado um valor de $p<0.05$ como significativo.
Resultados: Los resultados mostraron que el 51.9% de los consumidores de sustancias psicoactivas son físicamente inactivos. Hubo una asociación en los dominios raza/color de piel ($p=0.039$) y nivel de instrucción ($p=0.002$) con respecto al nivel de actividad física.
Conclusión: A partir de estos datos será posible establecer los grupos que necesitan más apoyo para promover la práctica del ejercicio físico.
Palabras Claves: Trastornos relacionados abuso sustancias, Actividad física, Salud Pública.

Level of physical activity among users of psychoactive substances

ABSTRACT

Objective: This study checked the level of physical activity among users of psychoactive substances.
Methods: A cross-sectional study was conducted at the Alcohol and Other Drugs Psychoactive Centers of Recife (Brazil). A total of 160 individuals aged 44.09±12.46 years participated. The participants were interviewed through the Global physical active questionnaire. The chi-square test of independence was applied to verify association between level of physical activity and type of psychoactive substance used, level of education, race/colour, sex and type of dwelling being accepted a $p<0.05$ as significant.
Results: The results showed that 51.9% of psychoactive substance users are physically inactive. There was an association in the domains race/skin colour ($p=0.039$) and level of instruction ($p=0.002$) regarding the level of physical activity.
Conclusion: From these data it will be possible to establish the groups that need more support to promote the practice of physical exercise.
Keywords: Substance-Related Disorders, Physical Activity, Health Care.

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Introdução

Hoje, é crescente o corpo de estudos referente a utilização da cannabis para tratamento de transtornos mentais[1]. Entretanto, grande parte de sua utilização é feita por indivíduos que buscam diversão e prazer[2]. Ao fazer uso com tais objetivos é comum evoluir para a utilização de forma abusiva das substâncias psicoativas (SPA), gerando diminuição da força muscular e da coordenação em nosso organismo[3].

Além do aspecto motor, a utilização abusiva de SPA podem comprometer de forma geral a qualidade de vida destes indivíduos, ocasionando pior saúde geral, emocional e mental do que a população em geral[4].

Para minimizar os efeitos decorrentes do uso de SPA, a prática de atividade física (AF) pode ser usada para reduzir os episódios de bebida, melhora da qualidade do sono, diminuição do desejo de consumir drogas, melhora dos níveis cognitivos e promover o aumento da interação social em usuarios de SPA, já que eles se veem segregados socialmente[5–8].

Atualmente, não existe diretriz que especifique como deve ser a prática de exercícios físicos para dependentes químicos, portanto é prudente seguir as recomendações do *American College of Sports Medicine* (ACSM), onde indivíduos adultos devem realizar 150min de treinamento aeróbico por semana[9]. Além disso, a prática em locais adequados podem servir como estímulos para a AF, para isso a cidade do Recife (Brasil) disponibiliza 42 polos para realização de AF de base comunitária (2019) e diversas ciclofaixas[10,11].

Mesmo assim, dados da Vigilância de fatores de risco e proteção para doenças crônicas por inquérito telefônico (Vigitel) mostraram que somente 37.3% da população na cidade do Recife foram classficadas como ativas físicamente[12]. Entretanto, esses dados podem variar em grupos específicos, pois o nível de atividade física (NAF) de pacientes pré-cirurgia bariátrica e professores da rede estadual de ensino classificados como ativos foi de 52.2% e de 53.7%, respectivamente[13,14]. Portanto, é possível que o NAF de usuários de SPA também apresente diferenças em relação a população do Recife e como não foram encontrados dados que pudessem estabelecer o NAF desse grupo, este estudo tem como objetivo verificar o NAF entre usuários de SPA.

Método

Estudo transversal aprovado no comitê de ética do Instituto de Medicina Integral Professor Fernando Figueira (IMIP) com parecer de nº 3.568.392 foi realizado em quatro Centros de Atenção Psicossocial tipo álcool e drogas (CAPS-AD) do município de Recife (Brasil). A coleta dos dados foi realizada entre os meses de outubro a dezembro de 2019. Os CAPS-AD são centros de tratamento para indivíduos dependentes químicos e são constituídos por equipes multiprofissionais que realizam atendimentos terapêuticos em grupo e/ou individual[15].

Foram entrevistados indivíduos que possuem transtorno decorrente ao uso abusivo de SPA registrado em prontuário por meio da Classificação Internacional de Doenças (CID-10). Para o cálculo do tamanho da amostra foi realizado censo (outubro/2019) do quantitativo de usuários admitidos nos CAPS-AD do município de Recife/PE. Foram obtidos 685 usuários, aceitando um nível de confiança de 85% e um erro de 5%, foi calculada uma amostra de 160 indivíduos. Posteriormente a aquisição deste dado, a seleção de usuários deu-se por meio de amostragem por cotas, respeitando a proporcionalidade entre usuários admitidos em cada serviço ao quantitativo estipulado.

