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EFEITOS DA RECUPERAÇÃO COM O ROLO DE ESPUMA SOBRE A DOR E A FUNCIONALIDADE APÓS SESSÃO DE EXERCÍCIOS RESISTIDOS: ENSAIO CLÍNICO RANDOMIZADO

Santa Maria, RS
2022

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Defesa de Dissertação apresentada ao Curso de Pós-Graduação em Ciências do Movimento e da Reabilitação, da Universidade Federal de Sana Maria (UFSM, RS), como requisito para obtenção do título de **Mestre em Ciências do Movimento e da Reabilitação.**

Orientador: Prof. Dr. Luis Ulisses Signori

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RESUMO

EFEITOS DA RECUPERAÇÃO COM O ROLO DE ESPUMA SOBRE A DOR E A FUNCIONALIDADE APÓS SESSÃO DE EXERCÍCIOS RESISTIDOS: ENSAIO CLÍNICO RANDOMIZADO

AUTOR: Bruno Cesar Correa Arbiza
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Exercícios físicos realizados em alta intensidade produzem uma reposta inflamatória, que clinicamente se caracteriza pela dor muscular de início tardio (DMIT) e pela diminuição da funcionalidade. Diversas formas de recuperação veem sendo estudadas nesta situação, as quais visam melhorar a performance de atletas e favorecer a adaptação a iniciantes de programas de exercícios. Dentre estas, a recuperação através da automassagem com auxílio do rolo de espuma (*foam roll* - RFR) vem sendo empregada recentemente nesta condição, mas não existem evidências que suportam a sua utilização. O objetivo do presente estudo foi comparar os efeitos das recuperações passiva (RP), ativa (RA) e RFR sobre a DMIT e em variáveis de aptidão física de voluntários saudáveis, após uma sessão de exercícios resistidos (ER). A presente pesquisa se caracteriza como um ensaio clínico randomizado, uni cego, cruzado, que incluiu 37 homens fisicamente ativos (22 ± 3 anos, 24,4 ± 2,3 kg/m^2). A sessão de ER (agachamento, *leg press* e cadeira extensora) compreendeu 4 séries de 10 repetições com 80% de 10 Repetições Máximas (teste de 10RM) realizadas num intervalo de 7 dias entre as sessões. As variáveis de aptidão física (força, potência, agilidade, amplitude de movimento, flexibilidade, velocidade e resistência à fadiga) foram avaliadas 1h após as sessões de ER. A DMIT foi avaliada 24h, 48h e 72h após sessão de ER. O projeto foi aprovado pelo Comitê de Ética e Pesquisa da UFSM sob o protocolo 2.538.028. Os resultados demonstram que na RP, o percentual de força dos membros inferiores (dominante e não dominante) foram 4,4% (IC95%: -1,4 à -7,4) menores que na RA e 5,3% (IC95%: -2,7 à -8,3) que na RFR. A agilidade melhorou 3,6% (DEM: 0,5; IC95%: 0,2 à 1s) na RA e 4,3% (DE: 0,6; 0,2 à 1,1s) na RFR, que na RP. Apenas a RFR reduziu (p<0,001) a DMIT (24h: 22,8%; 48h: 39,2%; 72h: 59,7%) em relação à RP. A RA e a RFR não apresentaram diferenças nas variáveis analisadas. As três formas de recuperações apresentaram resultados semelhantes nas demais variáveis. A RFR reduziu a DMIT, melhorou a agilidade e a força muscular podendo ser uma técnica a ser empregada na recuperação após ER. Entretanto, esta forma de recuperação apresenta resultados semelhantes à recuperação ativa nas variáveis funcionais analisadas.

Descritores: Recuperação de Função Fisiológica; Desempenho Atlético; Mialgia; Fadiga Muscular; Medicina Esportiva.

ABSTRACT

EFFECTS OF FOAM ROLL *RECOVERY* ON PAIN AND FUNCTIONALITY AFTER RESISTED WORKOUTS: RANDOMIZED CLINICAL TRIAL

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ADVISOR: Luis Ulisses Signori

Physical exercises performed in high physical activity an inflammatory response, which is clinically characterized by delayed onset muscle soreness (DMIT) and by the decrease in functionality. Several forms of recovery are applied in this situation, such as which aim to improve the performance of athletes and favor adaptation to beginners of exercise programs. Among these, recently recovery through self-massage with the aid of a foam roller (foam roller - RFR) has been used in this condition, but there is no evidence to support its use. The aim of the present study was to compare the effects of passive (RP), active (RA) and RFR recoveries on DMIT and and in physical fitness variables of healthy individuals, after a resistance exercise (RE) session. The present research stands out as a randomized, single-blind, crossover clinical trial, which included 37 physically active men (22 ± 3 years, 24.4 ± 2.3 kg/m^2). RE session (squat, leg press and extension chair) comprised 4 sets of 10 repetitions with 80% of 10 Maximum Repetitions (10RM test), with an interval of seven days between terminations. Variables of physical fitness (strength, power, agility, range of motion, flexibility, speed and resistance to fatigue) were evaluated 1h afterwards as a complement to RE. DMIT was assessed 24h, 48h and 72h after the RE session. The project was approved by the UFSM Ethics and Research Committee under protocol 2.538.028. The results show that in the PR, the percentage of strength of the lower limbs (dominant and non-dominant) was 4.4% (95% CI: -1.4 to -7.4) lower than the RA and 5.3% (95% CI %: - 2.7 to -8.3) than in the RFR. Agility improved 3.6% (DEM: 0.5; 95% CI: 0.2 to 1s) in RA and 4.3% (DEM: 0.6; 95% CI: 0.2 to 1.1s) non-RFR, which in RP. Only the RFR reduced (p<0.001) the DMIT (24h: 22.8%; 48h: 39.2%; 72h: 59.7%) in relation to the PR. RA and RFR are not independent in the analyzed variables. The three forms of recoveries have similar results in the other variables. RFR reduced DMIT, improved muscle agility and strength and can be a technique to be used in recovery after RE. However, this form of recovery results parallel to the active recovery in the defined variables analyzed.

Keywords: *Recovery* of Function; Athletic Performance; Myalgia; Muscle Fatigue; Sport Medicine

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DMIE	Dano Muscular Induzido pelo Exercício
DMIT	Dor Muscular de Inicio Tardio
ER	Exercício resistido
FR	Foam Roll
RA	Recuperação Ativa
RFR	Recuperação com Foam Roll
RP	Recuperação Passiva

SUMÁRIO

1. INTRODUÇÃO

A prática regular de exercícios físicos é amplamente recomendada pelos inúmeros benefícios a saúde. Nos EUA, as Diretrizes de Atividade Física recomendam a realização de exercícios de fortalecimento dois ou mais dias da semana (PIERCY et al., 2018). Os exercícios resistidos (ER) são um método de fortalecimento muscular, que por meio de carga externa, aumentam o esforço musculoesquelético e, se realizados com o controle da frequência, da intensidade e do volume, promovem respostas adaptativas benéficas ao organismo (SUZUKI et al., 2020). Estímulos adequados às estruturas musculoesqueléticas, circulatória e neural, melhoram a tolerância à carga de trabalho e aumentam o desempenho funcional (HIRONO et al., 2020). Além disso, o treinamento com resistência está associado à redução do risco de doenças relacionadas as doenças cardiovasculares, ao câncer e ao Diabetes tipo 2 (MATHUR; PEDERSEN, 2008). Por outro lado, quando realizados em alta intensidade geram um dano muscular induzido pelo exercício (DMIE) , que de forma aguda (imediatamente), é caracterizado pelo surgimento da dor muscular de início tardio (DMIT) e pela diminuição do desempenho funcional de diversas capacidades físicas (ARBIZA et al., 2020; DRINKWATER et al., 2019; KARGARFARD et al., 2016; MIKA et al., 2007, 2016; PEARCEY et al., 2015).

A sobrecarga e a progressão são os princípios básicos do treinamento esportivo (HIRONO et al., 2020). Programas de treinamento físicos frequentemente resultam nas sensações de fadiga e dor, e estão associados ao estresse mecânico e metabólico, os quais contribuem para o dano muscular induzido pelo exercício (DMIE) (FULFORD et al., 2015; MARKUS et al., 2021; PEAKE, 2019; SUZUKI et al., 2020). Estes sintomas em indivíduos destreinados podem levar a desistência e ao abandono das atividades físicas (HOWATSON; VAN SOMEREN, 2008). Entretanto, estas alterações são fisiológicas e possuem um papel crucial a médio e a longo prazo, pois aumentam os antioxidantes endógenos e levam a uma melhora de toda a capacidade do sistema musculoesquelético (KAWAMURA; MURAOKA, 2018) resultando em adaptações e a remodelação muscular (COFFEY, 2006; FULFORD et al., 2015; MARKUS et al., 2021; PEAKE, 2019; SUZUKI et al., 2020).

O dano muscular induzido pelo exercício (DMIE) é dependente do estímulo físico e pode ser separado em duas fases (MARKUS et al., 2021). A fase aguda inicia com o estresse mecânico e ou metabólico provocado por uma sessão intensa de exercícios (MISSAU et al., 2018; SUZUKI et al., 2020), enquanto que a fase subaguda ocorre no pós-exercício e envolve uma resposta inflamatória (FERREIRA et al., 2020). A fase aguda é uma resposta fisiológica protetora, que inicia com uma série de cascatas inflamatórias localizadas, que são dependentes da intensidade e da duração dos exercícios (SUZUKI et al., 2020). O DMIE ocorre principalmente na fase excêntrica dos ER (DABBS; CHANDER, 2018; OWENS et al., 2019; SUZUKI, 2019). Este se caracteriza pelos aumentos plasmáticos do lactato, dos marcadores inflamatórios (TNF-α, IL-1β e IL-6) (SUZUKI et al., 2020) a da presença das proteínas de dano muscular (Proteína C Reativa e Creatina Quinase) (BRITO et al., 2020; MISSAU et al., 2018; TEIXEIRA et al., 2014a, 2014b) e alterações eletrolíticas (FERREIRA et al., 2020). A segunda fase (subaguda) é caracterizada pelos aumentos adicionais dos mediadores pró-inflamatórios (TNF-α, IL-1β e IL-6), os quais são estimulados pelos macrófagos ativados (SUZUKI et al., 2020). Nesta fase, ainda ocorre à diminuição temporária da capacidade funcional e a DMIT (BRENTANO et al., 2017; KARGARFARD et al., 2016; MARKUS et al., 2021; SCHOENFELD, 2012).

Pesquisas que utilizaram um protocolo de ER para membros inferiores (Agachamento, Cadeira Extensora, *Leg Press*) utilizados na presente pesquisa, registraram o surgimento de DMIT em 24h e por até 72h após o término dos exercícios (ARBIZA et al., 2020; BRITO et al., 2020; MISSAU et al., 2018; TEIXEIRA et al., 2014a, 2014b). Salienta-se, que diferentes protocolos de ER também registram este fenômeno (HIRONO et al., 2020; MIKA et al., 2007, 2016). A presença de DMIT advinda do DMIE, apresenta seu pico entre 24 e 48h (ARBIZA et al., 2020), podendo perdurar por 4 a 5 dias após a sessão de exercícios (KANG; KIM; LEE, 2018), apresentado maiores efeitos em indivíduos sedentários ou destreinados (CHEUNG; HUME; MAXWELF, 2003; PAULSEN et al., 2012).

