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RECUPERAÇÃO PÓS-TREINAMENTO EM JOGADORES DE FUTSAL DE ALTO RENDIMENTO:

Existem perfis mais rápidos e mais lentos?

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Escola de Educação Física, Fisioterapia e Terapia Ocupacional - UFMG

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POST-TRAINING RECOVERY IN ELITE FUTSAL PLAYERS:

Are there faster and slower profiles?

Tese desenvolvida em regime de cotutela, apresentada ao Curso de Doutorado em Ciências do Esporte da Escola de Educação Física, Fisioterapia e Terapia Ocupacional da Universidade Federal de Minas Gerais, e à University of Health da University of Technology Sydney como requisito parcial à obtenção do título de Doutor em Ciências do Esporte / PhD (Sport and Exercise).

Orientador: Prof. Dr. Samuel Penna Wanner

Co-orientador: Prof. Dr. Rob Duffield

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CERTIFICATE OF ORIGINAL AUTHORSHIP

I, Carolina Franco Wilke declare that this thesis, is submitted in fulfilment of the requirements for the award of Doctor of Philosophy (Sports and Exercise), in the Faculty of Health at the University of Technology Sydney.

This thesis is wholly my own work unless otherwise reference or acknowledged. In addition, I certify that all information sources and literature used are indicated in the thesis.

I certify that the work in this thesis has not previously been submitted for a degree nor has it been submitted as part of the requirements for a degree at any other academic institution except as fully acknowledged within the text. This thesis is the result of a Collaborative Doctoral Research Degree program with Universidade Federal de Minas Gerais.

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Signature:

Date: 09 March 2019

Aos meus pais.

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“Faça as coisas o mais simples que você puder,

porém não se restrinja às mais simples.”

(Albert Einstein)

RESUMO

Objetivos: 1) caracterizar 48h de recuperação do desempenho físico, parâmetros fisiológicos e perceptivos de jogadores de alto rendimento de futsal após uma sessão de treinamento específica de alta intensidade; 2) investigar se os jogadores poderiam ser classificados em perfis de recuperação rápido ou lento pós-treinamento e identificar os fatores que os diferenciam; 3) investigar se tais perfis agudos de recuperação seriam mantidos durante um programa de monitoramento durante um período de pré-temporada e 4) investigar se a recuperação dos jogadores poderia ser melhorada com o treinamento. **Métodos:** Jogadores de futsal das equipes profissional (PROF) ou sub-20 (U20) participaram do estudo. No início e no final da pré-temporada, os participantes foram submetidos a uma sessão de treinamento de alta intensidade em que medidas psicofisiológicas e de desempenho foram registradas antes, imediatamente, 3, 24 e 48 horas após a sessão: Salto de contramovimento (CMJ), sprint de 10m com mudança de direção, concentração sanguínea de creatina quinase (CK), escala de percepção de recuperação (TQR) e Escala de Humor de Brunel. Além disso, cargas de treinamento externas (Player Load) e internas (percepção subjetiva do esforço e frequência cardíaca) foram monitoradas em cada sessão. Durante a pré-temporada de 10 semanas, a carga de treinamento e a recuperação (TQR, duração do sono e qualidade) também foram monitoradas. A análise estatística para responder aos respectivos objetivos consistiu em: 1 e 4) inferência baseada em magnitude; 2) classificação: análise hierárquica de cluster; comparações entre os clusters: análise de variância com um fator de variação; e 3) modelo de regressão linear mista. **Resultados / conclusões:** Após uma sessão de treinamento técnico-tático de futsal de alta intensidade de 70 min, o desempenho físico dos jogadores foi pouco modificado, a percepção de recuperação retornou aos valores iniciais após 24 h, enquanto CK e humor permaneceram elevados até 48 horas após a sessão. A análise de cluster baseada em 22 jogadores e 6 parâmetros identificou três perfis de recuperação. Um grupo de recuperação global (físico e psicológico) mais rápido, possivelmente afetado positivamente pela maior capacidade aeróbica. Curiosamente, dois grupos foram classificados com perfis de recuperação mais lenta distintos, condicionados por respostas nos parâmetros fisiológicos ou perceptuais, potencialmente influenciados pelo maior desempenho de potência e experiência dos atletas, respectivamente. Os perfis de recuperação aguda não influenciaram significativamente a percepção de recuperação diária desses jogadores, que foi afetada pela qualidade do sono e pela fase do microciclo, independentemente da carga de treinamento do dia anterior. Por fim, após 10 semanas de treinamento específico de futsal de pré-temporada, a recuperação de 7 jogadores U20 na maioria dos parâmetros avaliados foi melhor, mesmo que o desempenho físico tenha sido mantido.

Palavras-Chave: Recuperação, desempenho, treinamento.

ABSTRACT

Aims: 1) to characterize a 48 h timeline of recovery of physical performance, physiological and perceptual parameters of elite futsal players from a high-intensity-specific training session, 2) to investigate whether players could be classified into faster and slower post-training recovery profiles and the factors differentiating them; 3) to investigate whether such acute recovery profiles would be maintained during a pre-season ongoing monitoring program and 4) to investigate whether players' recovery could be improved following pre-season training. **Methods:** Elite futsal players from the professional and under-20 (U20) squads of the same Brazilian futsal team participated in the study. At the start and at the end of the pre-season, participants underwent a training session where performance and psycho-physiological measures were recorded before, immediately, 3, 24 and 48h post-session. Measures included countermovement jump (CMJ), 10m sprint with change of direction, creatine kinase (CK), total quality recovery scale (TQR) and Brunel Mood Scale. Additionally, external (player load) and internal (rating of perceived exertion – RPE and heart rate – HR) training loads were monitored during each session. During the 10-week pre-season, training load and recovery (TQR, sleep duration and quality) were also monitored. Statistical analysis to answer to respective aims comprised: 1 and 4) comparisons were performed using magnitude-based analysis; 2) classification was attained by a hierarchical cluster analysis and comparisons between clusters through one-way analysis of variance; and 3) effect of each parameter in TQR was tested using a linear mixed model. **Results/conclusions:** After a 70 min high-intensity technical-tactical futsal training session, players' physical performance was little modified, perception of recovery returned to baseline after 24 h, whereas CK and mood parameters remained elevated up to 48 hours after the session. A hierarchical cluster analysis based on 22 individual responses of these 6 parameters identified three recovery profiles. A faster global (physical and psychological) recovery profile existed, possibly positively affected by higher aerobic capacity. Interestingly, two groups were classified with distinct slower recovery profiles conditioned by responses in either physiological or perceptual parameters, potentially influenced by higher speed/power performance and higher age/experience of athletes, respectively. The acute recovery profiles did not significantly influence daily recovery perception of these players, which was affected by sleep quality and phase within the microcycle, regardless of the previous day's training load. Finally, after 10 weeks of pre-season futsal-specific training, 7 U20 players' recovery timeline in most evaluated parameters were improved even though physical fitness was maintained.

Keywords: Recovery, performance, training.

LISTA DE PUBLICAÇÕES INCLUSAS NA TESE

(*LIST OF PAPERS/PUBLICATIONS INCLUDED*)

ESTUDO 1. *Recovery time course of physical, physiological and psychometric parameters following training in Brazilian futsal players*

*Artigo submetido ao periódico *Journal of Sports Science and Medicine no dia 07 de março de 2019* (Qualis A2).

**Submitted to the Journal of Sports Science and Medicine on 07 March 2019. http://www.johk.pl/*

ESTUDO 2. *Faster and slower post-training recovery in futsal: multifactorial classification of recovery profiles.*

*Artigo aceito para publicação no dia 09 de Janeiro de 2019 no periódico *International Journal of Sports Physiology and Performance* (Qualis A1).

**Accepted for publication at the International Journal of Sports Physiology and Performance on 09 January 2019.*

ESTUDO 3. *Daily perceived recovery in futsal players; influence of recovery profile, training load and perceived sleep.*

*Artigo submetido ao periódico *International Journal of Sports Physiology and Performance* no dia 07 de março de 2019 (Qualis A1).

**Under review on the International Journal of Sports Physiology and Performance, submitted on 07 March 2019.*

ESTUDO 4. *Can training influence post-session recovery? A case study of Brazilian futsal players before and after a pre-season.*

*Artigo submetido ao periódico *Plos One* no dia 08 de março de 2019 (Qualis A1).

**Submitted to Plos One on 08 March 2019.*

LISTA DE ILUSTRAÇÕES E TABELAS

Estudo 4:

LISTA DE ABREVIATURA E SIGLAS

AUC	Área sob a curva
BRUMS	Escala de Humor de Brunel
CI	Intervalo de confiança
CK	Creatina quinase
CMJ	Salto com contramovimento
ES	Tamanho do efeito
FR	Cluster de recuperação mais rápida
HR	Frequência cardíaca
MBI	Inferência baseada em magnitude
PL	Player load
PrePS	Antes do início do período de treinamento de pré-temporada
PostPS	Após o início do período de treinamento de pré-temporada
PROF	Equipe profissional
RPE	Percepção subjetiva de esforço
SD	Desvio padrão
SLperc	Cluster de recuperação perceptiva mais lenta
SLphy	Cluster de recuperação fisiológica mais lenta
SME	Período do microciclo (início, meio e fim)
sRPE	Percepção subjetiva de esforço da sessão
TQR	Escala de qualidade total da recuperação
TRIMP	Impulso de treinamento
U20	Equipe sub-20
USG	Gravidade específica da urina
VO_2max	Consumo máximo de oxigênio
VT	Limiar ventilatório
%HRmax	Percentual da frequência cardíaca máxima

SUMÁRIO

1 INTRODUÇÃO

O processo de recuperação pós-exercício permite o retorno de alterações fisiológicas, perceptivas e/ou de desempenho induzidas por sessões de treinamento, jogos ou competições para valores próximos aos de repouso, por meio da interação de fatores centrais e periféricos (KELLMANN *et al.*, 2018)". A recuperação adequada entre jogos ou sessões de treinamento é importante para promover adaptações positivas nos atletas, além da prontidão para o desempenho esportivo. A tendência atual de calendários competitivos extensos e com alta frequência de jogos e competições ("calendários congestionados") impõe aos atletas a necessidade de manter desempenhos físico e técnico/tático adequados durante períodos prolongados. Essa sobreposição de estímulos contribui para um elevado estresse fisiológico e psicológico de atletas, além de reduzir o tempo disponível para a recuperação entre partidas e sessões de treinamento. Nesse contexto, é evidente a importância do cuidado com a relação entre estresse e recuperação dos atletas para garantir as adaptações desejadas ao treinamento, além de evitar estados de subtreinamento ou overtraining (BISHOP *et al.*, 2008).

Tal cenário impulsionou o aumento no número de estudos científicos que investigaram a efetividade de estratégias para reduzir o tempo de recuperação após jogos e sessões de treinamento. De fato, algumas delas reduziram o tempo para recuperação de atletas, como a imersão em água fria (DUFFIELD *et al.*, 2014), a massagem (DUPUY *et al.*, 2018) e a suplementação nutricional (WANNER *et al.*, 2016). Entretanto, o tamanho do efeito dessas intervenções é muitas vezes pequeno (HIGGINS *et al.*, 2017), possivelmente devido à elevada variação individual de respostas pós-exercício.

Uma consequência dessa variedade de respostas é que a prescrição de cargas de treinamento semelhantes para todos os atletas de uma mesma equipe, prática comum em esportes coletivos (NEDELEC *et al.*, 2014), pode gerar adaptações individuais diferentes, mesmo quando a intensidade do exercício é relativizada pela capacidade máxima dos atletas. Aubry *et al.* (2014) submeteram 24 triatletas com idade e capacidade aeróbica semelhantes a sete semanas de treinamento com mesmo volume e mesma intensidade relativa. Ao final desse período, um grupo de 11 atletas apresentou redução no desempenho, enquanto 12 melhoraram seu desempenho. Baseados na percepção reportada pelos atletas, os autores apontaram a recuperação inadequada entre sessões como uma das razões para o insucesso do treinamento em melhorar o seu desempenho após um período de supercompensação. Com isso, ilustra-se a importância de se ampliar o conhecimento acerca das diferentes "capacidades" de recuperação pós-exercício, e quais fatores podem influenciá-las. Considerando a importância da recuperação no desempenho esportivo, parece relevante investigar esse processo em situações reais que envolvam atletas de alto rendimento.

O futsal é um esporte caracterizado por conter ações de alta intensidade, gerando um elevado estresse psico-fisiológico em jogadores (RODRIGUES *et al.*, 2011). Após estímulos de jogos, os poucos estudos encontrados na literatura demonstram que o desempenho físico em esforços de curta duração (potência de membros inferiores, sprints, sprints repetidos e saltos repetidos) retorna a valores basais em até 24 h, enquanto marcadores de dano muscular e estresse oxidativo ainda podem estar aumentados após 48 h. Apesar de esse período de recuperação ser menor do que aquele observado em outras modalidades esportivas coletivas, como o futebol (SILVA *et al.*, 2018) e o rúgbi (JOHNSTON, GABBETT e JENKINS, 2015), é notório o alto número de sessões de treinamento realizadas em cada microciclo no futsal (SOARES-CALDEIRA *et al.*, 2014). Com isso, o entendimento da recuperação pós-treinamentos parece importante para o planejamento da aplicação de cargas que permitam que os atletas estejam aptos a desempenhar em treinos subsequentes e em dias de jogos.