A pesquisa teve como critérios de inclusão: indivíduos de ambos os sexos, ter idade acima de 18 anos e estar frequentando um CAPS-AD. Após explicitar os objetivos, riscos (constrangimento em responder qualquer pergunta) e benefícios deste estudo com assinatura do Termo de Consentimento Livre e Esclarecido, conforme resolução nº 466/2012, os indivíduos responderam um questionário sociodemográfico (droga utilizada, sexo, moradia, nível de instrução e raça/cor da pele) e o questionário *Global physical active questionnaire* (GPAQ)[16] que versa sobre o NAF por meio de três domínios diferentes (trabalho, deslocamento entre lugares e atividades recreativas) abordados em 15 perguntas que leva em consideração a frequência, duração e intensidade da AF.

As entrevistas foram individualizadas e realizadas pelo próprio pesquisador em sala reservada durante o horário de atendimento nos CAPS-AD e o participante poderia não responder e encerrar a qualquer momento a entrevista.

Para avaliar o tempo total gasto em AF durante a semana, a duração (minutos por dia) foi multiplicada pela frequência (número de dias praticados por semana), nas atividades vigorosas o valor ainda foi multiplicado por dois, e depois totalizadas.

O NAF foi classificado em três categorias: indivíduo fisicamente ativo sendo necessário realizar pelo menos 150mim de AF moderada semanal ou 75mim semanal quando de forma vigorosa, insuficiente ativo quando realizado acima de 10mim e inferior a 150min de AF e inativo para aqueles que não praticaram ao menos 10min de AF semanal[17].

O NAF foi utilizado como variável independente e as outras variáveis (moradia, sexo, nível de instrução, droga utilizada e raça/cor da pele) como variável dependente. Foi realizado estatística descritiva para caracterização da amostra e aplicado o teste Qui-quadrado de independência com correção de Yates e exato de Fisher quando necessário. Foi aceito um $p<0.05$ como significativo. Toda a análise foi realizada no programa estatístico *Statistical Package for the Social Sciences* (SPSS) versão 22.0.

Resultados

Foram entrevistados 160 sujeitos (44.09±12.46 anos). Sete indivíduos recusaram-se a participar do estudo por motivo de falta de interesse. Na Tabela 1, são apresentadas as características de base dos participantes. Na variável droga utilizada, cada indivíduo encontra-se em apenas uma categoria, os usuários que reportaram utilizar múltiplas drogas são aqueles que fazem uso de mais do que uma SPA.

Tabela 1. Características dos usuários de substâncias psicoativas frequentadores dos centros de atenção psicossocial- Recife, 2019.

Variável	Quantitativo (n)	Porcentagem (%)
Tipo de droga utilizada		
Álcool	72	45.0
Crack	21	13.1
Maconha	14	8.8
Cocaína	3	1.9
Cola	1	0.6
Cigarro	15	9.4
Múltiplas drogas	34	21.3
Total	160	100.0
Raça/cor da pele		
Branco	25	15.6
Preto	25	15.6
Pardo	97	60.6
Amarelo	4	2.5
Indígena	9	5.6
Total	160	100.0
Sexo		
Masculino	134	83.8
Feminino	26	16.3
Total	160	100.0
Nível de instrução		
Até quatro anos de estudo	41	25.6
Até oito anos de estudo	73	45.6
Até 11 anos de estudo	40	25.0
Acima de 12 anos de estudo	6	3.8
Total	160	100.0
Moradia		
Sozinho	35	21.9
Situação de Rua	10	6.3
Família	108	67.5
Outros	7	4.4
Total	160	100.0

Tabela 2. Valores de frequência absoluta e relativa do nível de atividade física entre usuários de substâncias psicoativas- Recife, 2019.