A queda do desempenho de diferentes variáveis funcionais também são evidencias do DMIE, dentre estas, a capacidade de gerar força (DABBS; CHANDER, 2018; KANG; KIM; LEE, 2018), a amplitude de movimento articular, a velocidade linear (PEARCEY et al., 2015), a agilidade (KARGARFARD *et al*., 2016) e a potência muscular (PEARCEY et al., 2015) sofrem repercussões negativas. A amplitude de movimento articular diminui após uma sessão de ER (DRINKWATER et al., 2019; POL et al., 2018), provavelmente devido ao edema intra e extra muscular, diminuindo o deslizamento dos tecidos, o que gera sensação de rigidez. Associado a este, a ativação eletromiográfica também é afetada (FROYD et al., 2018; MIKA et al., 2007; MOREL; HAUTIER, 2017), o que prejudica a capacidade de gerar força máxima em até 20% 1h após os ER (ARBIZA et al., 2020). Efeitos negativos foram evidenciados após ER sobre a velocidade máxima em linha reta (BEHARA; JACOBSON, 2017; FERRARI et al., 2013; MIKA et al., 2016), além de afetar negativamente a agilidade, pois fica reduzida a capacidade de percorrer um circuito multidirecional (ARBIZA et al., 2020; FROYD et al., 2018; LATORRE ROMÁN; VILLAR MACIAS; GARCÍA PINILLOS, 2017; PEAKE et al., 2017; PEARCEY et al., 2015). Testes com saltos verticais e horizontais ficam comprometidos após os ER intensos (ARBIZA et al., 2020; DRINKWATER et al., 2019; LATORRE ROMÁN; VILLAR MACIAS;

GARCÍA PINILLOS, 2017). Desse modo, sessões concomitantes de ER ou treinamentos de alta intensidade quando não acompanhados de um tempo de recuperação adequados, podem levar o praticante a experimentar sintomas de *overreaching* (sub-recuperação), o que predispõem a ocorrência de lesões musculoesqueléticas (MARKUS et al., 2021; POL et al., 2018). Por estas razões, essas alterações são amplamente estudadas com o objetivo de atenuar o DMIE eos seus efeitos fisiológicos os quais que reduzem a performance de praticantes de atividades físicas e/ou atletas, especialmente em períodos de competição e, ainda reduzir a susceptibilidade a lesões musculoesqueléticas (BAUMERT et al., 2016; POL et al., 2018).

Recuperar os níveis funcionais pré-exercício o mais breve possível é o objetivo das diferentes intervenções. Neste sentido, estratégias de recuperação não farmacológicas (*recovery*) veem sendo estudadas (BRITO et al., 2020; MISSAU et al., 2018; O'CONNOR et al., 2020; PEARCEY et al., 2015) e aplicadas clínicamente. Dentre estas, destaca-se a recuperação passiva (RP), a recuperação ativa (RA) e a recuperação através da automassagem com o rolo de espuma (RFR), que serão melhor detalhas a seguir.

A recuperação passiva (RP) é a modalidade mais utilizada, em especial entre indivíduos destreinados e também por atletas que não estão em competição, além de normalmente serem consideradas como uma intervenção controle nas pesquisas (ARBIZA et al., 2020; POL et al., 2018; SOLIGARD et al., 2016). Esta forma de recuperação preconiza o repouso após o término da atividade física (POL et al., 2018; SOLIGARD et al., 2016). Ao diminuir o estresse mecânico, menor será a resposta metabólica expressada pelo DMIE (MARKUS et al., 2021). Assim, o sistema imunológico busca encontrar a homeostase (DUPUY et al., 2018; OWENS et al., 2019), se adaptando a situação até alcançar um equilíbrio mecânico e metabólico (MARKUS et al., 2021). Neste contexto, a recuperação passiva é considerada um método de controle para outras intervenções (ARBIZA et al., 2020; BRITO et al., 2020; MISSAU et al., 2018).

Os exercícios de baixa intensidade, com a frequência cardíaca máxima teórica menor a 50% da frequência cardíaca máxima (100 bpm), são considerados estratégias ativas de recuperação (RA) (ARBIZA et al., 2020; PEAKE et al., 2017; PEARCEY et al., 2015). Caminhar ou pedalar em ergômetro são formas de recuperação ativas (ARBIZA et al., 2020; MIKA et al., 2007; PEAKE et al., 2017), as quais visam a remoção de metabolitos celulares por meio de leves contrações musculares (FERRARI et al., 2013; MIKA et al., 2016).

Estudos prévios demonstraram que a recuperação ativa apresenta melhores resultados em relação a repouso para manter e ou evitar a perda funcional após ER (ARBIZA et al., 2020; MIKA et al., 2007; PEAKE et al., 2017). Entretanto, a recente revisão de Ortiz et al., (2018) indica a imprecisão na abordagem das recuperações ativas e nas medidas de resultado, o que torna as conclusões imprecisas. Entretanto, utilizar a recuperação ativa por 20 min, após exercício envolvendo os mesmos músculos que estavam ativos durante o exercício fatigante é mais eficaz na recuperação da fadiga do que utilizar músculos não envolvidos no exercício (MIKA et al., 2016). A EMG após ER não demonstrou diferença após alongamento e/ou recuperação passiva, porém foi maior após recuperação ativa (MIKA et al., 2007). Peake et al (2017) compararam recuperação ativa em cicloergômetro com a imersão em água fria após uma intensa série de exercícios para os membros inferiores e, concluíram que as intervenções apresentam resultados semelhantes para minimizar as respostas inflamatórias e o estresse muscular. Entretanto, recente estudo de O'Connor e colegas (2020) demonstraram que a recuperação ativa e a pressoterapia são mais eficazes na eliminação de lactato do que o repouso durante as sessões de recuperação de até 30 minutos, mas após esse tempo a recuperação ativa apresentou melhores resultados na eliminação desta variável. Arbiza et al, (2020) demonstraram que a recuperação ativa apresenta melhores resultados que a recuperação passiva, em relação a DMIT (24h, 48h e 72h) e ao pico de torque isométrico de extensores de joelho (1h) após ER. Por outro lado, a recuperação passiva e a ativa não apresentaram efeitos sobre o salto vertical e a agilidade avaliados 24 horas após a sessão de ER (O'CONNOR et al., 2020).

A autoliberação miofascial (automassagem) com auxílio de um do rolo de espuma (*foam roll* - RFR) é outra forma de recuperação que vem sendo empregada em clínicas de reabilitação e em centros de treinamento esportivo (BEARDSLEY; ŠKARABOT, 2015; BEHM et al., 2020; DRINKWATER et al., 2019; LASTOVA et al., 2018; WIEWELHOVE et al., 2019). Nesta técnica, o indivíduo exerce um protocolo de movimentos sobre um rolo de espuma (BEHM et al., 2020; RIGHI et al., 2019; WIEWELHOVE et al., 2019). Estudo prévio sugere um maior efeito terapêutico, quando realizadas oscilações de 2 a 4 segundos (ida e volta) em aplicações entre 30 a 120 segundos sobre o mesmo grupo muscular (BEHM et al., 2020). O protocolo de recuperação com o rolo de espuma é considerado uma modalidade ativa de recuperação (LASTOVA et al., 2018), potencializada pela pressão exercida pelo rolo sobre uma musculatura alvo, o qual promove um efeito benéfico, auxiliando a depuração de metabolitos celulares e estimulando a concentração de agentes anti-inflamatórios (PABLOS et al., 2020). Uma sessão de recuperação com o rolo de espuma reduziu a DMIT e melhorou desempenho funcional (MACDONALD et al., 2014) e, é sugerido que a realização contínua (regularmente) desta técnica é benéfica tanto objetiva quanto subjetivamente (BUSHELL; DAWSON; WEBSTER, 2015; DRINKWATER et al., 2019). Estudos prévios demonstram a capacidade da recuperação com o rolo de espuma no aumento da amplitude de movimentos do quadril (BEHARA; JACOBSON, 2017) e do joelho (MACDONALD et al., 2014), na melhora da força muscular (FLECKENSTEIN et al., 2017), do salto vertical (DRINKWATER et al., 2019) e da agilidade (D'AMICO; GILLIS, 2019). Porém, diversos estudos ainda não identificaram diferenças funcionais antes e após os ER, comparando-a a diversas intervenções ativas e passivas (BEHARA; JACOBSON, 2017; BEHM et al., 2020; CHEATHAM; STULL; KOLBER, 2019; DRINKWATER et al., 2019; D'AMICO; GILLIS, 2019; MACDONALD et al., 2014).

Até o presente momento existem poucas evidências que suportam a sua aplicação na prática clínica (BEARDSLEY; ŠKARABOT, 2015; BEHM et al., 2020; LASTOVA et al., 2018). Neste contexto, a presente pesquisa visa investigar o nível de evidência desta forma de recuperação após sessão de ER. A hipótese da presente pesquisa é que a recuperação com o rolo de espuma apresenta melhores efeitos que a recuperações passiva e ativa sobre a DMIT e a funcionalidade de adultos saudáveis fisicamente ativos após uma sessão de ER.

Este estudo está vinculado ao projeto de pesquisa intitulado "Comparação de diferentes formas de recuperação sobre a funcionalidade após exercícios físicos: Ensaio Clínico Randomizado", registrado no Gabinete de Projetos sob o nº 047670 (ANEXO A) e aprovado no Comitê de Ética e Pesquisa da UFSM sob o protocolo 2.538.028 (ANEXO B). Todos os voluntários foram esclarecidos sobre os riscos e benefícios assinando um Termo de Consentimento Livre e Esclarecido (ANEXO C). Os dados foram registrados em uma ficha (ANEXO E) estão protegidos por um Termo de Confidencialidade (ANEXO D).

A presente qualificação de mestrado, além desta introdução, compreenderá: a apresentação dos objetivos da pesquisa, as justificavas do projeto, resultados em forma de artigo científico e a conclusão geral. O artigo está escrito na língua inglesa e está submetido à revista Science & Sports (ANEXO F).

2. OBJETIVOS

2.1. Objetivo **geral**

Estudar os efeitos das recuperações passiva, ativa e da automassagem com o rolo de espuma sobre a dor muscular de início tardio e variáveis de aptidão física de voluntários ativos saudáveis após sessão exercícios resistidos.

2.2. Objetivo específico

- Avaliar os efeitos da recuperação passiva (controle) sobre a intensidade da DMIT (24h, 48h e 72h) e as alterações nas variáveis de aptidão física (amplitude de movimento, flexibilidade, força, velocidade, agilidade e resistência à fadiga) 24h após sessão de exercícios resistidos em voluntários ativos saudáveis.
- Avaliar os efeitos da recuperação ativa sobre a DMIT e as variáveis de aptidão física (amplitude de movimento, flexibilidade, força, velocidade, agilidade e resistência a fadiga) após sessão de exercícios resistidos em voluntários ativos saudáveis.
- Avaliar os efeitos da recuperação da automassagem com rolo de espuma sobre a DMIT e nas variáveis de aptidão física (amplitude de movimento, flexibilidade, força, velocidade, agilidade e resistência a fadiga) após sessão de exercícios resistidos em voluntários ativos saudáveis.
- Comparar os efeitos das recuperações ativa, passiva e da automassagem com rolo de espuma sobre a DMIT e as variáveis de aptidão física após sessão de exercícios resistidos em voluntários ativos saudáveis.