2 REVISÃO DE LITERATURA

2.1 Recuperação

A recuperação pós-exercício físico é um fenômeno multifatorial, no qual fatores centrais e periféricos interagem para permitir o retorno de alterações fisiológicas, perceptivas e/ou de desempenho induzidas pelo exercício, para valores próximos aos de repouso (KELLMANN *et al.*, 2018). Dessa forma, é importante que o estudo e monitoramento da recuperação envolvam parâmetros das diferentes dimensões supracitadas para um entendimento global desse processo. Tal importância torna-se ainda mais evidente pelo fato de que diferentes parâmetros utilizados no monitoramento da recuperação apresentam tempos diferentes para retorno aos valores pré-exercício. Por exemplo, uma metanálise recente sobre a recuperação pós-jogo no futebol concluiu que, enquanto o desempenho de sprint, as respostas hormonais e os parâmetros relacionados à habilidade / técnica são restaurados em 72 h, o dano muscular, o desempenho no salto com contramovimento (CMJ) e o bem-estar percebido pelos atletas demandam mais tempo (SILVA *et al.*, 2018).

Essa característica multifatorial representa um desafio para a interpretação de resultados obtidos em programas de monitoramento de recuperação frequentemente utilizados em equipes esportivas de alto rendimento. Estudos que caracterizam a linha do tempo da recuperação de diferentes parâmetros após sessões de treinamento e jogos podem auxiliar nessa interpretação por meio da identificação de resultados "esperados" em diferentes intervalos de tempo pós-exercício. Tais informações podem ser utilizadas tanto por profissionais que utilizam esses parâmetros no monitoramento de atletas após exercícios, quanto por aqueles que não têm essa possibilidade, munindo tais profissionais de referências de intervalos médios dentro dos quais espera-se que atletas ainda estejam em processo de recuperação, ou já se encontrem aptos a desempenhar no esporte. Assim, é possível que a tomada de decisão acerca do intervalo entre sessões de treinamento e jogos, assim como da necessidade (ou não) da utilização de recursos que visam acelerar a recuperação, possa ser feita com maior segurança pelos profissionais envolvidos.

Mesmo sendo o conhecimento sobre a linha do tempo da recuperação após sessões de treinamento e jogos um passo importante para a melhor atuação de profissionais do esporte, o fato de os estudos acerca do tema reportarem somente valores médios dos parâmetros avaliados oculta a variabilidade da recuperação inter- e intra-atleta (HEIDARI *et al.*, 2018). Em consonância com o princípio da individualidade biológica do treinamento esportivo; (HOFFMAN, 2014; WEINECK, 2003) e com as características individuais (por exemplo: capacidade aeróbica) (TOMLIN, 2001) e contextuais (por exemplo: carga de treinamento) (JOHNSTON, GABBETT E JENKINS, 2015) já identificadas como fatores intervenientes no tempo necessário para recuperação de atletas; é sugerido que, além da análise de dados de monitoramento individuais (WARD *et al.*, 2018), a prescrição do tempo e estratégias que visam acelerar a recuperação também seja realizada de forma individualizada (KELLMANN *et al.*, 2018). Entretanto, equipes esportivas por vezes encontram dificuldades em atuar desta forma, devido ao número reduzido de profissionais frente ao número de atletas e/ou devido à incompatibilidade logística com a rotina dos atletas após sessões de treinamento ou competições. Nesse contexto, identificar grupos de atletas com perfis de recuperação mais rápido ou mais lento permitiria que os profissionais se concentrassem em grupos menores que compartilham algumas características predominantes.

Tal abordagem assemelha-se a estratégias de pesquisa em saúde, em que a identificação de padrões em situações multifatoriais (por exemplo: diagnóstico de doenças) auxilia os profissionais na seleção da intervenção mais eficaz. No esporte, métodos semelhantes já foram utilizados: Evans *et al.* (2018) aplicaram uma ferramenta estatística de classificação (análise de cluster) aos resultados de 8 avaliações diagnósticas, e classificaram 28 jogadores profissionais de rúgbi em 4 perfis de risco de lesão; esta informação foi usada como base para o desenvolvimento de programas preventivos direcionados às necessidades desses jogadores. Consequentemente, parece razoável sugerir que a identificação dos perfis de recuperação dos atletas poderia fornecer meios para uma prescrição mais precisa do tempo de recuperação, intervenções (para acelerar esse processo) e cargas de treinamento.

Variáveis fisiológicas associadas aos sistemas cardiovascular, neuromuscular e imunológico, variáveis perceptivas, cognitivas e psicológicas, além do desempenho em testes que avaliam diferentes capacidades físicas, têm sido utilizados para mensurar o estado de recuperação de um indivíduo imediatamente, horas e/ou dias após o exercício (BISHOP *et al.*, 2008; NEDELEC *et al.*, 2012). A escolha do(s) parâmetro(s) utilizados no esporte de alto rendimento está associada ao custo, demanda de tempo e logística. Para a avaliação do desempenho físico, testes que demandam pouco equipamento, que sejam de rápida aplicação e que avaliem capacidades físicas importantes para o desempenho esportivo são os mais populares. Nesse sentido, em esportes coletivos de invasão, o salto com contramovimento é utilizado como um indicador da potência de membros inferiores (ATTIA *et al*. 2017), enquanto os testes de sprint com ou sem mudança de direção são utilizados como indicadores das capacidades de aceleração, desaceleração e velocidade máxima (de acordo com a distância) frequentemente demandadas durante o jogo. Dentre os parâmetros fisiológicos, a concentração sanguínea de creatina quinase (CK), um marcador indireto do dano muscular, tem sido amplamente utilizada por demonstrar sensibilidade à carga de treinamentos e jogos (ALVES *et al.*, 2015; SILVA *et al.*, 2018). Avaliações psicométricas têm recebido grande atenção devido à facilidade de aplicação. A escala de qualidade total de recuperação (total quality recovery scale – TQR) (KENTTA e HASSMEN, 1998) demonstrou sensibilidade a estímulos agudos promovidos por jogos de basquete (DOEVEN *et al.*, 2017) e de futebol juvenil (PAUL *et al.*, 2018); e crônica durante uma temporada de voleibol de elite (DEBIEN *et al.*, 2018).

Como mencionado anteriormente, diferentes fatores externos podem influenciar o estado de recuperação de atletas e, consequentemente, os resultados dos parâmetros de monitoramento. O TQR apresentou correlações negativas com a carga de treinamento semanal em atletas de voleibol de elite (DEBIEN *et al.*, 2018). Microciclos de treinamento mais longos (9 dias) evidenciaram maior fadiga e menores escores de bem-estar em comparação aos microciclos mais curtos (5 dias) no rúgbi (MCLEAN *et al.*, 2010), sugerindo o impacto da fadiga acumulada. Além disso, um aumento na duração reportada de sono influenciou positivamente a recuperação percebida de jogadores colegiais de diferentes esportes (basquete, criquete, futebol, hóquei, netball, rúgbi e natação), (SAWCZUK *et al.*, 2018). Portanto, entender como diferentes fatores impactam a percepção de recuperação de atletas pode auxiliar profissionais do esporte a melhorar a manipulação de estratégias de treinamento e recuperação.

Além disso, estudos têm mostrado que a capacidade de recuperação de um atleta está associada à sua capacidade física, em especial à capacidade aeróbica (JOHNSTON, GABBETT e

JENKINS, 2015; TOMLIN, 2001). Entretanto, esta associação é baseada, principalmente, no conhecimento das adaptações fisiológicas que possibilitam o aumento do consumo máximo de oxigênio ($VO_{2máx}$) e que, teoricamente, poderiam auxiliar na recuperação após o exercício. Outro aspecto que reduz a robustez desta associação é o fato de estar baseada em evidências de estudos transversais que compararam a recuperação de grupos de indivíduos com alta e baixa capacidade aeróbica (TOMLIN, 2001). Johnston, Gabbett e Jenkins (2015) mostraram que atletas mais fortes e mais resistentes se recuperaram mais rapidamente após uma partida simulada de rúgbi. Entretanto, ainda não se sabe se o aumento da capacidade aeróbica por meio do treinamento físico é capaz de melhorar a recuperação pós-exercício.

2.2 Futsal

2.2.1 Demanda de jogos oficiais

O futsal é caracterizado pela realização de esforços físicos intermitentes e de alta intensidade (RODRIGUES *et al.*, 2011). Partidas oficiais são disputadas por 5 jogadores em cada time, sendo um deles o goleiro, em quadra coberta com dimensão de 38–42 x 18–25 m. Os 20 min de partida são interrompidos a cada parada no jogo e entre os dois tempos, o que eleva a duração média para aproximadamente 80 min (RODRIGUES *et al.*, 2011), durante os quais são percorridos entre 3 e 6 km em ações que incluem mudanças de direção, corridas de alta intensidade e sprints (DE OLIVEIRA BUENO *et al.*, 2014). Em média, os jogadores realizam 26 sprints com distância de 13,3 ± 5,7 m. Além disso, um estudo que caracterizou os sprints repetidos realizados durante partidas oficiais observou que a sequência mais comumente encontrada foi de dois sprints consecutivos, com intervalo de até 15 s entre eles (CAETANO *et al.*, 2015).

Mesmo com a regra de substituições ilimitadas e em tempo livre ao longo da partida, a alta intensidade dos esforços parece afetar, em parte, o desempenho físico dos atletas de futsal quando comparados o primeiro e o segundo tempo de jogo. Barbero-Alvarez *et al.* (2008) observaram redução da distância percorrida por minuto de jogo e aumento da distância em baixa intensidade no segundo tempo. Entretanto, outros estudos sugerem que a distância em ações de alta intensidade parece ser mantida durante todo o jogo. Por exemplo, nesse mesmo estudo, foi observada manutenção do percentual de ações em velocidade máxima, semelhante aos achados de Caetano *et al.* (2015), que não observaram diferença no número, distância ou velocidade máxima de sprints entre o primeiro e o segundo tempo. Entretanto, diferentemente de esportes coletivos jogados em campos de maior dimensão (RAMOS *et al.*, 2017), não têm sido observadas diferenças nas ações motoras de deslocamento entre jogadores de diferentes posições de linha no futsal (alas, pivôs e fixos) (BARBERO-ALVAREZ *et al.*, 2008).

Como consequência da alta demanda física, um elevado estresse fisiológico é observado nos atletas durante e após jogos. Estudos já reportaram valores médios de frequência cardíaca (FC) correspondentes a 85–95% da FC máxima (FCmáx) durante jogos oficiais (RODRIGUES *et al.*, 2011), e aumento na concentração de marcadores inflamatórios (interleucina 6 – IL-6 e proteína C reativa – PCR) e de dano muscular (creatina quinase – CK e lactato desidrogenase – LDH) após jogos oficiais (DE MOURA *et al.*, 2012; DE MOURA *et al.*, 2013). Ainda, estudos que realizaram jogos simulados com protocolos de deslocamento em quadra ou frações de jogos (4 x 10 min de jogo) verificaram redução do pico de torque em avaliação isocinética para as ações concêntrica e excêntrica de membros inferiores (DAL PUPO *et al.*, 2014); redução do desempenho em sprints repetidos, no CMJ (MOREIRA *et al.*, 2015) e da força máxima isométrica de membros inferiores (MILIONI *et al.*, 2016). A percepção subjetiva de esforço (PSE) reportada pelos atletas nesse contexto também é alta, entre “difícil” e “muito difícil” (MOREIRA *et al.*, 2015).

2.2.2 Características de treinamento

A mensuração da carga de treinamento tem recebido grande atenção por pesquisadores com o obejtivo de entender sua relação direta com o desempenho esportivo, seja de forma positiva (ou seja, melhoria do desempenho como consequência da administração de uma determinada carga) ou negativa (aumento da probabilidade de lesões, distúrbios de saúde, ocorrência *overtraining* e *dropout,* e a consequente redução no desempenho esportivo). Em esportes coletivos de invasão, nos quais as ações motoras são realizadas frente a situações que exigem tomadas de decisão, as ações realizadas pelos atletas (carga externa) e a resposta a esses estímulos (carga interna) dificilmente são padronizadas. Nesse contexto, a identificação de padrões médios de estímulos físicos promovidos por atividades frequentemente realizadas em treinamento é fundamental para alcançar o objetivo citado acima e permitir uma prescrição mais assertiva do treinamento.

Nesse sentido, realizamos um estudo para quantificar a carga de treinamentos técnico-táticos de futsal realizados durante o período competitivo e que incluíam atividades com características semelhantes àquelas de jogos oficiais (WILKE *et al.*, 2016). A média diária da PSEsessão (PSE x duração do treino) (FOSTER *et al.*, 2001) foi 448 ± 92 UA, semelhante a valores médios de 338 a 645 UA, relatados recentemente por Clemente *et al.* (2019), durante uma temporada de uma equipe portuguesa. A intensidade média das sessões de treinamento foi 74 ± 4% da FCmáx, o que corresponde a 9,3 kcal/min ou 7,7 METs. Os jogadores mantiveram intensidade alta em 20 ± 8% do tempo das sessões, moderada em 28 ± 6% e baixa em 51 ± 10%, sendo aproximadamente 40% da duração das sessões destinados às pausas entre exercícios ou para instruções, demonstrando assim a alta intensidade dos treinamentos. Quando as seguintes atividades – 1) envolvendo o mesmo número de jogadores de uma partida oficial com diferentes orientações técnico-táticas, 2) uma simulação de partida e 3) uma atividade com superioridade numérica (6x4 jogadores de linha) – foram comparadas, não se verificou diferença na intensidade mensurada por meio da FC. Esse é o único estudo do qual tenho conhecimento acerca da caracterização da intensidade de diferentes atividades de treinamento no futsal.