	Nível de atividade física				
	Inativo (% inativo grupo)	Insuficiente ativo (% insuficiente grupo)	Ativo (% ativos grupo)	Total	φ_c
Nível de instrução					
Até quatro anos de estudo	16 (39%)	23 (56%)*	2 (5%)	41	0.31
Até oito anos de estudo	42 (58%)	26 (36%)	5 (7%)	73	
Até 11 anos de estudo	24 (60%)	12 (30%)	4 (10%)	40	
Acima de 12 anos de estudo	1 (17%)	1 (17%)	4 (67%)*	6	
Raça/cor da pele					
Branco	14 (56%)	5 (20%)*	6 (24%)*	25	0.23
Preto	7 (28%)*	16 (64%)*	2 (8%)	25	
Pardo	53 (55%)	37 (38%)	7 (7%)	97	
Amarelo	3 (75%)	1 (25%)	0 (0%)	4	
Indígena	6 (67%)	3 (33%)	0 (0%)	9	
Tipo de droga					
Álcool	37 (51%)	30 (42%)	5 (7%)	72	0.12
Crack	12 (57%)	7 (33%)	2 (10%)	21	
Maconha	7 (50%)	5 (36%)	2 (14%)	14	
Cocaína	1 (33%)	1 (33%)	1 (33%)	3	
Cola	0 (0%)	1 (100%)	0 (0%)	1	
Cigarro	8 (53%)	5 (33%)	2 (13%)	15	
Múltiplas drogas	18 (53%)	13 (38%)	3 (9%)	34	
Sexo					
Masculino	69 (51%)	53 (40%)	12 (9%)	134	0.04
Feminino	14 (54%)	9 (35%)	3 (12%)	26	
Moradia					
Sozinho	17 (49%)	15 (43%)	3 (9%)	35	0.04
Situação de Rua	5 (50%)	4 (40%)	1 (10%)	10	
Família	58 (54%)	40 (37%)	10 (9%)	108	
Outros	3 (43%)	3 (43%)	1 (14%)	7	

*: associação por meio do teste qui-quadrado de independência, valores de resíduo ajustado acima de 1.96 ou inferior a -1.96. φc: V de cramer

A Tabela 2 apresenta o NAF dos indivíduos. Quando observado o NAF geral, 15 (9.4%) sujeitos foram considerados ativos, 62 (38.7%) insuficiente ativo e 83 (51.9%) inativo fisicamente. A análise estatística apontou que nos domínios nível de instrução [X2(6)= 19.15; p=0.002] e raça/cor da pele [X2(8)= 4.26; p=0.039] existe associação com o NAF, portanto a hipótese nula foi rejeitada.

Quando analisado a quantidade de indivíduos que reportaram algum tipo de gasto em AF nos domínios existentes para que estes fossem classificados como ativos, o domínio trabalho não foi referida por nenhum indivíduo (seja de forma vigorosa ou moderada). No domínio deslocamento entre lugares 26.6% dos indivíduos reportaram algum tipo de gasto em AF nesta categoria. Já no domínio atividades recreativas, 60% dos indivíduos reportaram gasto em AF na forma vigorosa e 53.3% referiram gasto em AF de maneira moderada.

Discussão

O presente estudo apresenta dados referente ao NAF de usuários de SPA. As características dos participantes deste estudo são similares às reportadas em outro trabalho com usuários de SPA quando observado a faixa etária e principal substância utilizada[18].

Os resultados do presente estudo mostraram que a maior parte dos participantes (90.4%) foram classificados como inativos e insuficiente ativos. Já é conhecido na literatura que existe uma relação negativa entre usuários de SPA e prática de AF entretanto, não era esperado um quantitativo tão grande de participantes que não atingiram o mínimo do NAF recomendado[19]. Alguns aspectos que podem explicar esse resultado são: dores, alterações neurológicas e a diminuição do contato com outras pessoas que o uso abusivo de SPA provoca[7,20].

Além disso, cor da pele (branca e preta) e nível de instrução foram associados ao NAF. As associações existentes entre raça/etnia e prática de atividade física ainda são inconclusivas, pois pessoas negras e baixa situação econômica, com a conseqüente dificuldade de aceso a áreas de lazer, estão associadas a um baixo NAF enquanto que pessoas brancas praticam mais atividades de treinamento muscular e ginástica, mesmo após a correção pela renda[19,21,22]. Além disso, a associação do alto nível de instrução é um dos determinantes para a prática de AF[23].

Em relação ao tipo de droga utilizada, a maior incidência de inativos recai sobre os usuários de crack, 57% foram classificados nesta categoria. O poder destrutivo desta substância, principalmente no sistema nervoso central, pode evidenciar a falta de AF nesta população[20]. Outro fator que pode contribuir para a inatividade física em usuários de SPA é a autoestima[24]. Foi observado que 77% possuem baixa autoestima e isso implica em não planejar metas e não possuir autoconfiança, acarretando em não efetuar ações esperadas dentro de um grupo social como praticar AF[24].

Nos domínios contemplados pelo questionário GPAQ a categoria trabalho não foi referida pelo grupo, o que é compreensível já que a maioria não possui emprego[18]. Esse fator também pode explicar a contribuição do deslocamento entre lugares para o NAF dos avaliados, pois é provável que alguns só consigam se deslocar a pé pela falta de renda. Atividade recreativa (vigorosa e moderada) foi o domínio com maior contribuição, alguns fatores podem apoiar esta categoria como o município dispor de vários pólos de AF de base comunitária e estes indivíduos possuírem maior tempo livre, principalmente por não trabalharem[10,18].