3. JUSTIFICATIVA

Após uma sessão intensa de exercícios é esperado o surgimento da DMIT em adultos saudáveis (FERREIRA et al., 2020; TEIXEIRA et al., 2014a), alterando a sensibilidade tanto em indivíduos destreinados (MISSAU et al., 2018), fisicamente ativos (ARBIZA et al., 2020), quanto em atletas (CHEUNG; HUME; MAXWELF, 2003; MIKA et al., 2016). Além da alteração da sensibilidade, os ER promovem uma resposta inflamatória musculoesquelética (HIRONO et al., 2020; POL et al., 2018), a qual interfere negativamente em diferentes variáveis de aptidão física, tais como: a amplitude de movimento articular (ADM), a força, a agilidade, a potência e a resistência à fadiga (ARBIZA et al., 2020; BEHM et al., 2020; PEARCEY et al., 2015). Estas alterações sobrecarregam o sistema neuromuscular e predispõe a lesões musculoesqueléticas (POL et al., 2018).

Estratégias de recuperação são amplamente pesquisadas a fim de amenizar o desconforto muscular,(BRITO et al., 2020; MISSAU et al., 2018; O'CONNOR et al., 2020), diminuir os riscos de lesões (SOLIGARD et al., 2016; VANDERTHOMMED; MAKROF; DEMOULIN, 2010) e principalmente manter ou melhorar o rendimento funcional durante tarefas subsequentes ao ER (ARBIZA et al., 2020; DUPUY et al., 2018; PEARCEY et al., 2015). Estas estratégias podem ser benéficas durante competições esportivas (POL et al., 2018; SOLIGARD et al., 2016) e podem facilitar a adaptação de iniciantes aos programas de ER (HOWATSON; VAN SOMEREN, 2008).

A forma de recuperação mais utilizada é a recuperação passiva, que consiste no repouso após as sessões de treinamento (BOND et al., 1991; HINZPETER et al., 2013; REY et al., 2018). Entretanto, estratégias de recuperação são amplamente empregadas nesta condição. As recuperações ativas são comumente realizadas, pois melhoram o fluxo sanguíneo e o retorno venoso favorecendo a recuperação muscular (ARBIZA et al., 2020; MIKA et al., 2016). A automassagem com o rolo de espuma também favorece a remoção de metabólitos pró-inflamatórios (BEHM et al., 2020; LASTOVA et al., 2018; WILKE et al., 2020).

Entretanto, os estudos utilizando a recuperação com o rolo de espuma ainda carecem de evidências para a sua aplicação na prática clínica (BEARDSLEY; ŠKARABOT, 2015; BEHM et al., 2020; LASTOVA et al., 2018), pois apresentam amostras pequenas (JAY et al., 2014; MACDONALD et al., 2014; PEARCEY et al., 2015), contendo poucas variáveis de aptidão físicas (BUSHELL; DAWSON; WEBSTER, 2015; DRINKWATER et al., 2019; D'AMICO; GILLIS, 2019) e, especialmente por compararem a um grupo controle que compreende apenas a recuperação passiva (D'AMICO; GILLIS, 2019; FLECKENSTEIN et al., 2017). Até o presente mo0mento, ao nosso conhecimento, nenhum ensaio clínico foi conduzido para comparar esta estratégia de recuperação frente à recuperação ativa, permanecendo ainda incerta a sua efetividade (ARBIZA et al., 2020; DRINKWATER et al., 2019; MIKA et al., 2016; PEARCEY et al., 2015) e, isso motivou o desenvolvimento da presente pesquisa, onde os resultados serão apresentados a seguir em forma de artigo científico apresentado a seguir.

4. ARTIGO

FOAM ROLLING RECOVERY ON PAIN AND PHYSICAL CAPACITY AFTER RESISTANCE EXERCISES: A RANDOMIZED CROSSOVER TRIAL

Short Title

Foam rolling recovery after resistance exercises

ABSTRACT

Objectives. - The aim of the present study was to compare the effects of recoveries passive, active, and self-massage with the aid of foam rolling on pain and physical capacity of healthy volunteers after a resistance exercises session.

Equipment and Methods. - 37 physically healthy men were submitted to three resistance exercises sessions with intervals of seven days (washout). Exercises sessions (squat, leg press and leg extension) were 4 sets of 10 repetitions with 80% of 10RM for each exercise, with a randomized order. Recoveries passive (sitting for 20min), active (cycle ergometer for 20min at 50% maximum heart rate), and self-massage with the aid of foam rolling (10 repetitions per target body area, followed by 1min rest, ~20min) were randomized and done immediately after each session. Muscle strength (dominant –and non-dominant lower limb) was evaluated before and 1h after exercises. Aspects such as range of articular movement, flexibility, speed, power, agility, and fatigue resistance were assessed subsequently (basal vs 1h after exercises). Pain was evaluated 24h, 48h, and 72h after exercises.

Results. - In dominant lower limb, the percentage of strength decreased by 16.3% after exercises ($P < .001$), but improved 5.2% after active and self-massage in comparison to passive recovery ($P < .001$). These results are similar to those found in non-dominant limb. Agility enhanced 3.6% in active and 4.3% in self-massage compared to baseline assessment ($P < .001$). Recoveries showed similar results in the other physical variables. Only self-massage has reduced the pain in 24h (22.8%), 48h (39.2%) and 72h (59.7%) if compared to passive recovery ($P < .001$).

Conclusions. - Self-massage with the aid of foam rolling reduces pain and improves agility and muscle strength in recovery after exercises.

KEYWORDS: Recovery of function; Athletic performance; Myalgia; Self-myofascial release; Massage; Muscle strength.

RÉCUPÉRATION PAR ROULEMENT DE MOUSSE SUR LA DOULEUR ET LA CAPACITÉ PHYSIQUE APRÈS DES EXERCICES DE RÉSISTANCE : UN ESSAI CROISÉ ALÉATOIRE

Titre court

Récupération du roulement de mousse après des exercices de résistance

RESUME

Objectifs. - Le but de la présente étude était de comparer les effets des récupérations passives, actives et d'auto-massage à l'aide d'un roulement de mousse sur la douleur et la capacité physique de volontaires sains après une séance d'exercices de résistance.

Équipement et méthodes. - 37 hommes en bonne santé physique ont été soumis à trois séances d'exercices de résistance avec des intervalles de sept jours (washout). Les séances d'exercices (squat, leg press et leg extension) étaient de 4 séries de 10 répétitions avec 80% de 10RM pour chaque exercice, avec un ordre aléatoire. Les récupérations passives (assis pendant 20min), actives (vélo ergomètre pendant 20min à 50% de la fréquence cardiaque maximale) et auto-massage à l'aide d'un roulement de mousse (10 répétitions par zone corporelle cible, suivies d'1min de repos, ~20min) ont été randomisées. et fait immédiatement après chaque session. La force musculaire (membre inférieur dominant et non dominant) a été évaluée avant et 1h après les exercices. Des aspects tels que l'amplitude des mouvements articulaires, la flexibilité, la vitesse, la puissance, l'agilité et la résistance à la fatigue ont été évalués par la suite (basal vs 1h après les exercices). La douleur a été évaluée 24h, 48h et 72h après les exercices.

Résultats. - Dans le membre inférieur dominant, le pourcentage de force a diminué de 16,3% après les exercices (P < 0,001), mais s'est amélioré de 5,2% après un massage actif et un auto-massage par rapport à la récupération passive (P < 0,001). Ces résultats sont similaires à ceux trouvés dans le membre non dominant. Agilité améliorée de 3,6% en mode actif et de 4,3% en auto-massage par rapport à l'évaluation initiale (P < 0,001). Les récupérations ont montré des résultats similaires dans les autres variables physiques. Seul l'auto-massage a réduit la douleur en 24h (22,8%), 48h (39,2%) et 72h (59,7%) par rapport à la récupération passive (P < 0,001).

Conclusion. - L'auto-massage à l'aide de rouleaux de mousse réduit la douleur et améliore l'agilité et la force musculaire lors de la récupération après les exercices.

MOTS CLÉS: Récupération fonctionnelle; Performance sportive; Myalgie; Libération auto-myofasciale; Massage; Force musculaire.

1. INTRODUCTION

Regular physical exercise is widely recommended for its numerous health benefits. The Physical Activity Guidelines for Americans recommends strengthening exercises two or more days a week [1]. Resistance exercises (RE) are a method for muscle strengthening that is performed with adequate volume, intensity, and frequency to improve functional performance. However, when performed at high intensity, these exercises induce an acute inflammatory response [2,3]. Chronically, this stimulus is part of the physiological process of muscle remodeling arising from physical training in exercise programs [4].

Clinically, these acute alterations after an intense RE session are manifested by muscle pain, muscle stiffness, reduced physical capacity, and decreased functional performance [5,6]. Muscle pain peaks between 24 and 48 hours (h), and can last from 4 to 5 days after the exercise session [7]. During this period, the physical capacity is reduced, evidenced by the reductions in the maximum strength [2,7], range of articular movement (ROM), agility, speed, and muscular power [6]. These changes interfere with the performance of athletes, compromising their performance in competitions, predisposing them to musculoskeletal injuries [8] and can lead beginners to non-adherence to exercise programs [9].

Non-pharmacological recovery strategies are adopted to decrease pain and regain and or maintain physical variables (Recovery) after intense RE [6,10–12]. Among these strategies, there are low-intensity exercises[1] called active recovery (AR), which are effective in attenuating pain and preserving strength, without harming other variables such as speed, power, and fatigue resistance [6,13]. Another form of active recovery is myofascial self-release (self-massage) with the aid of a foam rolling (FRR) [3,14–17]. Among the favorable effects meet reducing pain [6,18], increasing ROM [19–22], improvement flexibility [3,6,17,19] and recovery of strength [23]. This technique also helps in muscle fatigue improvement after exercise, preventing sports-related muscle injuries [23].

However, few studies with FRR support its application in clinical practice [14,16,17], mainly because it is compared only to passive recovery (PR) [15,23,24]. This is reinforced by a recent meta-analysis that has shown that the FRR applied after the execution of exercises reduces pain, but does not minimize the decrease of muscle performance (sprint, strength, jump) [15]. To date, to the best of our knowledge, no study has been conducted to compare FRR to AR after RE. Hence, it is hypothesized that the FRR has better effects than the PR and the AR. This research aims to compare the acute effects of FRR, AR, and PR on pain and the physical capabilities of healthy, physically active adults after an RE session.

2. METHODS

2.1. Study design

The data of this randomized, single-blind, three-arm clinical trial were registered with ClinicalTrials.gov (n. xxxxxxxxx). Data were collected between March 2019 and March 2020 at the Functional Evaluation and Rehabilitation Laboratories of our institution.