Em equipes brasileiras de alto rendimento, a frequência de jogos durante o período competitivo é de 1 a 3 partidas por semana, incluindo jogos por campeonatos metropolitanos, estaduais, nacionais e internacionais. Vale ainda ressaltar que, para promover ajustes técnico-táticos durante o período competitivo, é comum observar equipes com apenas um dia sem treinamentos na semana, mesmo durante períodos mais congestionados do calendário. No estudo citado acima (WILKE *et al.*, 2016), por exemplo, foram realizadas em média 5 sessões técnico-táticas por semana acrescidas de 2 sessões/semana de treinamento de força; além disso, já foi relatado um total de até 10 sessões por semana durante uma pré-temporada (SOARES-CALDEIRA *et al.*, 2014). Nesse contexto, fica evidente a importância de os atletas apresentarem uma boa capacidade de recuperação após estímulos de alta intensidade para garantir um bom desempenho em sessões de treinamentos, além de estarem aptos para desempenhar bem em jogos realizados ao final de um microciclo.

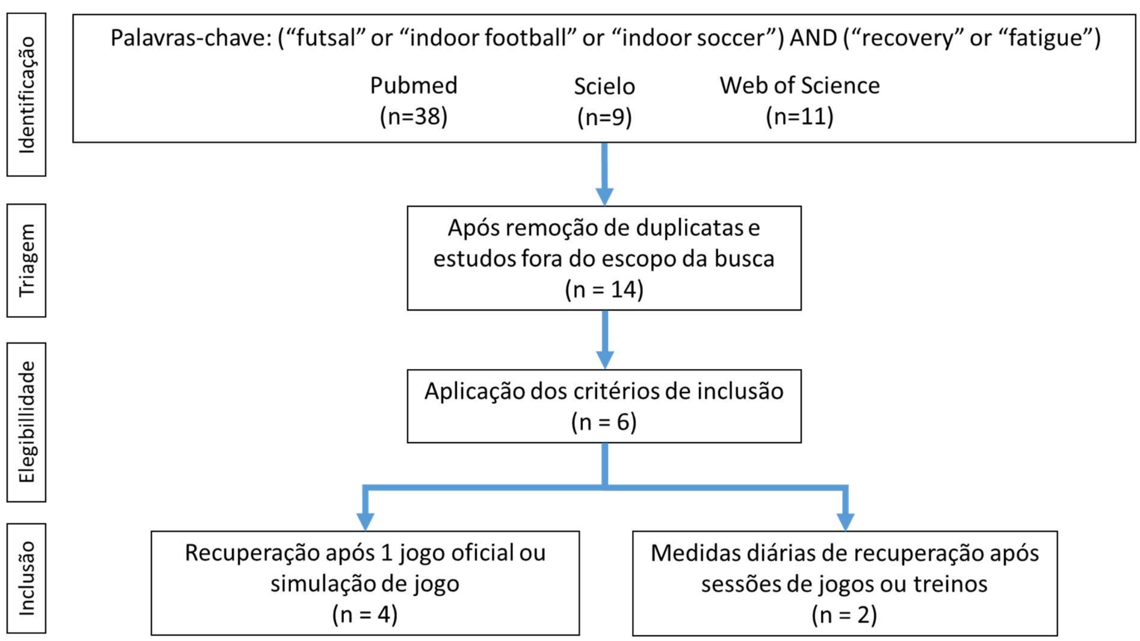
No principal campeonato nacional de futsal do Brasil (Liga Futsal), as equipes possuem um calendário de aproximadamente 1 a 3 jogos por semana durante um período de até 6 meses, dependendo da classificação para as fases finais da competição. Esse calendário, de característica semelhante aos calendários de outros esportes coletivos, faz com que o período de pré-temporada (antes do início das datas de competições oficiais) seja o momento mais propício para o aumento das capacidades físicas dos jogadores (MILOSKI *et al.*, 2016). Para tanto, treinamentos específicos de força, potência e velocidade são comumente utilizados. Contudo, treinamentos em quadra com atividades que se assemelham ao jogo (por exemplo: jogos reduzidos e simulações de jogos) também são frequentemente prescritos com o objetivo de desenvolvimento conjunto de habilidades técnico-táticas e de capacidades físicas específicas à modalidade (OLIVEIRA *et al.*, 2013). De fato, Oliveira et al. (2013) observaram um aumento das capacidades aeróbica e anaeróbica após a pré-temporada, e a manutenção desses ganhos durante a temporada em um time de futsal brasileiro. Outros estudos também observaram aumento da capacidade aeróbica e da capacidade de realizar sprints repetidos em jogadores sub-20 (U20) e profissionais (PROF) ao final da pré-temporada (SOARES-CALDEIRA *et al.*, 2014; MILOSKI *et al.*, 2016; NOGUEIRA *et al.*, 2018).

A capacidade aeróbica parece influenciar positivamente o desempenho físico de atletas (BARBERO-ALVAREZ *et al.*, 2008) e a sua percepção de esforço em treinamentos (MILANEZ *et al.*, 2011). Considerando essa informação e a influência da capacidade aeróbica na recuperação de atletas, citada anteriormente (TOMLIN, 2001), é razoável inferir que a melhora de capacidades físicas por meio do treinamento poderia melhorar também a recuperação de atletas. Entretanto, esta hipótese ainda não foi investigada.

2.2.3 Recuperação no futsal

Para revisão da literatura acerca do processo de recuperação no futsal, foi realizada uma busca sistemática nos bancos de dados Pubmed, Web of Science e Scielo, utilizando o termo "futsal" (e seus sinônimos "indoor football" e "indoor soccer" em inglês; e "futebol de salão em português), combinado com os termos "recuperação" ou "fadiga", com a seguinte frase de pesquisa: "(futsal OR indoor football OR indoor soccer OR futebol de salão) AND (recovery OR fatigue)". Apenas artigos científicos escritos em inglês ou português foram considerados. A busca, realizada em janeiro de 2019, resultou em 54 citações (Figura 1). Como critério de inclusão, foram considerados apenas os artigos que tivessem: 1) realizado avaliações em situações agudas, mensurando parâmetros de desempenho, fisiológicos e/ou psicológicos antes e, no mínimo, 2 vezes após uma situação experimental (treinamentos, jogos oficiais, coletivos durante treinamentos; ou protocolos em quadra simulando ações motoras de jogos); ou 2) realizado avaliações com objetivo de verificar a recuperação de atletas em dias consecutivos de treinamentos ou jogos, e que tenham reportado os resultados de cada um deles. Estudos que tiveram como amostra atletas de futsal, mas que realizaram como situação experimental protocolos de exercício sem relação direta com ações de jogos oficiais da modalidade (por exemplo: testes yoyo e sprints repetidos), não foram incluídos. Após a remoção de estudos duplicados ou fora do escopo do tema, e a aplicação dos critérios de inclusão, apenas 6 artigos foram retidos.

Figura 1: Fluxograma da revisão de literatura.



A tabela 1 resume os artigos retidos que investigaram a recuperação de atletas de futsal após estímulos agudos. Foram incluídas na tabela apenas aquelas variáveis que foram avaliadas, pelo menos, 2 vezes pós-jogo. Somente situações de jogos oficiais e simulados foram encontradas, sempre com a realização de 2 medidas pós-jogo, sendo uma imediatamente após e outra 5 h (TESSITORE *et al.*, 2008), 24 h (SOUZA *et al.,* 2010; MOREIRA *et al.*, 2015) ou 48 h após (DE MARCHI *et al.*, 2019).

Dos 4 estudos, 2 tiveram como objetivo principal investigar o efeito de uma ou mais estratégias pós-jogo de aceleração do processo de recuperação em comparação com situações controles (TESSITORE *et al.*, 2008; MOREIRA *et al.*, 2015). Imediatamente após a imersão em água fria, os resultados de desempenho físico foram piores do que na situação controle (MOREIRA *et al.*, 2015), enquanto não foram observardas diferenças nos momentos de recuperação (5 h e 24 h pós-jogo) entre a situação controle e as estratégias testadas (TESSITORE *et al.*, 2008; MOREIRA *et al.*, 2015; respectivamente). Além desses dois trabalhos, um terceiro estudo também teve como objetivo testar a eficácia da utilização de um método para acelerar a recuperação, porém realizado antes da partida; os autores encontraram resultados satisfatórios nas concentrações sanguíneas de lactato, CK, LDH, e proteínas carboniladas 48 h pós-jogo (DE MARCHI *et al.*, 2019). Com o objetivo de levantar informações sobre a recuperação de atletas de futsal, apenas os resultados das situações controles serão apresentados.

A recuperação do desempenho em testes físicos foi avaliada apenas nos dois estudos citados no paragrafo anterior (TESSITORE *et al.*, 2008; MOREIRA *et al.*, 2015). Em ambos, houve redução da altura de salto CMJ e da altura média em saltos repetidos (7 saltos consecutivos - (TESSITORE *et al.,* 2008); ou saltos realizados durante 15 s - (MOREIRA *et al.*, 2015) logo após a situação experimental. A redução do desempenho imediatamente após, seguida de recuperação 24 h após, também foi observada no tempo médio de sprints repetidos (5 x 30 m com 25 s de intervalo ativo) (MOREIRA *et al.*, 2015). O desempenho de sprint (10 m) foi avaliado em apenas um estudo (TESSITORE *et al.*, 2008), e os resultados mostraram que tal desempenho reduziu pós-jogo e retornou a valores basais 5 h após.

A maioria das variáveis analisadas nos quatro estudos foram fisiológicas. A concentração de CK se manteve aumentada até 48 h pós-jogo (SOUZA *et al.,* 2010; DE MARCHI *et al.*, 2019), diferentemente da concentração de LDH, que retornou a valores semelhantes aos valores pré-jogo nesse tempo (DE MARCHI *et al.*, 2019). Esses mesmos dois estudos investigaram o efeito de uma sessão de jogo (simulado e oficial, respectivamente) em marcadores de estresse oxidativo, que aumentaram em ambos, mantiveram-se alterados 24 h após (SOUZA *et al.*, 2010) e retornaram a valores pré-jogo 48 h após (DE MARCHI *et al.*, 2019).

Apenas um estudo investigou respostas perceptivas pós-jogos de futsal; foi avaliada a percepção de dor muscular, que permaneceu aumentada até 48 h após, momento em que o acompanhamento foi interrompido (MOREIRA *et al.*, 2015).

Em relação às respostas de fadiga e recuperação em dias consecutivos de estímulos, novamente foram encontrados artigos envolvendo apenas situações de jogos oficiais, sendo 1 jogo disputado por dia em 4 dias consecutivos (Tabela 2). O desempenho de saltos avaliado antes de todos os jogos apresentou piora em relação aos resultados obtidos antes do 1º jogo (FREITAS *et al.,* 2014), assim como a percepção de estresse e dor muscular (CHARLOT *et al.*, 2016). Já a percepção de fadiga e a qualidade de sono não foram modificadas ao longo da competição, mesmo com uma maior percepção de esforço (PSE) após os jogos 2 e 3 quando comparados ao jogo 1 (CHARLOT *et al.*, 2016). Após a fase final de um torneio estadual, os atletas reportaram piora nas dimensões de recuperação física e lesões, mas não nas outras dimensões que compõem o Questionário de Estresse e Recuperação para Atletas (REST-Q) (FREITAS *et al.,* 2014).

Tabela 1: Artigos que abordaram a recuperação de jogadores de futsal após um jogo, ou jogo simulado.

Autores	Amostra	Tratamento	Situação experimental	Intensidade	Tempos das avaliações	Variáveis	Resultados (situação controle) Pós	4-5h pós	24h pós	48h pós	Efeito do tratamento
De Marchi et al., 2018	6 jogadores profissionais (26 ± 7 anos)	Utilização de biofotomodulação pré-jogo (situações experimental e controle)	Jogo oficial (2 x 20min com interrupções)	Não foi mensurada	Pré, pós e 48h pós	[Lac] [CK] [LDH] TBARS Proteinas carboniladas	↑ ↑ ↑ ↑ ↑			↑ ↑ ↔ ↔ ↑	24% > tempo em jogo = distância percorrida < [Lac], [CK], Proteinas carboniladas pós e 48h < [LDH] e [TBARS] pós jogo.
Moreira et al., 2015	10 jogadores profissionais (24 ± 3 anos)	Imersão em água fria (IAF) Controle	Jogos simulados (4x 10min sem interrupções)	PSE (0-10): Jogo 1: 6.8 ± 1.4, Jogo 2: 6.7 ± 1.2 (Ambos de "Difícil" a "Muito difícil")	Pré, pós, 24h pós	Dor muscular CMJ Máxima altura média de saltos em 15s Sprints repetidos (5 x 30m)	↑ ↓ ↓ ↑		↑ ↔ ↔ ↔		Pior desempenho de CMJ, saltos em 15s, e sprints repetidos logo após a IAF x controle Sem diferença entre situações após 24h.
De Souza et al., 2010	6 jogadores profissionais (21 ± 1 anos)	Não	Jogo (2 x 20min com interrupções)	Não foi mensurada	Pré, pós e 24h após (após jogo 2)	[CK] Peroxidação lipídica Carbonilação de proteínas Tiol total não oxidado	↑ ↑ ↑ ↓		↑ ↑ ↑ ↓		
Tessitore et al., 2008	10 jogadores de faculdade (23 ± 2 anos)	20min pós-jogo: a) assentado b) exercício aeróbico de baixa intensidade (EABI) c) EABI na água d) eletroestimulação	Jogos amistosos (2 x 20min com interrupções)	% do tempo a 80%, 90% e >90% FCmáx: 1o tempo: 13.4 ± 10.0%, 47.4 ± 20.8% e 32.1 ± 28.4% 2o tempo: 13.9 ± 9.3%, 43.9 ± 21.0% e 36.9 ± 30.4% PSE (6-20) por jogo: 1= 12.2 ± 2.8; 2= 12.6 ± 2.7; 3= 12.5 ± 3.1; 4= 14.2 ± 2.7	Pré, 20 min pós e 5h pós	CMJ Bounce jumping Sprint 10m	↓ ↔ ↓	↓ ↔ ↔			Não foi verificado efeito significativo das intervenções estudadas em nenhuma variável analisada.