Com os resultados obtidos, sugere-se que os profissionais que trabalham nos CAPS-AD possam observar com mais cuidado e estimular mais a prática de AF daqueles que possuem menor nível de instrução, com menos opções de lazer e os que são usuários crack. Isso recai na prevenção para acometimento de doenças cardiovasculares, já que para esta população o risco é aumentado[20].

Estudos futuros são necessários para verificar se os resultados obtidos nesta pesquisa podem ser classificados como fatores determinantes para a prática de AF entre usuários de SPA. Além disto, outros estudos podem verificar se ocorrem modificações no NAF em decorrência do uso das SPA. Este estudo, possui determinada limitação pois não verificou o volume de substância utilizada por cada indivíduo, entretanto isso não influenciou nos resultados reportados.

Por fim, o estudo identificou que a maior parte dos indivíduos que fazem uso de SPA são inativos fisicamente e para aqueles que são classificados como ativos, o nível de instrução (acima de doze anos de estudo) é um fator associado a realização de AF.

Autoria. Todos os autores contribuíram intelectualmente no desenvolvimento do trabalho, assumiram a responsabilidade do conteúdo e, da mesma forma, concordam com a versão final do artigo. **Financiamento.** Este estudo não obteve financiamento para publicação. **Conflito de interesses.** Os autores declaram não haver conflito de interesses. **Origem e revisão.** Não foi encomendada, a revisão foi externa e por pares. **Responsabilidades Éticas.** *Proteção de pessoas e animais:* Os autores declaram que os procedimentos seguidos estão de acordo com os padrões éticos da Associação Médica Mundial e da Declaração de Helsinque. *Confidencialidade:* Os autores declaram que seguiram os protocolos estabelecidos por seus respectivos centros para acessar os dados das histórias clínicas, a fim de realizar este tipo de publicação e realizar uma investigação / divulgação para a comunidade. *Privacidade:* Os autores declaram que nenhum dado que identifique o paciente aparece neste artigo.

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Revisión

Autoeficacia para el desempeño de actividad física en personas mayores

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RESUMEN

La autoeficacia, concebida como la creencia en poder realizar una tarea a pesar de las dificultades, es uno de los más consistentes predictores de iniciación y mantenimiento de la actividad física en las personas de todas las edades, pero más aún, en edad avanzada. Por lo tanto, esta revisión describe primero la autoeficacia y su distinción de construcciones similares e incorpora la autoeficacia dentro de la teoría sociocognitiva donde se describió por primera vez. Luego, se describen los principales abordajes de diferentes disciplinas para promover la autoeficacia, y, en consecuencia, la actividad física; poniendo foco en la evidencia disponible en el área de ciencias de la salud sobre cómo impulsar las fuentes de esta importante autoconfianza en las personas mayores.
Palabras clave: Autoeficacia, Actividad física, Anciano, Persona mayor.

Self-efficacy for the performance of physical activity in the elderly

ABSTRACT

Self-efficacy, conceived as the belief in being able to perform a task despite the difficulties, is one of the most consistent predictors of initiation and maintenance of physical activity in people of all ages, but even more, in the elderly. Therefore, this review first describes self-efficacy and its distinction from similar constructions and incorporates self-efficacy into the socio-cognitive theory where it was first described. Then, the main approaches of different disciplines to promote self-efficacy are described, and consequently, physical activity; focusing on the evidence available in the area of health sciences of how to boost the sources of this important self-confidence in the elderly.
Keywords: Self-efficacy, Physical activity, Aged, Elderly.

Autoeficácia para a realização de atividade física em idosos

RESUMO

A autoeficácia, concebida como a crença em ser capaz de realizar uma tarefa apesar das dificuldades, é um dos preditores mais consistentes de iniciação e manutenção da atividade física em pessoas de todas as idades, mas ainda mais nos idosos. Portanto, esta revisão descreve primeiro a autoeficácia e sua distinção de construções semelhantes e incorpora a autoeficácia na teoria sócio-cognitiva em que foi descrita pela primeira vez. Em seguida, são descritas as principais abordagens de diferentes disciplinas para promover a autoeficácia e, conseqüentemente, a atividade física; enfocando as evidências disponíveis na área das ciências da saúde sobre como aumentar as fontes dessa importante autoconfiança nas pessoas idosas.
Palavras-chave: Autoeficácia, Atividade física, Idoso, Pessoa Maior.