2.2. Participants

The survey included literate male volunteers, aged between 18 and 30 years old, with a body mass index between 20 to 30 kg/m^2, non-smokers, who did not use dietary supplementation or medication and practiced physical activities (participation in team sports) more than three times a week. The subjects had also been away from RE during the time of the research. Volunteers with previous diagnoses of musculoskeletal, rheumatological, neurological, cardiovascular, hematological, oncological, and metabolic diseases were not included in the sample. Volunteers who had pain, symptoms of musculoskeletal disorders, and/or kinetic-functional disabilities on the days of assessment were also excluded. The volunteers were instructed not to consume alcoholic beverages and not to carry out high-intensity physical activities 72h before the evaluation and data collection. The research was approved by the Ethics and Research Committee (n. xxxxxxxxxx) and all volunteers signed the Free and Informed Consent Form.

2.3. Procedures

Volunteers were previously familiarized with the assessments of physical variables and the RE protocol. Data collections were carried out in four visits, with an interval of seven days (washout) between them. In the first visit, measurements variables of physical capacity (Basal), prescription of the RE load (100% of 10RM) and the randomization of interventions (PR, AR and FRR; kept confidential) were recorded. In the second, third and fourth visits, the interventions were performed immediately after the end of the RE session.

Muscle strength (isometric peak torque - IPT) was assessed before and 1h after each the RE session. The other variables of physical capacity (ROM, flexibility, speed, power, agility and fatigue resistance) were evaluated basal (1st visit) and immediately after the assessment of muscle strength on the RE sessions (2nd, 3rd and 4th visits). The sequence of evaluations of physical capacity variables was the same throughout the study. Pain was assessed for three days (24h, 48h and 72h) later after each RE session.

Interventions (1st visit) and the sequence of RE (on the same day - 2nd, 3rd and 4th visits) were randomized by software (www.random.org), placed in a brown envelopes. The evaluators were kept blind to the procedures. The study design is shown in Fig.1.

2.4. Evaluation and prescription of resistance exercises

The test of 10 maximum repetitions (10RM) was performed by a trained evaluator to prescribe the RE load. Initially, a warm-up was performed with 40% of the body mass for each exercise (squat, leg extension, and leg press) [10,11,25]. In the free squat protocol, the volunteers were instructed to reach 90º of knee flexion and subsequent torso flexion. In the leg extension, the volunteers started the exercise with the hips and knees flexed at 90º and the movement was carried out in its entire extension. While using the leg press, the hip was positioned at 120° to start the movement, and, during the execution, the knees reached the maximum extension, returning to 90° of flexion at the end of the movement. Load manipulation was performed by adding 5kg in each new attempt, with an interval of 2 to 3min between each set and 5min between exercises. The maximum values of the workload were reached between 3 and 5 attempts, being considered 100% of 10RM [10,11,25].

2.5. Resistance exercises protocol

The RE sessions consisted of a warm-up sets, with 15 repetitions at 40% of 10RM, and four sets with 80% of 10RM, with intervals of 1.5min between sets and 2min between exercises [10,11,25]. The RE consisted of executions in the leg extension machine, free squatting (Rack 1.6m high + Iron Bar 8kg, 170 x 2cm + Dumbbells), and leg press. The sequence of the RE (squat, leg extension, and leg press) was randomized (on the same day). At the end of the RE session, the volunteers were asked about the Subjective Perception of Effort (SPE) using a visual analog scale delimited from 1 (no effort) to 10 (maximum effort).

2.6. Interventions

The interventions were performed in an air-conditioned (24 ± 1°C) and silent room. The volunteers were instructed to remain properly hydrated in advance of the sessions, which was restricted during the RE sessions, evaluation, and interventions. During the PR the volunteers remained seated for 20min after the RE session [10,11,25]. Active recovery (AR) consisted of pedaling on a cycle ergometer (LX130, Movement - São Paulo) for 20min with intensity between 50 to 60 rpm, and the load adjusted so that the intensity reached 50% of the maximum theoretical heart rate (100 bpm) [12].

FRR was performed with the aid of a massage roller (measuring 30cm length x 15cm diameter) of expanded polypropylene (Foam Roller ® Original, Brazil, São Paulo) of high density (D45: 45 kg of the foam /mm^3). The subjects completed 10 repetitions per targeted body area, followed by 1 minute (min) of rest. Each repetition consisted of moving the targeted tissue through the roller in a fluid motion at a rate of 2 seconds (s) lower and 2s higher, as determined by a metronome. Continuous feedback was generated by the investigator to maintain the prescribed shape and pace [14]. The sequence for each targeted region was applied alternately (firstly, the dominant limb and, then, the non-dominant). The targeted regions were the same ones exercised in the RE sessions and followed the order: lateral gastrocnemius, medial gastrocnemius, hamstrings, iliotibial tract, quadriceps, adductors, and glutes. This intervention was applied for approximately 20min.

2.7. Outcomes

The primary outcome was pain. Secondary outcomes included functional variables (strength, ROM, flexibility, speed, power, agility, and fatigue resistance).

Muscle pain was assessed 24h, 48h, and 72h after the RE session using the Visual Analogue Scale (VAS). The physical capacity variables were assessed 1h after RE sessions. The evaluation sequences regarding the physical capacity variables were maintained throughout the research (Fig. 1) as described below.

Muscle strength was assessed using the isometric peak torque (IPT) concerning the dominant (DL) and non-dominant lower limbs (NDL) using knee extensors at 60° [2]. This measurement was performed using a traction-compression dynamometer (EMGSystem, São José dos Campos, Brazil), with a capacity of 500 kgf and a resolution of 0.1 kg, and analyzed by the EMGSystem Lab V1.2 2010 software. The measurement was taken with the volunteer sitting in an upright posture with 90º of hip flexion and hand support on the side. For the IPT evaluation, two maximal voluntary isometric contractions were performed (each of which was maintained for a period of 3s), with a three minutes rest between each contraction. The instruction given to the volunteers was to start the contraction as fast and strong as possible, keeping the effort until the end of 3s. Verbal stimuli were also used during executions. Contraction with the highest peak torque was used for the analysis of IPT and the data were presented in Nm. The variation in muscle strength (Δ) was demonstrated by the difference concerning IPT (IPT before – IPT after) and presented by the percentage from the moment before (100%) each RE session.

The ROM was assessed by the Lunge Test protocol [26], and flexibility by the Sit-and-Reach test (Wells and Dillon Bank). Speed was measured by the 30-meter test [2], power by the Single Leg Hop test [6], agility by the T-Test [27], and the fatigue resistance by the Sit-to-Stand test [28].

2.8. Sample size

The sample calculation was based on a previous study [11] and it was estimated that at least 30 volunteers would be needed to carry out the present study. Volunteers (healthy adults) after performing RE sessions equal to the present study were submitted different recoveries (cold water immersion and passive control). Pain was assessed 24h after the ER sessions, and presented a difference between recoveries of 2.3 points (VAS) and standard deviation (SD) of 2.6 points. These values were used for a 90% power and α=.05.

2.9. Statistical analyses

Data are presented as mean and standard deviation (±SD). The distribution of variables was tested by the Kolmogorov–Smirnov normality test. Interventions were compared by one-way and two-way analysis of variance (ANOVA) for repeated measures (time, recovery and interaction) followed by the Bonferroni post hoc test. Additionally, effect sizes (ES) differences between recoveries were calculated using Cohen's *d* and expressed by the following criteria: trivial <0.2, small 0.2–0.49, moderate 0.5–0.79, and large >0.8. Variations between and within groups are presented as mean difference (MD) and 95% confidence interval (95% CI). Differences were considered to be significant when $P < .05$.

3. RESULTS

A total of 50 volunteers were recruited. Among these, four were excluded on the day of the evaluation, for presenting musculoskeletal pain and/or discomfort. Of the 46 volunteers who underwent baseline assessments, nine were excluded from the statistical analysis due to a lack of follow-up sessions (four did not show up in the PR, three in the AR, and two in the FRR). The final sample consisted of 37 volunteers. The study flowchart is shown in Fig. 2. The sample had an average of 22 (±3.08) years of age, body mass of 77.8 (±9.6) kg, and a height of 1.79 (±0.06) m, which corresponds to a body mass index of 24.4 (±2.3) kg/m^2. The perception of effort (combined RE) at the end of the exercise sessions did not differ (PR: 8.2 ±1.1; AR: 8.2 ±1: FRR: 8.2 ±1.1; *P* = .949).

3.1. Muscle pain

Muscle pain is shown in Fig. 3. All volunteers had no pain (0 in the VAS score) before starting the RE sessions. The REs produced pain at 24h, 48h and 72h after the end of the sessions and this decreased during the experiment in the three recovery forms (Interaction: *P* = .985). However, the recoveries showed differences in time (*P* < .001) and among the Recovery forms (*P* < .001). In time, the PR in relation to 24h has a pain reduction of 34.8% after 48h (MD: -1.7; 95% CI: -2.3 to -1.2 points) and 60.9% after 72h (MD: -3; 95% CI: -3.6 to -2.5); between 48h and 72h, the decrease was of 40% (MD: -1.3; 95% CI: -1.8 to -0.7). The AR compared to 24h reduced pain by 41% after 48h (MD: -1.7; 95% CI: -2.3 to -1.2) and 77.8% after 72h (MD: -3; 95% CI: -3.6 to -2.5); between 48h and 72h, the decrease was of 52.2% (MD: -1.3; 95% CI: -1.2 to -0.7). The FRR compared to the first 24h reduced pain in 49.6% after 48h (MD: -1.9; 95% CI: -2.4 to -1.3) and 79.6% after 72h (MD: -1.2; 95% CI: -1.7 to, -0.6); and between 48h and 72h the decrease was of 60.3% (MD: -1.2; 95% CI: -1.7 to -0.6).

The different forms of recovery showed different results (*P* < .001) on muscle pain at the moments evaluated in the experimental protocol. In comparison to PR, AR did not reduce pain 24h (MD: -0.8; 95% CI: -1.7 to 0.2 points), 48h (MD: -0.8; 95% CI: -1.8 to 0.2) and 72h (MD: -0.8; 95% CI: -1.7 to 0.2) after RE session. However, 24h after the exercises, the FRR reduced pain in 22.8% (MD: -1.1; 95% CI: -2.1 to -0.2), in 39.2% after 48h (MD: -1.3; 95% CI: -2.2 to -0.3) and 59.7% (MD: -1.2; 95% CI: -2.1 to -0.2) 72h after the exercises. Effect size analysis suggests that, on pain, the FRR presents a moderate effect in 24h (*d* = -0.71), a large effect in 48h (*d* = -0.84) and in 72h (*d* = -0.86), when compared to PR. Active Recovery and FRR showed no difference in pain reduction 24h (MD: -0.4; 95% CI: -1.3 to 0.6), 48h (MD: -0.5; 95% CI: -1.5 to 0.5) and 72h (MD: -0.4; 95% CI: -1.4 to 0.6) after exercise sessions.