[Lac] = concentração de lactato, [CK] = concentração de creatina quinase, [LDH] = concentração de lactato desidrogenase, TBARS = substâncias reativas ao ácido tiobarbitúrico, CMJ = salto com contramovimento.
↑significa aumento em relação ao momento pré-jogo; significa redução ao momento pré-jogo; = significa não diferença em relação ao momento pré-jogo.

Tabela 2: Artigos que abordaram parâmetros de fadiga e recuperação de jogadores de futsal após jogos consecutivos

Título	Amostra	Situação experimental	Tempos das avaliações	Variáveis	Comparação com pré-Jogo 1: Jogo 2	Jogo 3	Jogo 4	Pós Jogo 4
Charlot et al., 2015	10 Atletas (25 ± 4 anos)	4 jogos em 4 dias consecutivos (primeira fase da competição)	Antes de cada jogo (Hooper Index)	Stress		↑	↑	
				Dor muscular	↑	↑	↑	
				Fadiga	↔	↔	↔	
				Sono	↔	↔	↔	
				PSE	↑1 e ↑4	↑	↔	
Freitas et al., 2014	Atletas profissionais (24 ± 5 anos)	4 jogos em 4 dias consecutivos (fase final da competição)	Na manhã anterior a cada jogo	Squat jump	↑	↑	↑	
				CMJ	↑	↑	↑	
			Antes do primeiro jogo e 24h após o último jogo	Escalas de Recuperação física e Lesões (REST-Q)				↑
				Escalas de Stress geral, emocional e social; Conflitos, Pressão, Fadiga, Perda de energia, Queixas físicas, Sucesso, Recuperação social, Bem-estar geral, Qualidade do sono, Distúrbios nos intervalos, Exaustão emocional, Estar em forma, Aceitação pessoal, Auto-eficácia e Auto-regulação				↔

PSE = Percepção subjetiva de esforço, CMJ = salto com contramovimento, REST-Q = Questionário de Estresse e Recuperação para Atletas
↑ significa aumento em relação ao jogo 1; = significa não diferença em relação ao jogo 1.

O fato de que os estudos encontrados apresentaram apenas uma medida imediatamente pós-jogo e outra medida em diferentes momentos de recuperação, em adição aos diferentes protocolos utilizados como situações experimentais, limita o entendimento da linha do tempo de recuperação de jogodores de futsal após jogos ou estímulos que simulam jogos. Considerando tais limitações, os dados existentes indicam que o desempenho de velocidade é restaurado em poucas horas, enquanto a potência de membros inferiores e a resistência de velocidade são restauradas em até 24 h. Entretanto, marcadores fisiológicos de dano muscular e estresse oxidativo ainda permanecem alterados 2 dias após jogos oficiais de futsal. Em relação aos parâmetros perceptivos, não é possível sugerir um tempo de retorno aos valores basais com base nos estudos encontrados, mas é importante citar que tais parâmetros se mostraram responsivos à realização de jogos de futsal.

Tendo como base a importância da recuperação para o desempenho esportivo, a necessidade de maior entendimento desse processo em situações de relevância prática para profissionais do esporte, a alta intensidade de jogos e treinamentos de futsal, o tempo de recuperação acima de 24 h para alguns parâmetros, em conjunto com a alta frequência de jogos e treinamentos ao longo da temporada; o presente projeto teve como proposta principal a investigação do fenômeno de recuperação de atletas de alto rendimento, utilizando como meio o futsal.

3 OBJETIVOS

3.1 Objetivo geral

Investigar padrões de variação e fatores intervenientes no processo de recuperação de jogadores de futsal de alto rendimento após sessões de treinamento.

Para isso, o projeto foi dividido em quatro estudos, de acordo com os objetivos específicos descritos abaixo.

3.2 Objetivos específicos

Estudo 1

Objetivo específico 1: Caracterizar a curva de recuperação do desempenho físico e de aspectos fisiológicos e perceptivos de jogadores de futsal das categorias sub 20 (U20) e profissional (PROF) até 48 h após uma sessão típica de treinamento de alta intensidade.

Estudo 2

Objetivo específico 2: Investigar se jogadores de futsal de alto rendimento podem ser classificados em diferentes perfis de recuperação (recuperação rápida ou lenta), tendo como base uma abordagem multifatorial.

Caso a hipótese nula referente ao objetivo específico 2 seja rejeitada:

Objetivo específico 3: Comparar as características dos atletas pertencentes aos diferentes perfis de recuperação detectados.

Estudo 3

Objetivo específico 4: Investigar se perfis de recuperação pós-treino de jogadores de futsal, identificados após uma única sessão no início da pré-temporada, são refletidos na recuperação observada durante a rotina de treinamento diário ao longo de quatro semanas de pré-temporada.

Objetivo específico 5: Investigar a influência da carga de treinamento do dia anterior, do sono e da fadiga acumulada durante a semana na percepção de recuperação diária dos atletas durante quatro semanas de pré-temporada.

Estudo 4

Objetivo específico 6: Investigar se um período de treinamento de pré-temporada pode melhorar a capacidade de recuperação de jogadores de futsal após uma sessão de treinamento de alta intensidade.

4 ORGANIZAÇÃO DA TESE

Cada estudo citado acima está apresentado a seguir em formato de artigo, de acordo com a formatação indicada por cada periódico, incluindo os respectivos título, autores, resumos, introduções, métodos, resultados, discussões e referências bibliográficas. O título e o periódico para qual cada um dos artigos foi submetido estão descritos abaixo.

Estudo 1. *Recovery time course of physical, physiological and psychometric parameters following training in Brazilian futsal players.*

*Artigo submetido ao periódico *Journal of Sports Science and Medicine no dia 07 de março de 2019* (Qualis A2).

Estudo 2. *Faster and slower post-training recovery in futsal: multifactorial classification of recovery profiles.*

*Artigo aceito para publicação no dia 09 de Janeiro de 2019 no periódico *International Journal of Sports Physiology and Performance* (Qualis A1).

Estudo 3. *Daily perceived recovery in futsal players; influence of recovery profile, training load and perceived sleep.*

*Artigo submetido ao periódico *International Journal of Sports Physiology and Performance* no dia 07 de março de 2019 (Qualis A1).

Estudo 4. *Can training influence post-session recovery? A case study of Brazilian futsal players before and after a pre-season.*

*Artigo submetido ao periódico *Plos One* no dia 08 de março de 2019 (Qualis A1).

5 ESTUDO 1

Recovery time course of physical, physiological and psychometric parameters following training in Brazilian futsal players

Heading title: Post-training recovery profiles in futsal

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Abstract

This study characterises the recovery timeline of physical and psycho-physiological responses of ten professional (PROF) and thirteen under-20 (U20) male futsal players following high-intensity training. Countermovement jump (CMJ), 10 m sprint with change of direction, creatine kinase (CK), total quality recovery scale (TQR) and Brunel Mood Scale were recorded before, immediately, 3, 24 and 48 h post-session. Magnitude-based inference analyses were used to compare measures within each group over time. CMJ was not reduced at any post-training time point in either team; however, PROF players *likely* reduced sprint performance after training (effect size = 0.75, confidence interval = 0.01- 1.49) and returned to baseline (i.e. pre-training values) 3 h afterwards, though U20 performance was unchanged. CK increased post-training (U20: 0.48, 0.29- 0.68; PROF: 0.80, 0.39- 1.22) and returned to baseline after 48 h for PROF players (-0.27, -0.47- -0.07), but not for U20 (0.60, 0.19- 1.02). TQR decreased 3 h after training (U20: -2.06, -2.96- -1.17; PROF: -2.33, -2.87- -1.78) and returned to baseline within 24 h for both teams. Vigor reduced (U20: -1.57, -2.10- -1.05; PROF: -0.39, -0.69 to - 0.09) and fatigue increased (U20: 2.42, 1.80 to 3.03, PROF: 1.58, 0.98 to 2.19) post-training. Practitioners may expect futsal players' power/speed performance to be recovered within 24 h after a high-intensity training session, despite continued disruption to other physiological and perceptual markers of fatigue and recovery.

Keywords: physical performance, team sport, training monitoring, CK, TQR.

Introduction

During official futsal matches, players cover distances of 3-6 km, typically inclusive of high-intensity changes of direction and repeated sprints (Caetano et al., 2015; De Oliveira Bueno et al., 2014). Consequently, a high physiological strain is evidenced in cardiovascular responses of 85–95% maximum heart rate (%HRmax) (Rodrigues et al., 2011), alongside post-match increased inflammatory and muscle damage markers (de Moura et al., 2013; de Moura et al., 2012). Further, elite futsal teams are involved in an extensive calendar, whereby Brazilian A-league teams perform 2 - 3 matches/week during the in-season (including state, national and international tournaments) and up to 5 matches/week in short-term tournaments. To prepare players for these demands, pre-season training programs have been reported to involve up to 10 sessions/week (Soares-Caldeira et al., 2014). Within this challenging context of high volume microcycles, adequate post-training recovery is difficult, yet important to ensure appropriate readiness. However, knowledge of the post-training recovery timeline in futsal to prepare for ensuing matches is scarce and would be of use to assist weekly periodization of training within congested training and competition schedules.

Recovery is a multifactorial phenomenon in which central and peripheral factors interact to allow the return of performance, physiological or perceptual perturbations to near baseline values (Minett and Duffield, 2014). Successful training programs should provide a sequence of stimuli (i.e. training) with sufficient recovery to promote performance enhancement (Kentta and Hassmen, 1998). Thus, understanding athletes' recovery timeline within ecologically valid training settings allows insight into appropriate prescription of training load or recovery strategies. For example, available literature in soccer show reduced power performance and wellness scores for up to 72 h post-match (Silva et al., 2018), whereas the post-match increase in creatine kinase (CK) concentration is evident up to 120 h (Nedelec et al., 2012); which collectively guides post-match training routines. In contrast, after a single training session comprising 4*vs*4 small-sided games soccer players' perceptual markers were restored within 24 h, and jump performance showed a transient improvement 2 h post-session (Sparkes et al., 2018). Such responses highlight that understanding the recovery timeline from typical situations (e.g. training or match) and loads (e.g. frequently administered training sessions) is important to understand the loads to which players are submitted. The recovery timeline from training is particularly an issue in futsal given the high volume of sessions performed in a weekly micro-cycle (Soares-Caldeira et al., 2014).

Regarding post-match recovery responses in futsal, Tessitore (Tessitore et al., 2008) reported decreased countermovement jump (CMJ) and 10 m sprint speed 5 h post-match following friendly games. Moreira et al. (2015) also observed post-match decrements in CMJ, repeated-jump and repeated-sprint ability, which returned to pre-match values within 24 h, whereas muscle soreness remained higher on the following day. These studies suggest futsal matches require shorter recovery times compared to other team-sports (Johnston et al., 2015; Silva et al., 2018); likely due to lower external loads (Caetano et al., 2015; De Oliveira Bueno et al., 2014). However, the fact that futsal players perform a high number of training sessions in each micro-cycle even during the in season (Soares-Caldeira et al., 2014), means the post-training recovery timeline characterization is important to ground the prescription of load and recovery to ensure readiness on match days. Importantly, recovery timeline varies according to players' characteristics such as physical capacity and training exposure (Johnston et al., 2015; Tomlin, 2001), which have been shown to differ between age categories in futsal (Nakamura et al., 2016). Therefore, although most recovery timelines in team sports are characterized for professional teams due to the higly congested schedule - and therefore are used as references by practitioners, differentiating the recovery profiles of professionals to younger players is warranted to provide practitioners with age-specific references. Therefore, the aim of this study was to characterize the 48 h recovery timeline of physical performance and psychophysiological factors of under 20 (U20) and professional (PROF) futsal athletes after a typical high-intensity technical-tactical training session.

Materials and methods

Study design

At the start of the 2016 preseason, participants undertook anthropometric and maximal aerobic power (VO_2max) assessments. During the initial weeks, a post-training recovery time course was determined with a series of psychometric, physiological and performance parameters measured before, immediately and 3, 24 and 48 h after a high-intensity technical-tactical training session consisting of routinely performed activities. Training was performed in the morning after 48 h rest, and abstinence from alcohol and caffeine.