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Introducción

La autoeficacia es un concepto que se ha estudiado ampliamente en diferentes disciplinas para explicar los comportamientos a lo largo de la vida[1]. En el contexto de atención en salud, se ha relacionado con diversas variables como el cáncer, las enfermedades crónicas, la competencia cultural, la actividad física y la pérdida de peso[2].

Varios modelos de salud identifican la autoeficacia como una variable en la investigación dirigida a mejorar los resultados de salud[3]. Más específicamente, la autoeficacia se cita con frecuencia en la literatura sobre el comportamiento de la salud en intervenciones destinadas a maumentar la actividad física de las personas[4], donde la población de personas mayores ha sido ampliamente estudiada[5].

La percepción de autoeficacia refleja la creencia en la capacidad de realizar con éxito una actividad/comportamiento[6]. Esta percepción puede influir en las actividades realizadas, el tiempo invertido y la persistencia en mantenerlo, especialmente cuando el individuo enfrenta barreras a este comportamiento[7]. La autoeficacia es una construcción clave de la teoría sociocognitiva y está asociada con comportamientos positivos relacionados con la salud, incluida la actividad física[8]. En los ancianos, existe un papel importante de autoeficacia para la adopción de actividad física[7,8]. El aumento de la autoeficacia, especialmente en las personas mayores, puede representar una estrategia importante para promover la actividad física[7-9].

Este documento se basa en la comprensión actual de la autoeficacia en el contexto de la actividad física para personas mayores. A través de una revisión de la literatura teórica y empírica, este artículo tiene como objetivo describir el concepto de autoeficacia y destacar su importancia en el ámbito del desempeño de la actividad física en personas mayores.

Método

Se revisó la bibliografía disponible en las bases de datos MEDLINE/PubMed y Web of Science (Tabla 1), con disponibilidad de textos completos (Open Access). La selección de trabajos se realizó en base a una estrategia de búsqueda mediante los términos MeSH: “aged” y “physical activity”, en combinación con los términos libres: “elderly” y “self-efficacy”. El total de artículos que respondieron a la búsqueda con fecha 20 de mayo de 2020 fue de 208. La búsqueda se acotó a un período de publicación entre los años 2010 y 2020. Se aplicó como criterio de inclusión ser artículos publicados sólo en idioma inglés, ser estudios originales observacionales, revisiones sistemáticas con o sin meta-análisis y tener acceso al texto completo. Se incluyeron los artículos que abordaran los conceptos de autoeficacia, autoeficacia para la actividad física y autoeficacia para la actividad física restringida sólo a la población de personas mayores. Como se observa en la figura, finalmente se seleccionarion 31 artículos. Como se observa en la Figura 1, se realizó un primer filtro por duplicados, un segundo filtro por lectura de 208 títulos, un tercer filtro por lectura de 107 resúmenes y finalmente se obtuvieron 31 artículos para lectura completa. Todos los trabajos fueron leídos por tres investigadores.

Bases de Datos	Comandos de Búsqueda
MEDLINE/PubMed	(“self-efficacy”) AND (“aged”[MESH] OR “elderly”) AND (“physical activity”[MESH])
Web of Science	#1: TS=self-efficacy #2: TS=aged #3: TS=elderly #4: TS=physical activity #1 AND #2 OR #3 AND #4

Tabla 1. Comandos de búsqueda en bases de datos.

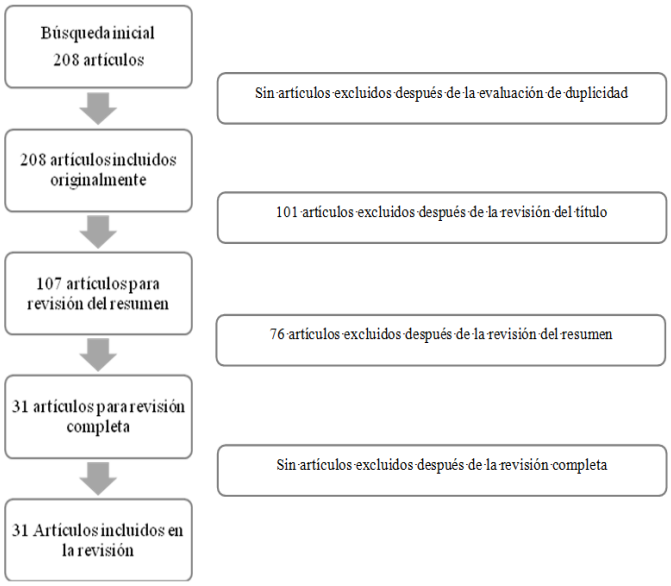

Figura 1. Flujograma de extracción de artículos

Antecedentes

Conducta humana

La conducta humana se define como las acciones que las personas toman, en función de la percepción de la situación, las intenciones de las acciones y las consideraciones antes de que se lleven a cabo[10]. A su vez, ésta se encuentra condicionada por el pensamiento y reguladas por dos tipos específicos de expectativas[8,11-15]:

a) Expectativas de eficacia: Se relacionan con la seguridad de poder llevar adelante un determinado comportamiento con éxito y generar así el resultado deseado.

b) Expectativas de resultado: Hacen referencia a la creencia de que la puesta en marcha de determinadas conductas conducirá a los resultados deseados.