3.2. Muscle strength

The strength results of the DL and NDL are shown in Table 1. The evaluations performed before the RE did not show any difference in the IPT for the DL ($P > .05$) and NDL ($P > .05$). The interaction (time x interventions) changed throughout the study for DL ($P = .017$), but remained similar for NDL ($P = .058$). In the DL, the IPT after RE had a decrease ($P<0.001$) of -115 Nm in the PR, of -79 Nm in the AR and of -78 Nm in FRR. The comparison between the recovery modalities showed different results ($P < .001$) after the RE. When compared to PR, the IPT was 30 Nm higher after AR and 43 Nm higher after FRR. However, there were no differences between AR and FRR after the RE session. Effect size analysis suggests a moderate effect for IPT with AR (ES = 0.68) and with FRR (ES = 0.66), if compared to PR. In the NDL, the IPT after RE had a decrease ($P < .001$) of -109 Nm in the PR, of -81 Nm in AR, and of -72 Nm in FRR. In comparison to PR, the IPT was 38 Nm higher after AR, and 42 Nm higher after FRR. However, there were no differences between AR and FRR after the resistance exercise session. Effect size analysis for IPT suggests a moderate effect with AR (ES = 0.55) and a large effect (ES = 0.83) with FRR in comparison to PR.

The results of the variation in muscle strength are shown in Fig. 4. After the RE in the DL, the percentage of strength decreased by 16.3% (95% CI: 13.1 to 19.4) in the PR, 11% in the AR (95% CI: 7.9 to 14.2), and, in FRR, there was an 11% reduction (95% CI: 7.8 to 14.2) of the total force. Regarding the PR, AR and FRR were respectively 5.2% (95% CI: 1.6 to -8.7) and 5.2% (95% CI: 1.7 to -8.8) less than the total strength, but there was no difference between the AR and FRR (MD: 0; 95% CI: -3.6 to 3.5) after the RE. The percentage of total NDL strength after RE decreased 15.9% (95% CI: 12.9 to 18.9) in the PR, 11.5% (95% CI: 8.5 to 14.5) in the AR, and 10.6% (95% CI: 7.6 to 13.6) in the FRR. The percentage of total strength in PR was lower by 4.4% (95% CI: -1.4 to -7.4) compared to AR, and 5.3% (95% CI: -2.7 to -8.3) compared to FRR, but there was no difference between AR and FRR (MD: -0.9; 95% CI: -4.5 to 2.6) after the exercise session. The percentages of total strength did not differ from the results in recoveries (PR, AR, FRR) between DL and NDL.

3.3. Physical capacity

The results of ROM, flexibility, speed, power, agility, and fatigue resistance are shown in Table 2. The agility in the baseline evaluation was similar to the PR (MD: 0.3; 95% CI: -0.1 to 0.8 s). However, this variable showed an improvement ($P < .001$), since the time for execution in the T-test was 3.6% (MD: -0.5; 95% CI: -0.2 to -1) less after AR and 4.3% (MD: -0.6; 95% CI: -0.2 to -1.1) less after the FRR. Effect size analysis for agility suggests a small effect with AR (ES = 0.49) and moderate effect (ES = 0.52) with FRR compared to the baseline assessment. The PR was similar to AR (MD: 0.2; 95% CI: -0.2

to 0.7) and FRR (MD: 0.3; 95% CI: -0.1 to 0.7), and there were also no differences between the AR and FRR (MD: -0.3; 95% CI: -0.3 to 0.5). The other variables did not change throughout the research. The volunteers did not present any complications and did not report any skeletal muscle injuries during the data collection.

4. DISCUSSION

The RE protocol for lower limbs induced muscle pain (24h, 48h, and 72h) and impaired the physical capacity (muscle strength and agility 1h after the exercise session). Active modalities (AR and FRR) reduced the pain, attenuated the decrease in muscle strength and improved agility when compared to PR. The result demonstrates that only self-massage was able to reduce the pain in the first 24 hours after RE, being more effective in reducing this clinical symptom than AR.

In present study, FRR was more effective in attenuating muscle pain than PR. These results are corroborated by previous studies [15,28], demonstrating that the FRR reduced pain between 48 to 96 hours after the squat exercise session [6,28]. A previous study demonstrated that these results occurred regardless of the type of foam roller, as different rolls were effective in increasing lactate clearance and decreasing pain [29]. Present study demonstrates that AR presented results similar to FRR. Recovery after dynamic muscle fatigue should involve light active exercises, such as cycling with minimal resistance [3], supporting the AR protocol used in the present study. On the other hand, an FRR session is characterized as a low-intensity aerobic activity [14]. These activities promote changes in blood flow, favoring the removal of metabolites and the reduction of sympathetic activity [30], which acts in the reduction of pain. A systematic review has shown that, sharply, the pressure exerted by the FRR improves endothelial and arterial functions, and increases parasympathetic activity [17]. Foam rolling recovery also improves pain tolerance in the contralateral limb to the massaged one [20], suggesting that this form of recovery causes a generalized acute modulatory response [3], through neural mechanisms, which can contribute to a temporary regulation of afferent pathways sensitive to pain. Although these mechanisms are still not well established [15], they explain, partially, the reason why only the FRR was better than the PR.

The present research demonstrated that the FRR and AR attenuated the loss of muscle strength resulting from the RE session. The decrease in strength is one of the main acute effects after an intense RE session [2,6,7]. Excessive consumption of post-exercise oxygen (EPOC) interferes with Na^{+}/K^{+}-ATPase activity, which acts on ATP/CP resynthesis, ion redistribution, lactate removal, directly interfering with muscle function, as it modulates skeletal muscle contractility and excitability, but this stimulus contributes to its remodeling [31]. In addition, stretching the muscle during eccentric action at high intensity results in a linear deformation, which affects the Z lines of the sarcomeres, reducing strength and torque [2]. These acute neurophysiological mechanisms limit the production of maximum strength after high-intensity exercises. The low-intensity aerobic activity of AR [5] and FRR [14] stimulates blood flow favoring the resynthesis of ATP/CP and the removal of metabolites [31], which would act in the recovery of muscle strength found in the present study by AR and FRR.

The active recoveries (AR and FRR) improved agility 1h after ER sessions. The results of the present research are corroborated by previous studies, which demonstrate that agility after RE with PR was worsened and that the FRR attenuated the decrease in agility 24h [6,27] 48h and 72h after RE [6]. These studies compared FRR to placebo (PR) [6] and sham [27] interventions, and their results suggest that active recoveries (AR and FRR) keep the musculoskeletal system prepared for new physical-functional requirements [5,14], which does not happen with PR. This is reinforced by a recent meta-analysis that suggests that this technique can be used preventively as a pre-exercise warm-up method [15]. In the present study, the speed after RE did not change, but the partial recovery of muscle strength by active recoveries (AR and FRR) contributed to the improvement of agility after RE.

The results of the present study demonstrated that power, ROM, flexibility, speed, and muscle fatigue resistance did not change after the RE session, nor after the interventions. These results are corroborated by previous studies [15,16,21,30], which demonstrated that these physical variables did not change after RE and after passive or active interventions. Drinkwater et al., (2019) compared FRR to PR after an intense RE session and found no differences in flexibility (knee flexion), speed, and fatigue resistance. However, this study observed the superiority of the FRR over power, 72h after RE, a moment that was not evaluated by the present research. D'Amico & Gills (2019) did not identify differences between the FRR and the PR on the perception of pain, ROM (hip abduction), flexibility (hamstring muscles), and power (vertical jump) after RE, corroborating the results of the present study.

Among the limitations, sample be composed only of men and RE protocol just for lower limbs. It is also important to highlight the absence of plasma biochemical markers of muscle damage and inflammation, which would help to clarify the mechanisms involved. Another factor that must be considered is that the physical variables were evaluated only 1h after the RE session, which does not allow us to presume a decrease regarding these variables over the inflammatory phase. It should be noted that these results refer to the acute effects on physically active volunteers and should not be extrapolated from the effects of this form of recovery on remodeling and myoregeneration throughout exercise programs. However, an experimental study in rats showed that FRR after toxic muscle injury (Notexin), decreased the production of pro-inflammatory agents and increased anti-inflammatory agents [32].

5. CONCLUSIONS

The present study demonstrated that active recoveries (AR and FRR) are more effective than passive recovery and preferably should be performed by physically active adults after high-intensity RE sessions. These strategies attenuate the decrease in muscle strength and favor the recovery of agility after the RE session. However, the FRR was more effective in reducing muscle pain (24h, 48h and 72h), than other forms of recovery after RE. Self-massage with FRR has better results in alleviating pain in this condition, and it can be recommended and incorporated in places where RE sessions and/or programs are performed, such as gyms. However, its application to the upper limbs lacks further clinical evidence.

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Disclosure of interest

The authors declare that they have no competing interest.

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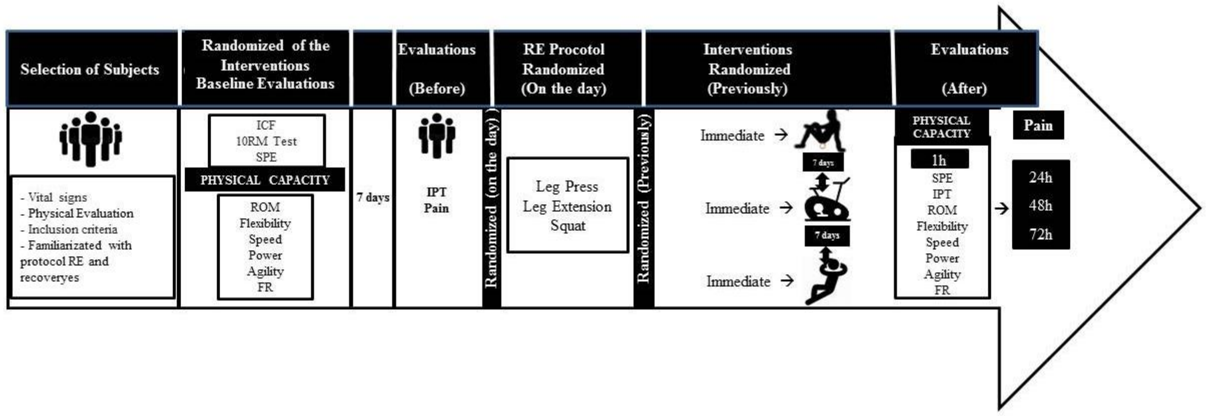
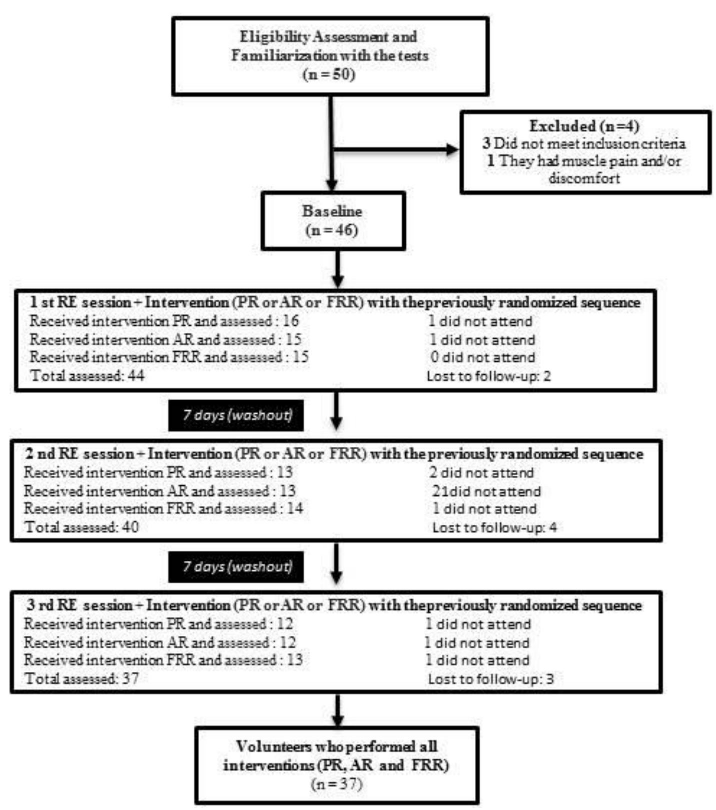
FIGURES