Subjects

Twenty-three male outfield futsal players (winger, pivot or defender) participated in this study consisting of 13 under-20 (U20) and 10 senior players (PROF) from the same professional Brazilian team. Group characteristics of U20 participants were: age 19 ± 1 y; body mass 68.0 ± 4.7 kg and stature 175 ± 7 cm; while the group characteristics of the PROF team were: age 26 ± 6 y, body mass 72.1 ± 7.9 kg, and stature 173 ± 4 cm. Athletes provided written informed consent prior to participation and were cleared to participate by the team medical physician. All procedures were approved by the Ethics Committee from the Universidade Federal de Minas Gerais (approval number 50166015.9.0000.5149).

Procedures

Participant characteristics and aerobic fitness assessment

Anthropometric measures included stature and body mass with players wearing only shorts and training shirt (MF100, Filizola®, Brazil). Players performed a maximal incremental test to determine VO_2max, maximal heart rate (HRmax) and ventilatory threshold (VT). The protocol consisted of 1% gradient treadmill running (HPX 380, Total Health®, Brazil) with initial speed of 6 $km \cdot h^{-1}$ and increments of 1.0 $km \cdot h^{-1}$ every min until volitional fatigue. VO_2 (K4b²; Cosmed®, Italy) and HR (RS801, Polar®, Finland) were recorded every minute and averaged at every 15 s for analysis. At the end of the exercise participants provided a rating of perceived exertion related to the entire session (session RPE; sRPE) using a 10-point scale (Foster et al., 2001). The exercise was terminated when at least one of the following criteria was observed: the participant 1) terminated the test; 2) failed to maintain the speed; 3) rated 10 on RPE; 4) showed signs of dizziness, confusion, or nausea. The spirometer was calibrated before each test according to the manufacturer's instructions. VO_2max and HRmax were considered as the highest values measured during the test. The VT was defined as the moment of increase in the ratio between ventilatory expired volume (VE) and VO_2 without a concomitant increase in VE and the expired volume of carbon dioxide (Amann et al., 2006). It was identified visually by two independent investigators, and a consensus-derived value was used.

Training session

Following 1 (PROF) and 2 (U20) weeks of pre-season, each team undertook a high-load technical-tactical training session of approximately 70 min on a 38 m x 20 m court. Initially, participants performed a 15 min warm-up consisting of different running intensities, changes of direction and a futsal specific activity. To ensure ecological validity, the training session was planned and conducted by respective coaches, with the only guidelines provided by researchers relating to the need for a high-intensity session representative of a typical training.

Thus, training simulated match-specific situations (e.g. number of players involved in plays, attack, defence or counterattack), though differed between the two groups due to competition schedules and technical-tactical abilities (Table 1). Due to logistical difficulties of collecting data from a professional team for 48 h (without other training during this period and during the previous 48h), only one session was tested as is often the case in such research (Dal Pupo et al., 2014; de Moura et al., 2013; Sparkes et al., 2018). Whilst we recognise that the single session does not represent all training modes and sessions, the use of a coach-driven high-intensity session represented a demanding load representative of what would be expected during a congested training week.

During the session, players wore a Global Positioning Satellite device coupled with a triaxial accelerometer with a sampling frequency of 100 Hz (SPI ProX2, GPSports Systems®, Australia), and a HR receiver (Polar®, Finland). The device was used in the indoor mode, in which only accelerometer and HR data were recorded.

External training load was analysed using Player Load (Schwellnus et al. 2016), calculated as the square root of the sum of the squared instantaneous rate of change in acceleration in all three axes (Boyd et al., 2011). Internal training load was quantified using HR as mean %HRmax and training impulse (TRIMP) (Edwards, 1993); and sRPE analysed using both individual absolute values and its internal training load index (TL-RPE) by multiplying sRPE by total session duration (Foster et al., 2001).

Table 1: Description of activities performed by each team during the experimental training session.

Team	Activity format (field players involved)	Duration	Rules
U20	4x4	21 min exercise 8 min interval 34 min exercise	• Free time and number of players` substitutions allowed • Short (30 s to 120 s) pauses during each block for instructions
PROF	3x3	3 min	Similar rules to an official match
	4x4	20 min	• Similar rules to an official match • Short (30 s to 120 s) pauses during each block for instructions
	Counter-attack: Sequence of 2x1, 3x2, 3x3 and 4x4	10 min	The team that started with the ball possession had to make a fast attempt to score a goal. Irrespective of the result (scored or not), either the goalkeeper or the coaching staff made a quick ball reposition to the opposite team that should perform a counter-attack as fast as possible. This sequence was repeated 4 times without interval. At each time, more players were added to the activity
	Increased cognitive demand game: 4x4	8 min	In addition to the regular ball of the game, each team had 2 extra balls that could only be played with the hands. The player in possession of this ball could freely move, but could not intercept, receive or pass the ball of the game

U20: under 20 team; PROF: professional team.

Recovery assessment

Players arrived 60 min before the session for pre-training measures, commencing with collection of a urine sample to evaluate hydration status by urine specific gravity using a portable refractometer (Uridens Inlab, São Paulo, Brazil). Next a capillary blood sample was collected from the fingertip for CK concentration analysis (Reflotron, Roche®, Switzerland).

Then a customized wellness questionnaire was completed that included a) sleep quantity and quality (1 = very bad to 5 = very good); b) perception of recovery using the total quality recovery scale (TQR), ranging from 6 (worse than very, very poor recovery) to 20 (better than very, very good recovery) (Kentta and Hassmen, 1998). Finally, a Portuguese version of the Brunel Mood Scale (BRUMS) was completed to determine vigor and fatigue based on the sum of four items (vigor: lively, energetic, active, alert; fatigue: worn out, exhausted, sleepy and tired) scored from 0 (nothing) to 4 (extremely) (Rohlfs et al., 2004; Terry and Fogarty, 2003).

At the end of these procedures, players performed a 15 min warm-up followed by countermovement jump (CMJ) and a 20 m sprint test with change of direction. CMJ consisted of four jumps performed on a force platform (Ergo System®, Globus, Italy) with 15 s interval between trials. Participants performed hip and knee flexion up to approximately 90° followed by a rapid hip and knee extension to achieve the highest possible height maintaining their hands in the waist. The mean jump height was used in ensuing statistical analyses (Szmuchrowski et al., 2012). To evaluate the ability to accelerate, decelerate and change direction, a 20 m sprint test with a 180° change of direction at 10 m, adapted from the 5-0-5 test (Draper and Parker, 2010) was used. Photoelectric cells (Multisprint, Hidrofit®, Brazil) were positioned at the start/finish line and at 10 m to determine time to complete 10 m and 20 m. Due to technical malfunctions only the first 10 m time was used for analysis of players' combined ability to accelerate and decelerate, and results are refered as 10-m test.

Following all testing, participants undertook the training session described earlier. Immediately after the end of the session, CMJ, 10 m and CK assessments were repeated. In addition, approximately 15 min after the session players reported sRPE and BRUMS. Following post-training testing, no recovery interventions or training sessions were performed by the teams over 48 h. During this time, participants were instructed to abstain from alcohol, caffeine and high-intensity physical exercise. The collection of capillary blood for CK analysis; TQR and BRUMS questionnaires; warm up and physical tests adopted prior to the beginning of the session were then repeated 3, 24 and 48 h after the end of the training session to determine the timeline of recovery for each variable. Because of logistical restriction of the training facilities on the days of evaluation, the PROF team did not perform the physical tests and the CK concentration evaluation 24 h after the session; though players recorded wellness and BRUMS questionnaires.

Statistical analysis

Magnitude-based inference analysis (MBI) (Batterham and Hopkins, 2006) was used to determine changes over the time course of post-training recovery (immediately, 3 h, 24 h and 48 h post) for each variable for U20 and PROF teams separately. To further discuss eventual differences detected in the recovery timeline between the respective groups, MBI was also used to compare baseline (pre-training) and training load measures between U20 and PROF teams. Smallest worthwhile differences were assessed using the between-subject standard deviation multiplied by 0.2. The quantitative chances of finding differences in the variables tested were assessed qualitatively as: <1%, *almost certainly not*; 1% to 5%, *very unlikely*; 5% to 25%, *unlikely*; 25% to 75%, *possibly*; 75% to 95%, *likely*; 95% to 99%, *very likely*; >99%, *most likely*. If the chances of having positive and negative results were both <5%, the true difference was classified as *unclear*. The minimum classification considered to detect meaningful differences was a *likely* difference (>75%) (Hopkins, 2002). The magnitude of differences was analysed using the standardized differences based on Cohen's *d* effect sizes (ES), with confidence intervals set as 90%.

Results

Physical fitness and pre-training measures

Descriptive characteristics of U20 and PROF teams, including ES and 90% CI, are provided in Table 2. Although differences in VO_2max were *unclear*, the PROF players attained VT at a *likely* higher percentage of VO_2max. Regarding the pre-training measures, the PROF team reported *most likely* lower TQR and vigor, as well as *likely* higher fatigue than the U20 team. Finally, hours of sleep the night before the session was *very likely* higher for the U20 compared to PROF. All other variables showed *unclear* differences between the groups.

Table 2: Physical performance, physiological and perceptual parameters of Under 20 and Professional teams before the training session (mean ± SD).

	U20			PROF			ES	CI (90%)
Physical performance								
VO_2max ($mlO_2.kg^{-1}.min^{-1}$)	52.6	±	4.8	50.8	±	3.8	-0.38	[-1.10- 0.34]
%VO_2max at VT	45	±	10%	51	±	11*	0.58	[-0.16- 1.32]
Max speed ($km.h^{-1}$)	15.6	±	1.1	15.9	±	1.7	0.29	[-0.66- 1.23]
Countermovement jump (cm)	32.3	±	3.5	33.4	±	3.4	0.31	[-0.39- 1.01]
10 m (s)	1.57	±	0.07	1.60	±	0.06	0.43	[-0.25- 1.12]
Pre-training measures								
Creatine Kinase (U/L)	271	±	262	191	±	116	-0.38	[-0.06- 1.61]
Total Quality Recovery	14.6	±	1.3	13.0	±	0.9#	-1.35	[-2.04- 0.67]
Vigor	10.3	±	2.3	8.4	±	4.2*	-0.53	[-1.26- 0.20]
Fatigue	2.5	±	2.0	4.0	±	2.3*	0.68	[-0.03- 1.39]
Urine Specific Gravity ($g.mL^{-1}$)	1024	±	7	1025	±	7	0.16	[-0.56- 0.87]
Sleep hours	7.4	±	0.8	6.4	±	0.8#	-1.19	[-1.92- -0.47]
Sleep quality	3	±	1	3	±	1	-0.39	[-1.09- 0.31]

U20: under 20 team; PROF: professional team; ES = effect size; CI = confidence interval. **Likely* different from U20; #*Most likely* different from U20.

Training load

The training sessions' duration was respectively 68 and 70 min for the U20 and PROF teams. All other training load parameters are provided on table 3. The PROF team performed *likely* higher PL (ES = 0.77 [CI = -0.06 to 1.61]), reported a *likely* higher sRPE (0.83 [0.13 to 1.53]) and *most likely* higher TL-RPE compared to the U20 team (1.16 [0.46 to 1.87]). In contrast, U20 players showed *likely* higher mean HR (%HRmax) during the session compared to PROF (-0.94 [-1.81 to -0.07]). Differences in TRIMP were *unclear* (0.36 [-0.50- 1.23]).

Table 3: Training load parameters for the under 20 and the professional teams (mean ± SD).

	U20	PROF	ES	CI (90%)
Player load (AU)	559 ± 92	646 ± 119*	0.77	-0.06 to 1.61
HRmax (%)	81 ± 4%	77 ± 4%*	-0.94	-1.81 to -0.07
TRIMP (AU)	229 ± 23	236 ± 25	0.36	-0.50 to 1.23
sRPE (AU)	6.1 ± 1.7	7.6 ± 1.6*	0.83	0.13 to 1.53
TL-RPE (AU)	413 ± 113	555 ± 122#	1.16	0.46 to 1.87

U20: under 20 team; PROF: professional team; HRmax (%) = Percentage of maximal heart rate; sRPE = score attributed to the rating of perceived exertion after the training session; TL-RPE = session rating of perceived exertion x session duration. ES = effect size; CI = confidence interval. **Likely* different from U20; #*Most likely* different from U20.

Recovery timeline– objective measures

For the U20 team, changes from baseline in CMJ performance were not meaningful throughout the 48 h recovery period, though was *likely* higher at 48 h compared to 3 h post session (0.31 [0.06-0.55]; Fig 1). In contrast, a *likely* decrease in 10 m sprint performance was evident 24 h and 48 h after training compared to baseline (0.49 [-0.08-1.05] and 0.49 [0.00-0.99], respectively). Blood CK concentration was *very likely* increased immediately post (0.48 [0.29-0.68]) and *most likely* higher 3 h (1.03 [0.61-1.45]) and 24 h post compared to baseline (1.14

[0.60-1.68]). Subsequently, CK likely decreased at 48 h compared to 24 h (-0.34 [-0.53- -0.16]), but was still likely higher than at baseline (0.60 [0.19-1.02]).