Autoeficacia

El concepto de autoeficacia fue introducido por Bandura como eje central de la Teoría Sociocognitiva, la cual postulaba que los diversos procedimientos psicológicos tienen relación directa con la creación y con el fortalecimiento de las expectativas[8,15]. Esta teoría enfatiza el rol de los fenómenos autorreferenciales, como el medio por el cual el ser humano es capaz de actuar en su entorno y posibilitar así su transformación. Así, los individuos desarrollan autopercepciones acerca de su propia capacidad las cuales funcionan como mediadoras para el logro de metas y la toma de decisiones[6,16].

Fuentes de autoeficacia

La teoría social-cognitiva propone cuatro principales fuentes para el desarrollo de creencias de autoeficacia[17].

1) La experiencia de dominio: Describe las experiencias de éxito en el cumplimiento de una tarea en el pasado y, por lo tanto, constituye un indicador auténtico de la capacidad de realizar tareas similares en el futuro. La experiencia de dominio es, por lo tanto, considerada la fuente más importante de creencias de autoeficacia[6]; y se ha descrito como una forma efectiva de aumentar las creencias de autoeficacia para la actividad física en protocolos de intervención[18].

2) La experiencia indirecta: Describe el acto de observar a otras personas que realizan con éxito una tarea difícil. Esta observación aumenta las creencias individuales de autoeficacia a través de

procesos de modelado social[19]. Investigaciones previas han revelado que las personas mayores consideran la ausencia de experiencia indirecta (o modelos a seguir) como barreras para la actividad física regular[19]. Estudios experimentales han encontrado que la autoeficacia para la actividad física puede mejorarse mediante la experiencia indirecta[18].

3) La persuasión verbal: Representa el tratar de convencer a alguien de sus habilidades para realizar una tarea con éxito. Este proceso puede ser una fuente de autoeficacia, pero se supone que sus efectos son mucho menos sustanciales que los de la experiencia de dominio o la experiencia indirecta. Estudios sugieren que los intentos de persuadir a otros de sus habilidades podrían incluso interpretarse como control o presión, y que, en consecuencia, se ha encontrado que la persuasión verbal no está relacionada o incluso se encuentra negativamente asociada con la actividad física y la autoeficacia, o solo es efectiva si se combina con la experiencia de dominio[18,20,21].

4) Los estados fisiológicos y afectivos: Se consideran una fuente principal de autoeficacia[6]. Se basan en procesos de evaluación; por ejemplo, si un efecto negativo como la agitación inmediatamente antes de una tarea difícil se interpreta como falta de preparación o vulnerabilidad, la autoeficacia y el rendimiento podrían verse afectados[22]. Según Bandura[6,11-15], esto va más allá de la mera excitación fisiológica, y las personas consideran su estado fisiológico general, como sentirse agotados, enfermos o heridos cuando consideran su confianza para poder realizar una tarea[13,23]. El afecto positivo puede influir en la autoeficacia si se interpreta como un signo de preparación y confianza en las capacidades propias. Se cree que el afecto positivo previo a una tarea activa los recuerdos de éxitos anteriores y, por lo tanto, fomenta las creencias de autoeficacia[13].

Autoeficacia y ámbitos de salud

Se ha descrito la autoeficacia como determinante respecto a la efectividad de los tratamientos y el afrontamiento de algunas condiciones clínicas crónicas, pero también como un elemento importante de promoción y prevención[24]. De forma que, aquellos que presentan una alta percepción de autoeficacia tienen más probabilidad de realizar cuidados preventivos, presentar mejor estado de salud, una recuperación más rápida, y además, se distinguen por realizar una búsqueda más rápida y anticipada de tratamientos, afrontando la patología con mayor optimismo[17].