Fig. 1: Study design



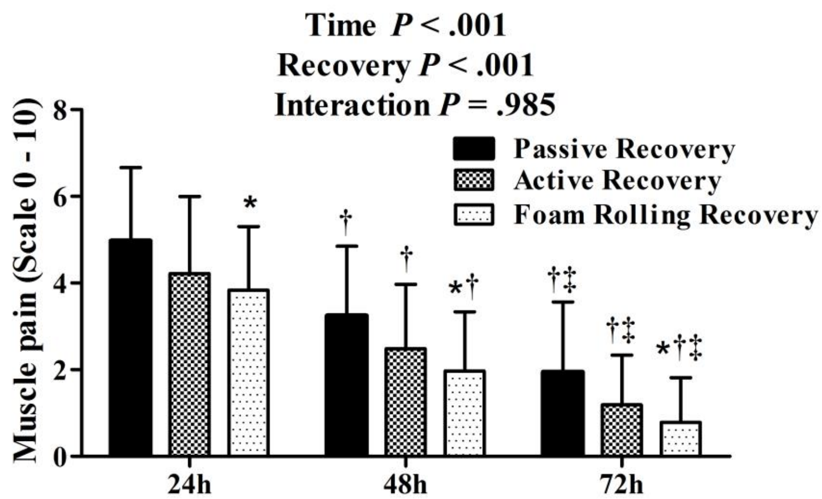
Legend: RE: Resistance Exercises; ICF: Informed Consent Form; RM: maximum repetition; SPE: Subjective Perception of Effort; ROM: range of articular movement; IPT: Isometric Peak Torque; FR: fatigue resistance min: minutes; h: hours.

Fig. 2: Study flowchart



Legend: RE: resistance exercises; PR: Passive Recovery; AR: Active Recovery; FRR: Foam Roller Recovery; n: number.

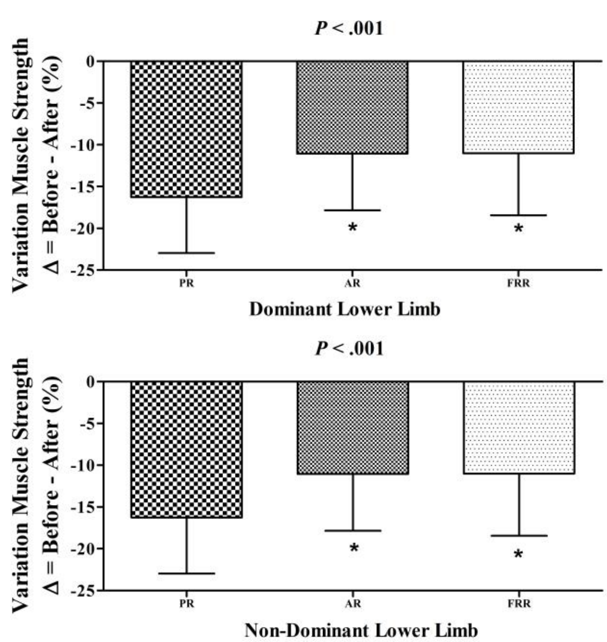
Fig. 3: Results of interventions on muscle pain



Legend: h: hours.

* $P < .05$ vs Passive Recovery; † $P < .05$ vs 24h; ‡ $P < .05$ vs 48h.

Fig. 4: Results of interventions on dynamometry.



Legend: Delta (difference between before - after resistance exercises); PR: Passive Recovery; AR: Active Recovery; FRR: Foam Roller Recovery;

* $P < .05$ vs Passive Recovery.

Table 1. Results of interventions on isometric peak torque.

Variable	PR	AR	FRR	PR vs AR MD (95% CI)	PR vs FRR MD (95% CI)	AR vs FRR MD (95% CI)	2-way ANOVA (Value *P*) Time	Recovery	Interaction
DL - IPT (Nm)									
Before	723 ± 131	716 ± 117	729 ± 122						
After	605 ± 113†	638 ± 105*†	648 ± 113*†	30 (2, 58)	43 (15, 71)	13 (-15, 41)	$P < .001$	$P < .001$	$P = .017$
MD (95% CI) Before vs After	-115 (-192, -38)	-79 (-156, -2)	-78 (-155, -1)						
NDL - IPT (Nm)									
Before	684 ± 116	695 ± 106	698 ± 125						
After	575 ± 102†	613 ± 108*†	617 ± 121*†	38 (6, 71)	42 (9, 74)	3 (-29, 36)	$P < .003$	$P = .001$	$P = .058$
MD (95% CI) Before vs After	-109 (-172, -45)	-81 (-145, -18)	-72 (-136, -9)						

Values are presented as mean ± standard deviation (SD). MD: mean difference; 95% CI: 95% confidence interval. IPT: Isometric Peak Torque; DM: Dominant Limb; NDL: Non-Dominant Limb; PR: Passive Recovery; AR: Active Recovery; FRR: Foam Roller Recovery.

* $P < .05$ vs Passive Recovery; † $P < .05$ vs Before.

Table 2. Results of interventions on physical capacity variables.

Variables	Basal	PR	AR	FRR	One-way ANOVA (Valor *P*)
Power - SHT (cm)					
DL	132.3 ± 22	130.7 ± 23.4	129.9 ± 20.3	132.1 ± 23.5	*P* = .784
NDL	129.9 ± 22.2	129.8 ± 22.9	129.7 ± 21.5	130.5 ± 23.5	*P* = .989
ROM - LT (cm)					
DM	13.5 ± 3	12.9 ± 3	13.5 ± 2.7	13.4 ± 3.1	*P* = .085
NDM	14.6 ± 2.2	13.8 ± 2.1	14.5 ± 3	14.3 ± 3.1	*P* = .159
Flexibility - WDB (cm)	26.4 ± 6.7	27.2 ± 7.2	26.5 ± 7.2	27.2 ± 7.5	*P* = .142
Speed - T30 (s)	4.7 ± 0.5	4.7 ± 0.3	4.6 ± 0.3	4.6 ± 0.3	*P* = .128
Agility - TT (s)	14 ± 1.6	13.6 ± 1.2	13.4 ± 0.8*	13.3 ± 0.9*	*P* < .001
Fatigue Resistance - SST (rep)	19.6 ± 2.2	19.2 ± 2.7	19.4 ± 2.4	19.8 ± 2.5	*P* = .300

Values are presented as mean ± standard deviation. (SD); IPT: Isometric Peak Torque; DL: Dominant Limb; NDL: Non-Dominant Limb;

PR: Passive Recovery; AR: Active Recovery; FRR: Foam Roller Recovery; rep: Repetitions; s: seconds. ROM: joint range of motion; LT: *lunge test*; cm: centimeters; WDB: sit-and-reach test (Wells and Dillon Bank); SHT: *Single Hop Test*; TT: *test T*; T30: 30 meter test; SST: sit and stand test; * *P* < .05 vs Basal.

5. CONCLUSÃO GERAL

O presente projeto de pesquisa (Classificação CNPq 4.00.00.00-1) foi vinculado ao Curso de Fisioterapia (04.08.03.00.0.0), autorizado pelo Departamento de Fisioterapia e Reabilitação (04.37.00.00.0.0) e executado em conjunto com pelos Programas de Pós-Graduação em Reabilitação Funcional (04.10.27.00.0.0) e Programa de Pós-Graduação em Educação Física. O mesmo teve início em janeiro de 2018 e foi desenvolvido pelo Grupo de Pesquisa em Fisiologia e Reabilitação – GPFR (CNPq 028) utilizando os laboratórios de Avaliação Funcional (Sala 4011 do Prédio 26D) e Intervenção Funcional (Sala 2013 do Prédio 26D), os quais dispõem de equipamentos para avaliação das variáveis de aptidão física, execução dos protocolos de ER e as intervenções, respectivamente. Os incentivos para a realização do projeto compreenderam em uma bolsa de iniciação científica FIPE-CCS da UFSM de Junho a Dezembro de 2019 e uma bolsa de mestrado CNPq (Março de 2020) com duração de um ano.

Este projeto pesquisa foi registrado no Gabinete de Projetos sob o nº 047670 (ANEXO A) e aprovado no Comitê de Ética e Pesquisa da UFSM sob o protocolo 2.538.028 (ANEXO B). Deste projeto já foram publicados dois artigos científicos, que compreendem uma revisão integrativa sob o título: “Efeitos da autoliberação miofascial com *foam roller* ou *roller massager* sobre a dor e a função musculoesquelética após exercícios” (RIGHI, N. C. et al., FISIOTERAPIA BRASIL, v. 20, p. 310-316, 2019) e um Ensaio Clínico Randomizado sob o título: “Efeitos da recuperação passiva e ativa sobre a dor e a funcionalidade após exercícios resistidos” (ARBIZA, et al. REVISTA CONTEXTO & SAÚDE, v. 20, p. 163-169, 2020). Além destes artigos está sendo apreciado pela banca de qualificação de mestrado o artigo que compõem esta dissertação intitulado: “*foam rolling recovery on pain and physical capacity after resistance exercises: a randomized crossover trial*” que foi submetido a revista *Human Movement Science* em 26 de junhoe 2022 (ANEXO F).

A presente pesquisa avaliou diferentes estratégias de amenizar os efeitos agudos dos ER sobre a dor e diferentes capacidades físicas de adultos jovens. Os resultados deste Ensaio Clínico Randomizado demonstraram que ao realizar exercícios resistidos intensos com os membros inferiores dos voluntários em recuperação passiva (recuperação controle) apresentaram a DMIT por 72h e apresentaram uma decréscimo funcional (força, potência, agilidade, amplitude de movimento, flexibilidade, velocidade e resistência à fadiga) 1h após sessão de exercícios resisitidos. As modalidades ativas empregadas nesta pesquisa, foram capazes de reduzir a DMIT e melhoraram as valencias força e a agilidade. Inda, o *recovery* de automassagem com o rolo de espuma apresentou melhores efeitos que a recuperação ativa sobre a DMIT.