For the PROF team, CMJ performance also presented no meaningful differences from baseline, but *likely* increased 48 h-post compared to post-training measures (0.33 [0.13-0.54]). In contrast, players were *likely* slower in the 10 m sprint test immediately post-training compared to pre-training (0.75 [0.01-1.49]). Subsequently, sprint performance returned to pre-training values at 3 h post (*unclear*; 0.49 [-0.63- 1.60]), and was *likely* and *very likely* improved compared to post (-0.75 [-1.41- -0.09]) and 3 h (-0.64 [-0.93- -0.34]). CK concentration *very likely* increased after the training session (0.80 [0.39- 1.22]), remaining *most likely* increased at 3 h (0.81 [0.66-1.96]). 48 h after the session, CK *most likely* decreased compared to both immediately post (-0.78 [-1.06- -0.49]) and 3 h post-session (-1.05 [-1.28- -0.81]); and was *possibly* lower than baseline (-0.27 [-0.47- -0.07]).

Recovery timeline– subjective measures

U20 players' perceived recovery (TQR) *most likely* decreased 3 h post session (-2.06 [-2.96- -1.17]), then *most likely* increased at 24 h (1.08 [0.61-1.54]), showing *unclear* values to baseline (-0.33 [-0.97- 0.32]; Fig 2). However, after 48 h TQR scores returned to be *likely* lower than baseline (-0.65 [-1.46- 0.16]). Vigor scores *most likely* decreased immediately and 3 h after the session (-1.57 [-2.10- -1.05] and -1.70 [-2.27- -1.13], respectively). Although it *very likely* increased at 24 h and 48 h compared to both post (24 h: 0.69 [0.28- 1.09]; 48 h: 0.91 [0.41-1.41]) and 3 h post session (24 h: 0.60 [0.33-0.88]; 48 h: 0.77 [0.43-1.12]), vigor remained *very likely* lower than baseline (24 h: -0.69 [-1.16- -0.23]; 48 h: -0.41 [-0.89- 0.07]). Fatigue scores *most likely* increased post-session compared to baseline (2.42 [1.80-3.03]), then *likely* decreased at 3 h (-0.35 [-0.65- -0.05]), returning to pre-training values 24 h following training (-0.04 [-0.44- 0.37]).

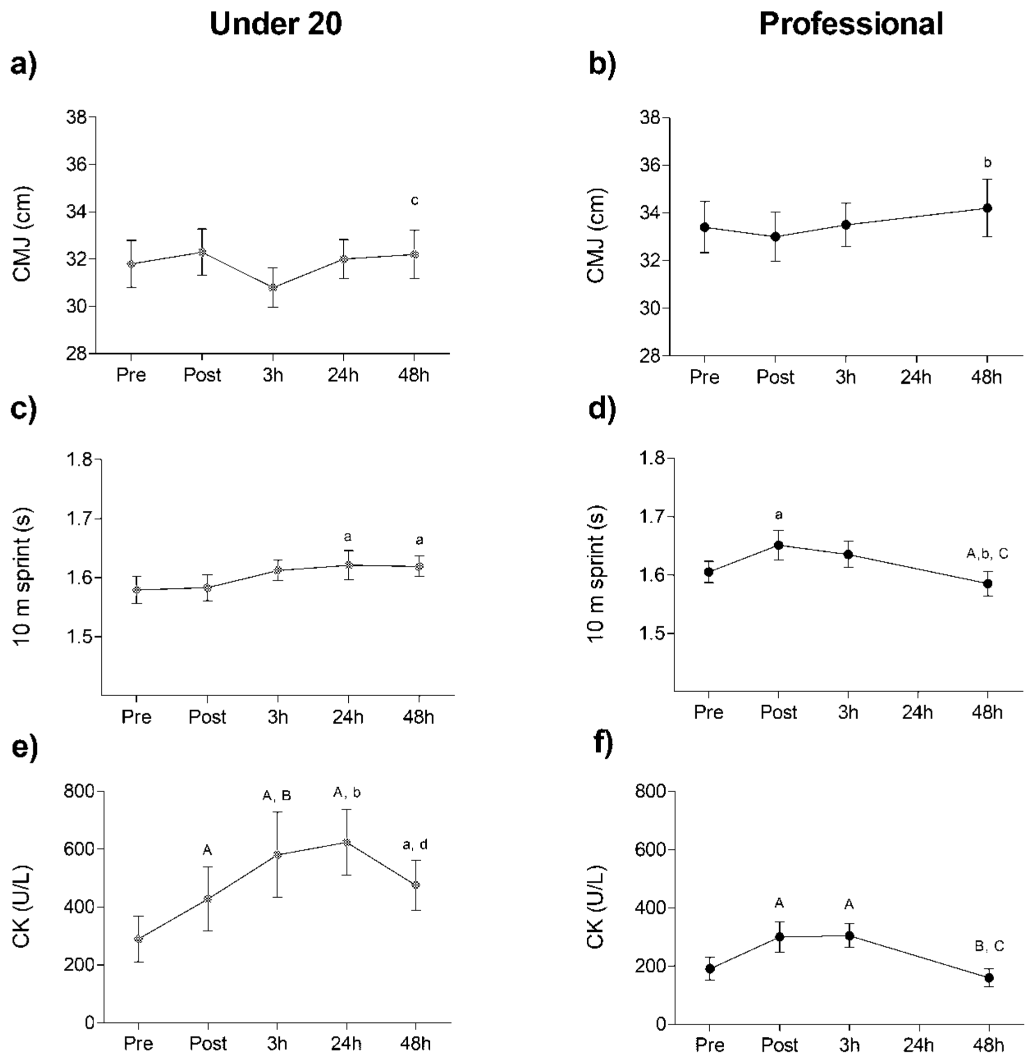

Figure 1: Timeline of objective recovery markers of under 20 (graphs a, c and e) and professional players (graphs b, d and f) after a technical-tactical futsal training session (mean ± SD). a and d) countermovement jump high; b and e) 10 m sprint time; c and f) creatine kinase concentration; Lower case letters indicate a *likely* difference, whilst upper case letters indicate a *very likely* or *most likely* difference between two moments of evaluation. A or a = different from pre-training, B or b = different from post session, C or c = different from 3 h post session, D or d = different from 24 h post session.

PROF players' TQR *most likely* decreased at 3 h (-2.33 [-2.87- -1.78]), then *most likely* increased 24 h and 48 h after the session (24 h: 2.46 [1.82-3.10]; 48 h: 2.37 [1.36-3.38]), while differences from baseline were *unclear* (24 h: 0.19 [-0.59- 0.98] and 48 h: 0.10 [-1.24- 1.43]). Vigor scores *likely* decreased immediately and 3 h post-training compared to baseline (-0.39 [-0.69- -0.09] and -0.44 [-1.01- 0.14], respectively), followed by an increase 24 h and 48 h after the session, when differences were *unclear* compared to baseline (-0.13 [-0.67- 0.41] and 0.20 [-0.30- 0.69], respectively). Contrarily, fatigue perception was *likely* and *very likely* increased after (1.58 [0.98-2.19]) and 3 h after training (1.23 [0.59-1.86]), respectively, and depicted *unclear* differences from baseline only 48 h after training (0.24 [-0.28- 0.76]).

Discussion

This was the first study to describe the recovery timeline of U20 and PROF players after a high-intensity futsal-specific training. Post-training physical performance responses were mixed, with no change in CMJ, although a transient impairment in 10 m sprint was evident for the PROF team (but not U20). Furthermore, CK, TQR, fatigue and vigor scores were markedly changed after the session, and although TQR was restored within 24 h, the other parameters required up to 48 h to return to baseline. Accordingly, a 48 h recovery time frame seems appropriate for elite futsal athletes after high-intensity training with similar configuration from the ones studied herein, and provides an initial context to training load and recovery planning in congested weekly micro-cycles.

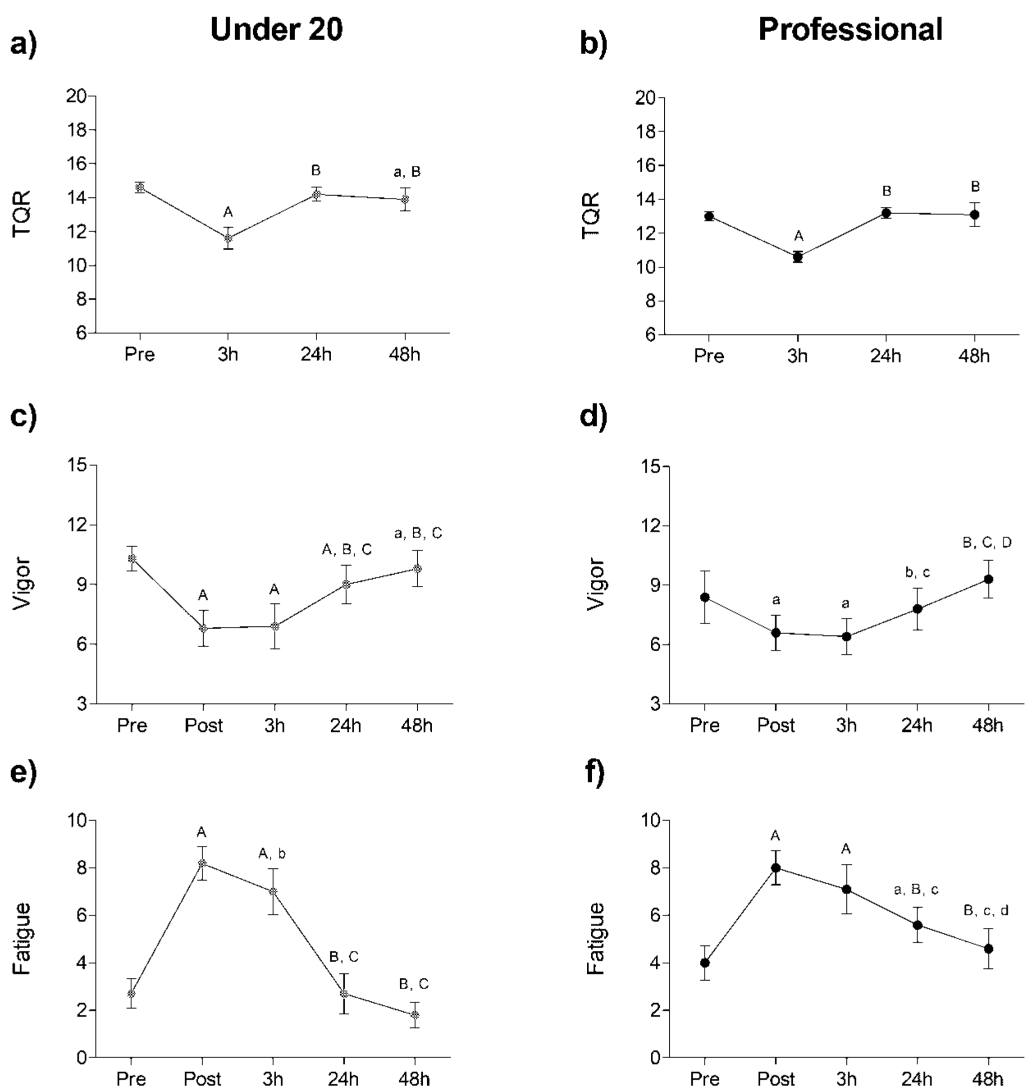

Fig 2: Timeline of subjective recovery markers of under 20 (graphs a, c and e) and professional players (graphs b, d and f) (mean ± SD). a and b) total quality recovery scale (TQR); c and d) Vigor (BRUMS); e and f) Fatigue (BRUMS). Lower case letters indicate a *likely* difference, whilst upper case letters indicate a *very likely* or *most likely* difference between two moments of evaluation. A or a = different from pre-training, B or b = different from post session, C or c = different from 3 h post session, D or d = different from 24 h post session.

As hypothesised, the technical-tactical training sessions resulted in high internal load, as evidenced by mean HR and sRPE values, similar to official matches (≈86%HRmax) (Rodrigues et al., 2011) and higher than other in-season technical-tactical training sessions (≈74%HRmax, sRPE ≈5) (Wilke et al., 2016). Given this is the first study to report PL in futsal, no other comparative data is available; though results are lower than values reported in soccer matches (Dalen et al., 2016), but comparable to soccer small-sided games training (Sparkes et al., 2018). Despite the PROF team' session resulting in *likely* higher external load (i.e. PL), players depicted *likely* lower mean %HR and *unclear* differences in TRIMP compared to the U20 team. Whether such a response relates to the *likely* higher VT in PROF compared to U20 remains speculative; though higher Yo-Yo Intermittent Recovery Test Level 1 performance was also previously observed in professional vs U20 futsal players (Nakamura et al., 2016).

Post-training CMJ performance was not impaired by training in both teams, differing from previous studies that reported decreases in CMJ after friendly matches (Moreira et al., 2015; Tessitore et al., 2008). The shorter playing time in the present training sessions may have led to lower external loads and preservation of lower-body force production (Minett and Duffield, 2014), and thus CMJ height (Murphy et al., 2015), though such assumption is limited since external load was not reported in previsous studies. Further, sprint performance of U20 players was unchanged immediately and 3 h post-training, yet decreased thereafter. This result was unexpected and may have been influenced by the lower vigor scores reported by the players at 24-48 h, which can influence ones' willingness or motivation to perform (Terry, 2000). In contrast, 10 m sprint performance decreased in the PROF team just after training, returned to baseline at 3 h and improved after 48 h. Such results compare favourably with Tessitore et al. (Tessitore et al., 2008), who reported decreased post-match 10 m sprint performance until 5 h post-match. Collectively, these results suggest that when prescribing two sessions on the same day, intervals longer than 3-5 h would prevent possible deleterious effect on speed/power performance from previous session.