Autoeficacia en el desempeño de la actividad física

Diversos estudios muestran que las percepciones de autoeficacia juegan un papel significativo en la conducta para hacer actividad física, donde aquellas personas con mayores niveles de autoeficacia muestran frecuentemente un mayor compromiso y adherencia a un programa regular de actividad física que aquellas con niveles más bajos de autoeficacia, lo cual es consecutivamente un fuerte predictor del mantenimiento de actividad física durante al menos seis meses siguientes al inicio del programa[25]. Simultáneamente, se ha establecido que los valores de conocimiento y autoeficacia se correlacionaron positivamente con la conducta de hacer actividad física, pero los valores previos de la autoeficacia se correlacionaron negativamente con cambios en la conducta de ejecutar algun tipo de actividad física, es decir, la adopción inicial y participación voluntaria[26]. En este sentido, la mayor evidencia se concentra en la práctica de yoga, donde se ha observado que su realización regular conduce a la experiencia de un cuerpo sano y entrenado, mejoran el compromiso y la autoeficacia[27]. La autoeficacia está influenciada por estados fisiológicos adversos y emocionales inestables, como dolor muscular, fatiga, estado de ánimo, estrés y miedos como el miedo al movimiento.

Autoeficacia en el desempeño de la actividad física en personas mayores

A lo largo de la vida, son múltiples las barreras que se declaran para permanecer físicamente activo, como el cansancio, tener una lesión anatómica o una alteración funcional, carecer de vitalidad o padecer dolor, y el proceso de envejecimiento puede sumarse a estas. Por lo que mantener un estilo de vida físicamente activo se convierte en una tarea difícil para muchas personas. Otro caso, es que las personas también difieren mucho en cuanto a la limitación que perciben de las mismas barreras. Por ejemplo, una persona puede no disfrutar de la posibilidad de caminar por sí misma, mientras que otra persona puede disfrutar la oportunidad de un tiempo solo. Como consecuencia, hay personas mayores con diversas limitaciones funcionales que aún realizan actividad física regularmente, mientras que otros permanecen sedentarios a pesar de que no experimentan limitaciones funcionales. Muchas de estas discrepancias pueden explicarse por diferentes niveles de autoeficacia percibida para la actividad física[28].

La teoría sociocognitiva trata de explicar este fenómeno de tener un funcionamiento físico suficiente por un lado, y sin embargo, abstenerse de ser físicamente activo por otro, postulando que los individuos necesitan sentirse capaces para estar físicamente activos[6]. Las habilidades percibidas subjetivamente de los individuos y sus creencias de autoeficacia, en lugar de sus capacidades objetivas, son importantes para iniciar y mantener la actividad[29].

Las personas con altos niveles de autoeficacia tienden a sentirse más capaces, elegir objetivos más ambiciosos e invertir más esfuerzo para alcanzar esos objetivos. Con respecto a la actividad física, ser autoeficaz significa, por ejemplo, que la persona se siente capaz de caminar regularmente durante 30 minutos diarios, incluso cuando hay condiciones climáticas subóptimas. Si bien se supera en repetidas ocasiones la duda inicial de dar un paseo en clima frío y lluvioso, una persona no dudaría en realizar actividad física en estas circunstancias y percibir mayores capacidades para actividades futuras, precisamente porque superaron las barreras anteriores. Los niveles iniciales de autoeficacia aumentan la probabilidad de un desempeño exitoso[30,31].

La autoeficacia es un predictor confiable de muchos comportamientos relacionados con la salud, como una alimentación saludable, detección y consumo de alcohol, y también se ha demostrado que predice de manera confiable los cambios en muchos comportamientos relacionados con la salud[31,32]. En línea con esto, la autoeficacia es el constructo de cognición social que se asocia más consistentemente con la actividad física en adultos[33]. En general, hay buenas razones para creer que la autoeficacia tiene un papel causal en el cambio del comportamiento de la actividad física, especialmente en adultos de 60 años y mayores[34,35].

A pesar del gran número de estudios que respaldan el efecto de la autoeficacia en la actividad física, sorprendentemente hay poca investigación sobre los orígenes de las creencias de autoeficacia en el dominio del comportamiento de la salud. Esta falta de evidencia firme puede explicar por qué muchas intervenciones no promueven el cambio de comportamiento. Dado esto, las suposiciones teóricas de Bandura sobre las fuentes en las cuales los humanos construyen sus creencias de autoeficacia siguen siendo, sólidas bases teóricas y frecuentemente citadas. Sólo hasta hace poco, se han establecido métodos empíricos para detectar las fuentes más confiables de autoeficacia para la actividad física, que se basan en el uso de taxonomías de técnicas de cambio de comportamiento que pueden considerarse los "ingredientes activos" en las intervenciones de cambio de comportamiento[29,34]. El desarrollo de tales taxonomías ha permitido el uso de análisis moderadores en metanálisis, para investigar qué técnicas de cambio de comportamiento están asociadas con cambios más

grandes en la autoeficacia para la actividad física en estudios de intervención anteriores, incluidos los estudios en adultos mayores[33-35].