Os resultados da presente pesquisa sugerem que a adoção desta estratégia de recuperação após ER pode amenizar o desconforto muscular e atenuar a perda do rendimento funcional em atividades subsequentes aos exercícios. A automassagem com o rolo de espuma é uma alternativa de *recovery* promissora por seus efeitos benéficos sobre a DMIT e nas variáveis de aptidão física. Esta é uma técnica de baixo custo e fácil e rápida aplicação (autoaplicada), a qual poder ser realizada em grupos com apenas um instrutor, pois possui protocolos de entendimento simples. A pratica da mesma, pode favorecer a adaptação de iniciantes de musculação, os quais podem ser intolerantes a dor. Além destes, praticantes de atividade física e atletas podem se beneficiar com a redução dos sintomas dolorosos e pela restauração acelerada do desempenho funcional, especialmente quando se requer esforços intensos de forma subsequente, como em situação de treinamentos e em competições. Futuros estudos devem ser desenvolvidos incluindo outras variáveis, como as bioquímicas e as psicológicas, a fim de investigar os mecanismos envolvidos na homeostase e os efeitos psicofuncional, tanto de homens quanto de mulheres praticantes de ER em uma única sessão e durante os programas de treinamento.

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ANEXO A - REGISTO NO GAP

Visualização de documento

Detalhes | Tramitações | Operações

Número
23081.047690/2017-60

Criado em
09/11/2017 18:17

Fluxo
Registro de projetos / Web

Cód. Assunto
192.100

Descrição do Assunto
Registro de Projeto

Procedência
LUIS ULISSES SIGNORI - 1673921 (Servidor)

Interessado(s)
LUIS ULISSES SIGNORI - 1673921 (Servidor)

Resumo do Assunto
Projeto nº 047670

Fechar

ANEXO B - APROVAÇÃO PELO CEP

Visualização de documento

Detalhes | Tramitações | Operações

Passo de fluxo / Destino	Enviado em	Recebido em
Envia para análise da chefia 04.37.00.00.0.0 - DEPARTAMENTO DE FISIOTERAPIA E REABILITAÇÃO - DFSR	09/11/2017 18:17	13/11/2017 07:19
Encaminha para análise técnica do projeto 04.25.00.00.0.0 - GABINETE DE PROJETOS - CCS - GaP-CCS	13/11/2017 07:20	13/11/2017 09:03
Encaminha para análise de mérito do projeto 04.01.06.00.0.0 - COMISSÃO DE PESQUISA - CCS - ComPesq-CCS	13/11/2017 09:03	14/11/2017 10:46
Encaminha para comitê de ética 01.09.00.03.0.0 - NÚCLEO ADMINISTRATIVO DOS COMITÊS - NA-Comitês	14/11/2017 10:48	23/11/2017 10:20
Registra o projeto 01.10.00.00.0.0 - PRÓ-REITORIA DE PLANEJAMENTO - PROPLAN	14/03/2018 09:44	

Remetente
GABRIELA HEINZ

Despacho
Para registro. Projeto aprovado no cep conforme parecer 2.538.028.

Sem anexos

Fechar

ANEXO C - TERMO DE CONSENTIMENTO LIVRE E ESCLARECIDO (TCLE)

Eu Professor Dr. Luís Ulisses Signori, responsável pela pesquisa “Comparação entre diferentes formas de recuperação da função muscular após exercícios resistidos: ensaio clínico randomizado”, o convidamos a participar como voluntário deste nosso estudo.

Esta pesquisa pretende estudar os efeitos de quatro modalidades terapêuticas sobre a dor e a função muscular de voluntários saudáveis submetidos a exercícios de musculação. Através deste estudo queremos diminuir os desconfortos após a realização dos exercícios, os quais interferem na funcionalidade muscular e no desempenho de atletas, sendo esta também uma das causas do abando a prática de atividades físicas por indivíduos destreinados. Para sua realização serão realizadas quatro sessões de exercícios de musculação (resistidos), seguidos de quatro intervenções (recuperação passiva – repouso; recuperação ativa - exercícios em bicicleta ergométrica; recuperação com imersão na água fria; recuperação com automassagem). Cada sessão de exercícios terá um intervalo de uma semana. Sua participação constará da realização de uma avaliação física, realização dos exercícios e as quatro intervenções (uma semana de intervalo entre cada sessão) e uma avaliação física após os exercícios. Após a realização das coletas de dados em cada sessão a nossa equipe entrará em contato em 24 e 72h para acompanhar seu estado de saúde.

Os riscos que compreendem na realização de exercícios de musculação são os mesmos que os praticantes estão expostos nas academias. Neste sentido, o senhor poderá sentir dor muscular, que são os mesmos sintomas referidos após a realização de atividades físicas intensas e que fazem parte adaptação aos exercícios. Entretanto, após estes exercícios serão realizadas recuperação ativa (exercícios leves em bicicleta ergométrica – 20min), recuperação passiva (25minutos sentado) recuperação por imersão em água fria (10min) e automassagem (15min) que reduzem este sintoma. Os benefícios aos voluntários baseiam-se em realizar uma avaliação da condição funcional e aptidão física, os quais são parâmetros para prescrição de exercícios e podem identificar risco a doenças cardiovasculares assintomáticas. Os resultados das avaliações serão devolvidos e esclarecidos aos voluntários, assim os mesmos poderão obter informações sobre seu estado de saúde e riscos de doenças cardiovasculares. Durante todo o período da pesquisa você terá a possibilidade de sanar qualquer dúvida ou pedir qualquer outro esclarecimento. Para isso, entre em contato com algum dos pesquisadores ou com o Comitê de Ética em Pesquisa. Em caso de algum problema relacionado com a pesquisa, você terá direito à assistência gratuita que será prestada própria equipe que desenvolve o projeto.

Você tem garantida a possibilidade de não aceitar participar ou de retirar sua permissão a qualquer momento, sem nenhum tipo de prejuízo pela sua decisão. As informações desta pesquisa serão confidenciais e serão divulgadas, apenas, em eventos ou publicações, sem a identificação dos voluntários, a não ser entre os responsáveis pelo estudo, sendo assegurado o sigilo sobre sua participação. Os gastos necessários para a sua participação na pesquisa serão assumidos pelos pesquisadores. Fica também, garantida indenização em casos de danos comprovadamente decorrentes da participação na pesquisa.

AUTORIZAÇÃO

Eu, ..., após a leitura ou a escuta da leitura deste documento e ter tido a oportunidade de conversar com o pesquisador responsável, para esclarecer todas as minhas dúvidas, estou suficientemente informado, ficando claro que minha participação é voluntária e que posso retirar este consentimento a qualquer momento sem penalidades ou perda de qualquer benefício. Estou ciente também dos objetivos da pesquisa, dos procedimentos aos quais serei submetido, dos possíveis danos ou riscos deles provenientes e da garantia de confidencialidade. Diante do exposto e de espontânea vontade, expresso minha concordância em participar deste estudo e assino este termo em duas vias, uma das quais foi-me entregue.

…... …..

(Assinatura do paciente) (Assinatura do responsável pelo estudo)

Santa Maria, ___/___/_____

ANEXO D - FICHA DE AVALIAÇÃO

Dia 1 - Data da Avaliação: / /20... Hora do fim:			
Avaliadores:			
ANAMINESE			
Nome Completo:			
Endereço:			Telefone:
Massa:	Altura:		IMC
Dominância (D):	IPAQ	Data de Nascimento	

AVALIAÇÂO FUNCIONAL				
Dinamometria (kg)	Pré D:			
	Pré ND:			
	Pós D:			
	Pós ND:			
Single Hop Test (cm)	Dom			
	ND			
Lounge Test (cm)	Dom			
	ND			
Banco de Wells (cm)				
Teste dos 30m (seg)				
T Test (seg)				
TSL 30s (rep)				
DMIT (EVA) Hora:				

CARGA DO PROTOCOLO DE EXAUSTÇAO			
Agachamento (kg)	Dom	10RM:	80%:
	ND	10RM:	80%:
Leg Press (kg)	D	10RM:	80%:
	ND	10RM:	80%:
Cadeira Extensora (kg)	D	10RM:	80%:
	ND	10RM:	80%:
Observações:			

Dia 2 - Data da Intervenção: / /2019 Hora do fim:				
Avaliadores:				
AVALIAÇÂO FUNCIONAL				
Dinamometria (kg)	Pré D:			
	Pré ND:			
	Pós D:			
	Pós ND:			
Single Hop Test (cm)	Dom			
	ND			
Lounge Test (cm)	Dom			
	ND			
Banco de Wells (cm)				
Teste dos 30m (seg)				
T Test (seg)				
TSL 30s (rep)				
DMIT (EVA) Hora:				

Dia 3 - Data da Intervenção: / /2019 Hora do fim:				
Avaliadores:				
AVALIAÇÂO FUNCIONAL				
Dinamometria (kg)	Pré D:			
	Pré ND:			
	Pós D:			
	Pós ND:			
Single Hop Test (cm)	Dom			
	ND			
Lounge Test (cm)	Dom			
	ND			
Banco de Wells (cm)				
Teste dos 30m (seg)				
T Test (seg)				
TSL 30s (rep)				
DMIT (EVA) Hora:				

Dia 4 - Data da Intervenção: / /2019 Hora do fim:
Avaliadores:

AVALIAÇÂO FUNCIONAL				
Dinamometria (kg)	Pré D:			
	Pré ND:			
	Pós D:			
	Pós ND:			
Single Hop Test (cm)	Dom			
	ND			
Lounge Test (cm)	Dom			
	ND			
Banco de Wells (cm)				
Teste dos 30m (seg)				
T Test (seg)				
TSL 30s (rep)				
DMIT (EVA) Hora:				

OBSERVAÇÕES

Assinatura do Avaliado

Assinatura do Responsável

ANEXO E – TERMO DE CONFIDENCIALIDAE

Título do projeto: **COMPARAÇÃO ENTRE DIFERENTES FORMAS DE RECUPERAÇÃO DA FUNÇÃO MUSCULAR APÓS EXERCÍCIOS RESISITIDOS: ENSAIO CLÍNICO RANDOMIZADO**

Pesquisador responsável: Professor Dr. Luís Ulisses Signori

Instituição: Universidade Federal de Santa Maria

Telefone para contato: 55 91057362

Local da coleta de dados: Universidade Federal de Santa Maria (UFSM), prédio 26D, do Centro de Ciências da Saúde (CCS), salas 4011 e 4013.

Os responsáveis pelo presente projeto (nº 047670) se comprometem a preservar a confidencialidade dos dados dos participantes envolvidos no trabalho, que serão coletados por meio de testes físicos-funcionais e questionários, no prédio 26D, do Centro de Ciências da Saúde (CCS), sala 4013, que serão coletados entre dezembro de 2017 a junho de 2020.

Informam, ainda, que estas informações serão utilizadas, única e exclusivamente, no decorrer da execução do presente projeto e que as mesmas somente serão divulgadas de forma anônima, bem como serão mantidas no seguinte local: UFSM, Avenida Roraima, 1000, prédio 26D, Departamento Fisioterapia Reabilitação, sala 4011, 97105-970 - Santa Maria - RS. Essas informações serão guardadas por um período de cinco anos, sob a responsabilidade do professor Luís Ulisses Signori, na sala 4011. Após este período os dados serão destruídos.

Este projeto de pesquisa foi revisado e aprovado pelo Comitê de Ética em Pesquisa com Seres Humanos da UFSM, no número de registro 2.538.028.

....

Professor Dr. Luís Ulisses Signori - Pesquisador responsável

Santa Maria, RS.