Despite modest effects of training on physical performance, CK concentration increased substantially, followed by a reduction at 48 h post-training in both teams, consistent with responses in 4 x 4 small sided games in soccer (Sparkes et al., 2018). Such results also align with previously reported increases in lactate dehydrogenase and inflammatory markers after futsal matches (de Moura et al., 2013; de Moura et al., 2012). When interpreted with the physical performance responses, these results suggest that some extent of muscle damage markers persist up to 24 h after a high-intensity futsal session; even though performance can be maintained. Therefore, elevated CK should be expected within weekly micro-cycles, and monitoring following a rest day may be more informative of players' recovery status from muscle damage. When interpreting CK results in a field setting, practitioners should be aware of the high within- and between-subject variation in its values and the incongruent timeline with physical performance measures (Howatson and Milak, 2009).

TQR, vigor and fatigue were markedly impaired up to 3 h after training for both U20 and PROF. Although TQR returned to baseline within 24 h in both teams, perception of fatigue only returned to baseline after 48 h in PROF players, whilst vigor remained impaired for the U20. The prolonged recovery time of vigor and fatigue aligns with mood disturbances 24 h after a comparable 60 min 4 x 4 session in soccer (Sparkes et al., 2018). Additionally, the mismatch between vigor and fatigue timeline within and between teams reflects the multifactorial and ephemeral nature of mood (Terry, 2000), which must be acknowledged when interpreting the results. Nonetheless, the fact that TQR, vigor and fatigue were altered after the session when no performance changes were detected provides further support of their responsiveness to training stimulus (Crowcroft et al., 2017; Rohlfs et al., 2004). The perceptual results also indicate that coaching staff should consider allowing more than 3 h interval between two training sessions in the same day, in account of players still showing explicit signs of incomplete recovery from the previous session.

Although this study provides valuable insights to professionals working in futsal, certain limitations must be acknowledged. Common to research in high-performance teams, there were limitations in how much we could change the teams' training routines. The need to four days dedicated to data collection limited us to one experimental situation with each team with specific training designs. Therefore, intra-individual variability could not be assessed, and generalization of the results is limited. Additionally, the missing parcel of CMJ, sprint and CK 24 h after training from the PROF team prevented obtaining the complete recovery profile of this group. Finally, the absence of training stimulus during the 48 h after the session established to control for confounding factors on the recovery period does not reflect teams' schedule on days preceding games and therefore limits the ecological validity of truly congested training schedules. Continuous monitoring of players' training loads and recovery is strongly recommended to assist the coaching staff to plan the training stimulus and assure they are ready to perform on match days.

Conclusion

Overall, physical performance showed only minimal post-training changes, whilst markers of perceived recovery returned to baseline after 24 h. However, CK and some mood parameters remained elevated until 48 h post-session. Additionally, the recovery time frame varied between the age groups, with the PROF team showing better timeline in most parameters compared to the U20 team, Therefore, it appears that prescribing 70-min high-intensity specific futsal sessions 48 h before a match is feasible in elite level provided it is carefully monitored through a multifactorial approach, as some players may still experience lower readiness to perform.

Disclosure of interest

The authors report no conflict of interest

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6 ESTUDO 2

Faster and Slower Post-Training Recovery in Futsal: Multifactorial Classification of Recovery Profiles

"Faster and Slower Post-Training Recovery in Futsal: Multifactorial Classification of Recovery Profiles" by Wilke CF et al.
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Section: Original Investigation

Article Title: Faster and Slower Post-Training Recovery in Futsal: Multifactorial Classification of Recovery Profiles

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Title: Faster and slower post-training recovery in futsal: multifactorial classification of recovery profiles.

Running head: Classification of recovery profiles in futsal

Submission type: Original Investigation

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ABSTRACT

Purpose: To investigate the classification of faster vs slower recovery profiles in elite futsal players and factors that distinguish between them. **Methods:** Twenty-two male futsal players were evaluated for the time-course of post-training recovery in countermovement jump (CMJ), 10m sprint, creatine kinase concentration (CK), total quality recovery (TQR) and Brunel Mood Scale (fatigue and vigor) before, post, 3, 24 and 48h after a high-intensity training session. Hierarchical cluster analysis was used to allocate players into different recovery profiles using the area under the curve of the percentage differences from baseline of each variable. One-way ANOVAs and effect sizes (ES) were used to compare the time-course of each variable and players' characteristics between clusters. **Results:** Three clusters were identified and labelled as faster (FR; n=6), slower physiological (SL_{phy}; n=7) and slower perceptual recovery (SL_{perc}; n=6), respectively. FR presented lower (better) AUC in 10m sprint than SL_{phy} ($p=0.001$) and SL_{perc} ($p=0.008$). FR also showed higher (better) AUC in TQR compared to both SL_{phy} ($p=0.018$) and SL_{perc} ($p=0.026$). SL_{perc} showed higher (better) AUC in CMJ than SL_{phy} ($p=0.014$), though presented higher (worse) fatigue AUC compared to SL_{phy} ($p=0.014$) and FR ($p=0.008$). AUC of CK was higher (worse) in SL_{phy} compared to FR ($p=0.001$) and SL_{perc} ($p<0.001$). SL_{phy} was younger than SL_{perc} ($p=0.027$), whereas FR were slower 10m sprinters than SL_{phy} ($p=0.003$) and SL_{perc} ($p=0.013$) and tended to have a higher VO_{2max} than SL_{phy} (ES=1.13). **Conclusions:** Differing post-training recovery profiles exist in futsal players, possibly influenced by their physical abilities and age/experience.

Keywords: Cluster analysis, classification analysis, team sport, performance.

Introduction

Post-exercise recovery is a complex process involving the return of performance, physiological or perceptual perturbations to near pre-exercise values[1]. This concept is made opaque by the multi-factorial nature and varying timelines of different parameters[2]. For example, a recent meta-analysis on post-match recovery in soccer concluded that while sprint, hormonal and skill/technical parameters are restored within 72 h, muscle damage, countermovement jump (CMJ) and perceived well-being take longer[3]. However, high inter-individual variability of the recovery timeline exists (i.e. faster and slower recovery); often influenced by a variety of external (i.e. training/match loads, sleep and nutrition) and internal factors (i.e. aerobic and intermittent-sprint capacities[4-6]), creating further challenges to interpret recovery. Thus, the ability to identify faster or slower multifactorial recovery profiles may aid the prescription of recovery strategies.

It is often recommended that recovery time, appropriate recovery strategies and training load should be prescribed individually[1, 7]. Albeit optimal, this invokes a challenge to coaching staff given the diverse player requirements alongside restricted facilities and staff availability. In this context, identifying faster and slower recovery athletes may allow practitioners to focus on smaller groups based on predominant characteristics[8]. Such an approach is akin to strategies in health research, where identifying certain patterns in multifaceted conditions (e.g. disease diagnosis) assists professionals in selecting the most effective intervention[9, 10]. Similar methods in sport has precedent; whereby the application of a statistical classification tool to 8 screening tests classified 28 professional rugby union players into 4 injury risk profiles[11]. This information was used as a basis for developing preventative programs targeting players' respective needs. Accordingly, it seems reasonable to suggest that identifying athletes' recovery profiles could provide means for more accurate management of recovery time, interventions and training loads.

Futsal features a relatively short post-match recovery time compared to other team sports[4, 7]. Previous studies report restoration of physical performance within 24 h post-match, whereas perceptual markers take longer[12, 13]. However, these characteristics occur within the context of highly congested tournaments (i.e. up to 5 games in 7 days[14]; and ≈10 training sessions per microcycle[15]). Within such congested schedules, individuals respond and cope differently with physiological and perceived fatigue, though adequate recovery is a common requirement for subsequent performance. Hence, futsal constitutes an appropriate test-bed to investigate faster and slower recovery profiles. Therefore, the aim of this study was to investigate whether elite futsal players can be classified into different recovery profiles (i.e. faster vs slower) based on multiparameter post-training evaluation. A secondary aim was to compare player characteristics between recovery groups that differentiates post-training timeline characteristics.

Methods

Subjects

Twenty-two male field futsal players participated in this study (age: 21.5 ± 5.2 years, weight: 69.6 ± 7.0 kg, height: 174.1 ± 5.6 cm). They were members of either the professional (PROF) or under-20 (U20) squad of the same first division Brazilian team. Players provided written informed consent after explanation of all procedures and were cleared by the team's medical physician to participate in the study. The study was approved by the University Research Ethics Committee (50166015.9.0000.5149).

Design
At the start of the 2016 pre-season, an observational design was implemented, with players undertaking anthropometric and maximal aerobic capacity (VO_2max) assessments. After 1 (PROF) and 2 (U20) weeks of training, they underwent a high-intensity technical-tactical training session representative of a typical major training session to provide a fatiguing stimulus. Perceptual, physiological and performance assessments were completed before, immediately and 3, 24 and 48 h post-session to evaluate the time course of recovery. In the 48h preceding and prior to all experimental sessions, players were instructed to maintain their habitual diet and refrain from alcohol, caffeine and high-intensity exercise.

Methodology
Participant description
At the beginning of the season, stature and body mass (in training shorts and shirt) were measured. VO_2max, maximal heart rate (HRmax) and ventilatory threshold (VT) were then determined during a maximal incremental test. Participants ran on a treadmill (HPX 380, Total Health®, Brazil) with fixed 1% inclination, initial speed of 6 $km \cdot h^{-1}$ and continuous increments of 1.0 $km \cdot h^{-1}$ every minute, until volitional exhaustion. VO_2 ($K4b^2$; Cosmed®, Italy) and HR (RS801, Polar®, Finland) were continuously measured and recorded every minute. A 10-point scale[16] was used to assess their rating of perceived exertion (RPE) at the end of each stage. The exercise was ceased when at least one of the following criteria was observed: the volunteer 1) requested the interruption of the test; 2) failed to maintain the stipulated speed; 3) rated 10 on the RPE scale; 4) showed any signs of dizziness, mental confusion, pallor, cyanosis or nausea. The spirometer was calibrated before each test according to the manufacturer's instructions. VO_2max and HRmax were considered the highest values measured during the test.

Training session
A 70 min high-intensity technical-tactical training session was performed in the morning on a 38 m x 20 m indoor futsal court. The session was developed and conducted by each squad's coach to ensure ecological validity with a highly-fatiguing training session. Although sessions were not explicitly standardized, coaches were instructed to be 70-min in duration of high-intensity via full-court, drill-based sessions. Accordingly, both contained only futsal-specific activities (i.e. small-sided games and game simulations) performed on a full court, with varying technical-tactical instructions.

Before the beginning of the session, a 15-min warm up consisting of different running speeds, sprints, changes of direction, and futsal specific activity was conducted by the strength and conditioning coach. During the session, players were equipped with a heart rate receiver (Polar®, Finland) and a Global Positioning System device coupled with a triaxial accelerometer (SPI ProX2, GPSports Systems®, Australia). The device had a sampling frequency of 100 Hz and was used in the indoor mode, whereby only the accelerometer and HR data were recorded. Units were positioned between the athletes' shoulder blades in a customised designed vest. Player Load was used as a measure of external training load[17]. Internal load was quantified using HR and RPE. Mean HR was calculated relative to the players' maximal HR in the incremental test (%HRmax), and the training impulse (TRIMP) according to Edwards[18]. RPE was analysed as an indication of training intensity using the individual absolute values and as an index of overall training load (session RPE; sRPE) as a product of RPE by the session duration[16].

Recovery timeline characterization

Players arrived 60 min prior to the session for pre-training assessments, starting with 1) hydration status by urine specific gravity (USG) using a portable refractometer (Uridens Inlab, São Paulo, Brazil). This was followed by 2) creatine kinase (CK) concentration from capillary blood samples collected from the fingertip (Reflotron, Roche®, Switzerland; with intra-assay coefficient of variation of <3%[19]). In turn, 3) players answer a customized wellness questionnaire that included i) sleep hours and quality (1 = very bad and 5 = very good), ii) the total quality recovery scale, ranging from 6 (worse than very, very poor recovery) to 20 (better than very, very good recovery) (TQR [20]), and iii) a Portuguese version of the Brunel Mood Scale (BRUMS[21]), whereby vigor and fatigue constructs consist of the sum of four items scored from 0 (nothing) to 4 (extremely).

Following the warm-up, participants performed a countermovement jump (CMJ) and 20m sprint test with a 180^{o} change of direction at 10m. The CMJ was performed on a force platform (Ergo System®, Globus, Italy) with a squat until reaching approximately 90^{o} of knee and hip flexion, followed by fast knee and hip extension, keeping the hands in the waist. The mean value of four jumps separated by 15s was used for analysis. For the sprint test, photoelectric cells (Multisprint, Hidrofit®, Brazil) were positioned at the start and finish lines and at 10m mark to assess time to complete 10 and 20m. Due to technological malfunction, only the first 10m times were used for analysis and this test is referenced as 10m sprint. Once the training session was completed, CMJ, sprint and CK concentration were repeated, and approximately 15min later players answered to BRUMS and RPE. All procedures performed before the session were then repeated 3, 24 and 48 h after training to assess the time course of recovery for each variable. Due to restriction on the days of testing in the training facilities, the 24 h post-training physical tests and CK concentration assessment were not performed by the PROF team (n=9), though both wellness and BRUMS questionnaires were still recorded. Players were familiarized with testing procedures in the days preceding the experimental session.