Según Bandura, la experiencia de dominio es "la fuente más efectiva de información de eficacia porque proporcionan la evidencia más auténtica de si uno puede dominar lo que sea necesario para tener éxito"[6]. Las creencias y las acciones de los individuos pueden reforzarse mutuamente, sugiere una espiral ascendente entre las experiencias de dominio y la autoeficacia[36]. Por lo tanto, para desencadenar dominio y autoeficacia, es necesario que en algún momento de su vida la persona haya tenido experiencias personales relacionadas con la actividad física.

Con el fin de impulsar esta experiencia de dominio en intervenciones para promover la actividad física en personas mayores, se han aplicado diferentes técnicas de cambio de comportamiento, por ejemplo, en el ensayo McAuley et al.[8], las personas mayores que asistieron a un programa de actividad física permitiéndoles recordar o volver a contar las experiencias positivas de actividad que hicieron, finalizaron frecuentemente el programa con creencias de autoeficacia más altas.

Por otro lado, para muchas personas mayores las experiencias de dominio pueden haber ocurrido por última vez hace un tiempo considerable, y en este sentido, una técnica sugerida por Bandura, para construir experiencias de dominio, es dividir los objetivos en pasos más pequeños que pueden lograrse más fácilmente[6]. Para una mejora de las creencias de autoeficacia para la actividad física en personas mayores, la técnica de establecer tareas graduadas parece ser un enfoque prometedor, ya que un metanálisis encontró que las intervenciones serían más efectivas si incluían esta técnica como comportamiento de cambio[34].

Como la mayoría de las personas tienden a interpretar los errores como un signo de incapacidad, se corre el riesgo de perder todo esfuerzo y experimentar una recaída total. Por lo que es importante que las intervenciones puedan preparar a las personas mayores para contratiempos y fallas temporales para ayudar a evitar el llamado “efecto de violación de la abstinencia”[37]. Cuando aprenden a atribuir fallas a causas externas, como el final de un día estresante o una situación muy tentadora, la autoeficacia se puede mantener y entrenar para futuras situaciones de riesgo.

Bandura también identifica las imágenes mentales y la persuasión verbal como otros posibles orígenes de las creencias de autoeficacia[6]. Entre las personas sedentarias, imaginar los resultados de la actividad física (imágenes de aproximación) y los pasos que deben cumplirse para alcanzar sus objetivos relacionados con la actividad física (imágenes de proceso), también podría ser una forma de establecer un sentido de dominio y mejorar autoeficacia[38]. Sobre la persuasión verbal, se ha demostrado que es más efectiva cuando se deriva de fuentes confiables como los profesionales de la salud[39]. Sin embargo, si alguien ya posee una fuerte creencia en no poder lograr el éxito, tal vez incluso subrayado por experiencias negativas con actividad física en el pasado, es más probable que la persuasión verbal resulte en una autoeficacia más baja que en una más alta; por lo tanto, esta fuente de autoeficacia debe abordarse con cuidado y experiencia para evitar la reactancia[6,40].

La experiencia indirecta, como ver a otros tener éxito en una tarea o disfrutar de un comportamiento es otro factor importante. La experiencia indirecta activa las creencias de poder lograr resultados similares con comportamientos similares, especialmente entre aquellos que tienen bajas creencias de sus propias capacidades[6]. La investigación cualitativa señala el hecho de que las personas mayores consideran que la ausencia de modelos a seguir es una barrera para la actividad física regular[19]. Si bien se supone que los modelos de afrontamiento de divulgación sobre las mismas dificultades que tuvieron que enfrentar otras personas con características similares como edad, género o nivel de experiencia son particularmente efectivos[6], la investigación sobre la efectividad de estos modelos es escasa en el área de actividad física entre las personas mayores y, por lo tanto, no está claro cuáles son las dimensiones sobresalientes por las cuales las personas mayores juzgan la similitud. El modelado no debe confundirse con una mera retroalimentación normativa, ya que se encontró que proporcionar información normativa sobre el comportamiento de los demás disminuye la efectividad de las intervenciones para promover la autoeficacia para la actividad física entre personas mayores de 60 años[34].

Conclusiones

La autoeficacia es claramente una parte fundamental del trabajo cognitivo en el inicio y en el mantenimiento de la actividad física regular en todos los grupos etarios, pero particularmente en las personas mayores, ya que enfrentan más barreras que los más jóvenes. Conocer los fundamentos de la autoeficacia puede ayudar a eliminar y superar algunas de estas barreras al momento de promover la actividad física en las personas mayores.

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