2018

ANEXO F - NORMAS PARA SUBMISSÃO

Guide for authors

GENERAL PRESENTATION

Science & Sports is the means of expression of the French society of exercise and sports medicine (SFMES). Every article concerning life sciences or health sciences in French or in English is welcome in this Journal of sciences and medicine of man in movement, which publishes 6 issues a year. Including an ongoing professional development section, the journal provides general reviews, original articles, best practices, brief notes about advances in the field of physiology and physiopathology or about clinical and technical facts, letters to the editor, book reviews and an agenda of the main scientific congresses on sports and exercise medicine.

1. ELECTRONIC SUBMISSION ON EDITORIAL MANAGER (EM)

Authors are required to submit their manuscript through:
https://www.editorialmanager.com/SCISPO/default.aspx?pg=mainpage.html
Electronic required configurations are presented under item 6.

Using Editorial Manager (EM) in short

First time users must use the « register » button in the horizontal list of links, at the top of the screen. Then enter your first names (first name), name (last name), and email address. Additional information is then required: heading, preferred mode of contact, country, address, user name chosen. Once you have entered this information, a confirmation email is sent to you, specifying your user name (username) and password (password). Registering is required only once, at the very first use. Whenever logging on, click « log in » to identify, enter the user name and password, then click the « author login » button to enter the system. Once identified and in the system, to submit a manuscript, follow the sequence indicated to enter information related with the submission, as well as to download the files of your manuscript.

2. LEGAL REQUIREMENTS

Publication policy

By submitting an article for publication, all authors and their possible co-authors warrant that they have approved the said article, this article has not been submitted for publication in another journal and has not been previously published. The work submitted must comply with the ethical guidelines of the Helsinki Declaration. It must have been submitted, if they required, either to an advisory committee for the protection of persons in biomedical research or to an ethics committee. When a work has been submitted to one of these institutions, it must be mentioned in the text.

Science & Sports adheres to the recommendations for manuscripts submitted to international journals, proposed by the group of Vancouver. Authors are encouraged to consult these for further information. Intended for authors, editors and reviewers, they provide standards for the presentation of a manuscript, rules for responsibility and ethics to be respected and enforce good practice covering conflicts of interest and duplicate publication. Studies in animals, must comply with the recommendations of the European Convention on “protection of vertebrate animals used for experimental ends or other scientific purposes of 31 May 1986, and its application directive of 28 November 1986”, transcribed into French law in the by-laws of 20 October 1987 and 19 April 1988.

3. PREPARATION OF THE MANUSCRIPT

Texts must be supplied in .doc using Word and NOT in PDF format.

1. The layout of the manuscript must comply with authoring instructions:

1. Heading page: title
2. Summary and keywords
3. Manuscript, references, tables, illustrations and legends

Manuscripts that do not comply with recommendations will be automatically rejected and returned to authors.

Page 1: Heading page

Includes on a separate page:

- A precise and concise title in French and English
- A short title of no more than 80 characters (including spaces)
- Authors details (limited to 6 authors): family names + initial of the given names

- The affiliation of each author (full postal address of the departments or laboratories concerned)
- For the corresponding author: name, phone fax number, and email address

2: Summaries, keywords

Except for the letters to the editor (no summary, no keywords), each article includes a summary in French and English, without abbreviation nor reference. Summaries must be organized as follows:

-for reviews: (1) Objectives; (2) News; (3) Prospects and projects; (4) Conclusion (commented);

-for original articles: (1) Objectives; (2) Equipment and methods (clinical or experimental equipment, - and methods used); (3) Results (whenever possible with their statistical meaning);

-for brief notes: (1) Introduction; (2) Summary of facts and results. (3) Conclusion (commented).

Keywords must allow article indexing and comply with the list of the Medical Subject Headings of the Index Medicus. They can be modified definitely by the editorial staff.

Page 3 and following: Manuscript

Title (with no authors' details), summary and keywords All these items should be provided in French and in English.

Manuscript

Pages must be numbered and paragraphs (and sub-paragraphs) must be numbered in Arabic numerals. Lines of each page must be numbered. The nomenclature is coherent and invariable. Scientific symbols and units must comply with international standards.

Illustrations

Illustrations are separated from the text, numbered in Arabic number and indexed in the text by reminding their number. Lettering (symbols, digits, etc.) must be uniform for all figures, and with a sufficient size to remain legible after reduction. Figures and tables must not be included twice. Each illustration must include the necessary indications of orientation and framing.

Tables are entered with double line spacing and indicate their number, a heading and possibly explanatory There are no publication charges for texts and figures in black and white, only reproduction of color figures are charged to authors

Abbreviations

They are explained at their first occurrence in the text, and their number reduced to a minimum. No reference to the author names, address or mail or phone number must appear in the main text. Abbreviations of the names of reviews are those of the Index Medicus (new series) National Library of Medicine. In this system, all abbreviations start with a capital letter and written without abbreviative points; this also applies to initials of author first names. Models for references are presented below.

References

Limited to authors cited, the references are all called in the text, and numbered according to the order of occurrence. Call numbers must be included in the text between square brackets, separated with dashes when they are consecutive references, e.g. [1–4], and commas when non-consecutive references: [5, 7, 12]. References must be presented according to the standards set by the Vancouver Convention (International Committee of Medical Journal Editors. Uniform requirements for manuscripts submitted to biomedical journals. Fifth edition. N Engl J Med 1997;336:309–16). Up to six authors, these must be named; beyond, only the first six must be cited, followed with a comma and the words “et al.”. Unpublished work must not be included to the reference list, unless formally accepted for publication (indicate “to be published”, between brackets after the name of the review). It may only be cited in the text with the “observations unpublished” or “personal communication”; in the latter case, the editorial staff reserves the right to check this statement.

Example for references

Articles in Journal

1 Denison HJ, Syddall HE, Dodds R, Martin HJ, Finucane FM, Griffin SJ, et al. Effects of Aerobic Exercise on Muscle Strength and Physical Performance in Community-dwelling Older People from the Hertfordshire Cohort Study: A Randomized Controlled Trial. J Am Geriatr Soc 2013;61:1034-6.

2 Guézennec CY. Alimentation calcique et effet de l’entraînement physique sur l’os. Science & Sports 1996;11:205–10.

Articles in suppl. of a volume

3 Lacombe D. Les protéines de la morphogenèse osseuse (BMP). Arch Pediatr 1997;4 (Suppl 2):121-4.

Articles in suppl. of an issue

4 Sabourin F. Fractures des os du carpe en dehors du scaphoïde. Science & Sports 1996;11(1 Suppl 1):5-7.

Book

5 Riché D. Équilibre alimentaire et sports d'endurance. Paris: Vigot; 1990.

Book with multiple authors

6 Monod H, Amoretti R, Rodineau J, editors. Médecine du sport pour le praticien. Paris : Simep ;1994.

Book chapter

7 Brion R. Échographie du sportif. In: Monod H, Amoretti R, Rodineau J, editors. Médecine du sport pour le praticien. Paris: Simep; 1994. p. 197-202.

Report from a congress

8 Saillant G, Thoreux P, Roy-Camille R. La tendinite d'Achille chez le sportif. In: Science & Sports. IXe congrès national scientifique de la Société française de médecine du sport. Paris: Elsevier; 1989. p. 327-31.

Thesis

9 Nansion E. La boxe française féminine: étude auprès de 70 pratiquantes [thèse]. Lille: université de Lille-II ; 1992. **Référence Internet**

10 Doe J. Title of subordinate document. In: The dictionary of substances and their effects. Royal Society of Chemistry. 1999. http://www.rsc.org/dose/title of subordinate document. Accessed 15 Jan 1999.

Limits for manuscripts (word count is without references, tables, figures and summary)

	Characters	Keywords	Pages	Number of References	Figures or tables
Review	60 000	2 to 5	30	70	6
Original Article	40 000	2 to 5	20	40	6
Brief note	8 000	2 to 5	4	8	2
Letter to the editor	5 000	0		5	1

**Letters to the editor intend to publish short clinical cases. They are divided in two paragraphs (1/case itself; 2/discussion) with no summaries, no keywords and no subheadings.*

Disclosure of interest

The publication abides by international practices relative to declaration of interest concerning the submitted publications. Any manuscript submission must be accompanied with a disclosure of interest. There is a competing interest when an author and/co-author have any financial or personal relationships with other people or organizations liable to influence (bias) their professional judgment concerning an essential value (good of the patient, research integrity…). Examples of potential competing interest include employment, consultancies, stock ownership, honoraria, paid expert testimony, patent applications/registrations, and grants or other funding. See also: www.elsevier.com/conflictsofinterest. The main competing interest includes financial interests, clinical trials, occasional business involvements and family connections.

For all publication authors must declare any relations that could be considered as a potential competing interest.

- If there is no competing interest, the following note must be added directly to the manuscript: The author [authors] declare[s] that he [they] has [have] no competing interest.

- If there is one (or more) competing(s) interest, all should be listed at the end of the manuscript (before the bibliographic references) in accordance with the presentation below. The initials of the author(s) concerned and the name of the company should be added to the potential competing of interest needing to be declared.

Examples

- C.R., E.L. Financial interests in the company Barbot S.A.

- E.L. Owner, manager, employee, part of a decision-making body in a company. Other regular activities in the company Chups SAS

- J.-J.E. Clinical trials: acting as main investigator, coordinator or main experimenter for RTM SARL

- P.L. Clinical trials: as co-investigator, secondary experimenter, collaborator in the study for Light & Co

- F.W. One-off interventions: expert/survey report for EFS Associated

- M.D. One-off interventions: advisory activity for SFC

- C.G. Conferences: invitations as contributor for KKS & Son - M.S. Conferences: invitations as auditor (travelling and accommodation expenses paid for by the company) for Regis SA

- C.-A.S. Substantial financial contributions to the budget of an institution you are responsible for Aphelion

- M.F. Close relatives as employees of a company mentioned above.

4. MULTIMEDIA AND SUPPLEMENTARY FILES

It is now possible to submit multimedia and supplementary files with manuscripts, such as images, movies, animations, audio files, spreadsheets, presentations, etc., which can only be accessed through Science Direct. Your printed article will indicate that further material can be found online. To find out more about the accepted formats and requirements, please see our website http://www.elsevier.com/locate/authorartwork. During the online submission, multimedia and supplementary files can be uploaded by selecting “Multimedia and Supplementary Files” in the “Item” menu.

Examples of accepted files are:

- for images: .gif, .tif, .jpg, .svg, .png, etc.,
- for videos: .mov, .avi, etc.,
- for spreadsheets: .xls, etc.
- for presentations: .ppt, .pps, etc.

5. AFTER SUBMISSION

Any manuscript proposed is submitted to the opinion of expert proof-readers, the approval of which, after any modifications, is required for its publication (the average time of the peer review process is estimated at 2 months). The editorial staff reserves the right to change the layout of the manuscript to adapt it to the review’s style. The authors concerned will receive, before the proofs of their article, a form of transfer of rights which the corresponding author must sign on behalf of all authors, as well as an order form for off-prints. Content modifications are not accepted in proofs. Corrections are limited to typography. The authors will perform any action to return to the publisher the form of transfer of rights duly signed, as well as these proofs with the note “OK for printing”, within 48 hours after their reception, regardless of the period of the year. In case of delay, the publisher reserves the right to print without the author’s off-print approval. Once published, right to reproduce must be asked directly to the journal.

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authorsupport@elsevier.com