Statistical analysis

Firstly, to determine the profile of recovery for each marker, the percentage difference between pre-training and each post-session time point was determined. These values were then transformed to a z-score and used to calculate the area under the curve (AUC) of the entire 48 h post-training timeline for each variable via the trapezoidal method as a representation of post-training recovery kinetics.

Then, using AUC of the 6 recovery parameters, an agglomerative hierarchical cluster analysis based on Euclidian distance and average linkage criteria was performed(Python 2.7, Python Software Foundation, https://www.phyton.org/). Briefly, each subject's data for each measure is plotted in a multi-dimensional plan and the Euclidian distance between subjects is calculated. The lower the distance between two subjects, the more similarities they share, which further enables their classification into groups (clusters). The threshold difference of 115 was used to optimise clustering based initially on dendogram differentiation, and then by theoretical and meaningfulness of the resulted grouping.

Finally, to investigate the differences and characteristics between the identified clusters, the AUC and the % change from baseline of each variable at each time point were compared. Normality of distribution and homogeneity of variance assumptions were checked using the Shapiro-Wilk and Levene's tests, respectively. Normally distributed data were compared using a one-way analysis of variance (ANOVA), followed by the Tukey's post hoc test when applicable. Data that did not meet the ANOVA assumptions (recovery timeline variables: CK

48h post-session; TQR 24h post; Vigor immediately and 48h post; Fatigue immediately, 3h, 24h and 48h post. Pre-training variables: age; VT; CK, vigor and sleep quality) were compared using Kruskal Wallis, followed by pairwise comparisons when applicable (SPSS® software, version 22). Cohen's d effect sizes (ES) were also calculated for each pairwise comparison[22]. The magnitudes of the ES were qualitatively interpreted using the following thresholds: < 0.2, trivial; 0.2–0.6, small; 0.6–1.2, moderate; 1.2–2.0, large; 2.0–4.0, very large and; > 4.0, nearly perfect [22].

Results

Cluster analysis resulted in the classification of players into 3 respective groups (Figure 1A). Cluster 1 consisted of 6 U20 players, cluster 2 included 7 players (4 U20 and 3 PROF), and 6 players were grouped in cluster 3 (2 U20 and 4 PROF). However, 3 athletes were not included in any group due to the average linkage distance threshold (1 U20 and 2 PROF).

As context to the recovery profiles, both external and internal training loads were not significantly different (p>0.05) between the 3 groups (Table 1); however, small - moderate effect sizes were evident for PL and TRIMP between clusters 2 and 3 (ES = -0.95, CI = [-2.10- 0.21] and -1.07 [-2.22- 0.09], respectively); as well as for % HRmax between clusters 1 and 2 (-0.86 [-2.10- 0.37]).

Table 1: Training load parameters of the three clusters (mean ± SD).

Training load parameter	Cluster 1	Cluster 2	Cluster 3	p	ES
Player Load	596 ± 94	536 ± 113	652 ± 104	0.292	-0.50 / -0.95 / 0.51
% HRmax	81 ± 5%	77 ± 4%	79 ± 4%	0.343	-0.86 / -0.54 / -0.44
TRIMP	228 ± 29	215 ± 22	242 ± 22	0.301	-0.42 / -1.07 / 0.49
RPE	5.8 ± 1.3	6.3 ± 2.0	7.0 ± 1.7	0.502	0.25 / -0.36 / 0.71
sRPE	397 ± 83	446 ± 137	503 ± 110	0.353	0.25 / -0.36 / 0.71

ES = Effect size, presented in the following order of comparisons: Cluster 1 *vs* Cluster 2 / Cluster 2 *vs* Cluster 3 / Cluster 1 *vs* Cluster 3. B = different from Cluster 2.

Figure 1B presents the AUC for each recovery variable of the respective clusters. Of note, lower AUC for 10m sprint, CK and Fatigue; and higher AUC for CMJ, TQR and Vigor represents a better post-session response and/or a shorter time to return to baseline. For ease of interpretation, clusters with the best or worse AUC in each variable will be reported to contrast with other clusters. Cluster 3 showed significantly higher (better) AUC in CMJ than cluster 1 (p=0.014; ES=1.63, CI = [0.65- 2.60]). For 10m sprint performance, AUC of cluster 2 was significantly lower (better) than clusters 1 (p=0.001; -1.82 [-2.79- -0.86]) and 3 (p=0.008; -2.59 [-3.54- -164]). A significantly higher (worse) AUC of CK was evident in cluster 1 compared to clusters 2 and 3 (p=0.001; 2.26 [1.33- 3.20] and p<0.001; 3.46 [2.49- 4.43], respectively). Cluster 2 showed higher (better) AUC in TQR compared to both cluster 1 (p=0.018; 1.43 [0.49- 2.36]) and cluster 3 (p=0.026; 1.55 [0.63- 2.46]). Similarly, AUC for vigor scores in cluster 2 was significantly higher (better) than cluster 3 (p=0.003; 2.07 [1.15- 2.99]). Regarding fatigue, cluster 3 presented significantly higher (worse) AUC compared to cluster 1 (p=0.014; 1.50 [0.53- 2.47]) and cluster 2 (p=0.008; 1.69 [0.72- 2.66]). Collectively,

based on the most prominent characteristics of recovery depicted by each cluster, we classified them as follows:
Cluster 1 = slower physiological recovery group (SL_{phy})
Cluster 2 = faster recovery group (FR)
Cluster 3 = slower perceptual recovery group (SL_{perc}).

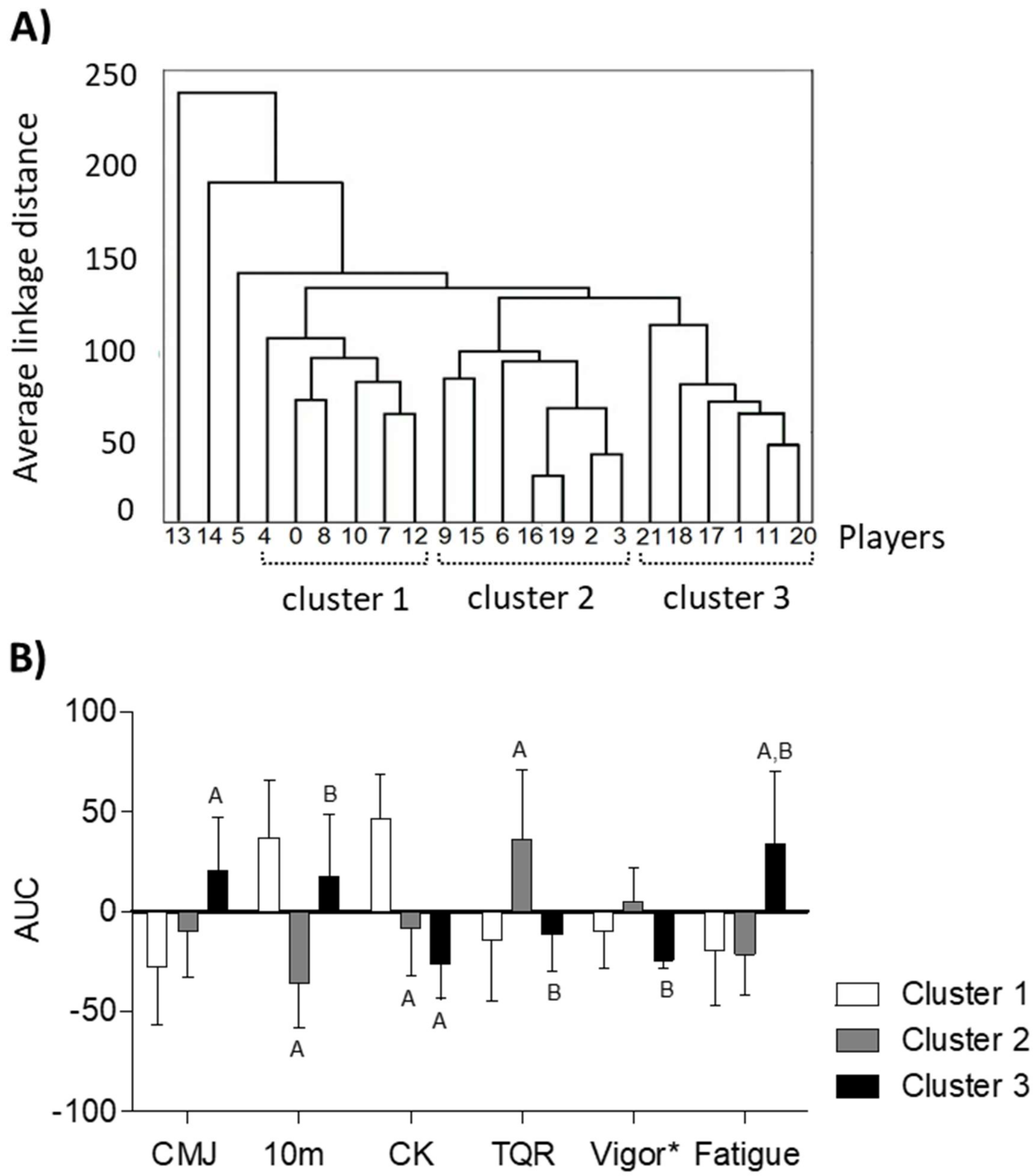

Figure 1. A) Dendrogram resulted from the cluster analysis. B) Area under the curve (AUC) of each recovery variable for the 3 clusters. The data in panel B is expressed as mean ± SD.; A = different from Cluster 1; B = different from Cluster 2. Legend: CMJ: countermovement jump, CK: creatine kinase, TQR: total quality recovery scale.

Subsequently, to test the appropriateness of the above cluster descriptors, the mean percentage changes relative to baseline in each parameter over the 48 h post-training recovery were compared (Figure 2). Immediately post-session, changes in physical performance (CMJ and 10m sprint) and CK were not significantly different between the 3 clusters (CMJ: p=0.467; 10m sprint: p=0.692; CK: p=0.447; ES ranging from -0.60 [-1.60- 0.41] to 0.71 [-0.20- 1.62]). However, CK concentration presented a significantly higher increase in SL_{phy} at 3 h post-session compared to FR (p=0.027; 1.27 [0.28- 2.26]) and SL_{perc} (p=0.022; 1.35 [0.37- 2.34]), as well as higher changes 48 h after training than SL_{perc} (p=0.005; 2.61 [1.62- 3.60]). The % change in 10m sprint performance of FR participants was significantly lower (better) compared to SL_{phy} at 3 h (p<0.001; -2.81 [-3.74- -1.88]) and 48 h (p=0.007; -1.85 [-2.79- -0.91]); as well as lower than SL_{perc} players 3 h (p=0.002; -2.07 [3.01- -1.13]). Contrastingly, 3 h after training the changes in CMJ were significantly better in the SL_{perc} group compared to FR (p=0.013; 1.59 [0.63- 2.55]) and SL_{phy} (p=0.001; 2.16 [1.19- 3.13]), whereas differences were not significant at 48 h.

In respect to perceptual responses, no significant differences amongst clusters were evident in the change in TQR 3h post-session (p=0.246). However, its subsequent increase was significantly higher in FR compared to SL_{per} at 24h (p=0.041; 1.12 [0.19- 2.05]) and compared to SL_{phy} at 48h post-session (p=0.027; 1.37 [0.40- 2.34]). Similarly, the decrease in vigor immediately (p=0.218) and 3h after the session (p=0.245) were not significantly different between clusters. However, changes were significantly higher in FR compared to SL_{perc} at both 24h (p=0.011; 1.88 [0.96 to 2.80]) and 48h after training (p=0.012; 2.07 [1.16-2.98]). Fatigue scores were only different 24h post-session, when the SL_{perc} group presented higher changes from baseline compared to SL_{phy} (p=0.011; 1.88 [0.89 to 2.87]).

When comparing participant characteristics between the 3 clusters (Table 3), anthropometric measures were not significantly different (p>0.05), though SL_{perc} players were younger than SL_{phy} (p=0.027; -1.04 [-2.03- -0.05]) and moderate effect sizes were evident compared to FR (p=1.000; -0.55 [-1.52- 0.42]) clusters. Regarding physical performance, SL_{phy} and SL_{perc} players were significantly faster in the 10m sprint compared to FR (p=0.003; -1.99 [-2.96- -1.02] and p=0.013; -1.89 [-2.84- 0.93], respectively). Although no significant difference was evident for VO_{2max} (p=0.128), there was a moderate - large effect for higher values in FR in comparison to SL_{phy} (1.13 [0.15- 2.11]) and for SL_{perc} in comparison to SL_{phy} (0.70 [-0.33- 1.73]).

From baseline measures, only vigor scores were significantly higher in SL_{phy} than in FR participants (p=0.041, 1.16 [0.23- 2.10]). Moderate effect sizes were found for TQR (-1.16 and -0.88), vigor (-1.59 and -1.05) and sleep quality (-0.83 and 1.14) when comparing FR to both SL_{phy} and SL_{perc}, respectively. In addition, effect sizes were moderate for tension (-0.81 and -0.84) and depression (-0.98 and -0.63) when comparing SL_{perc} to FR and SL_{phy}, respectively.

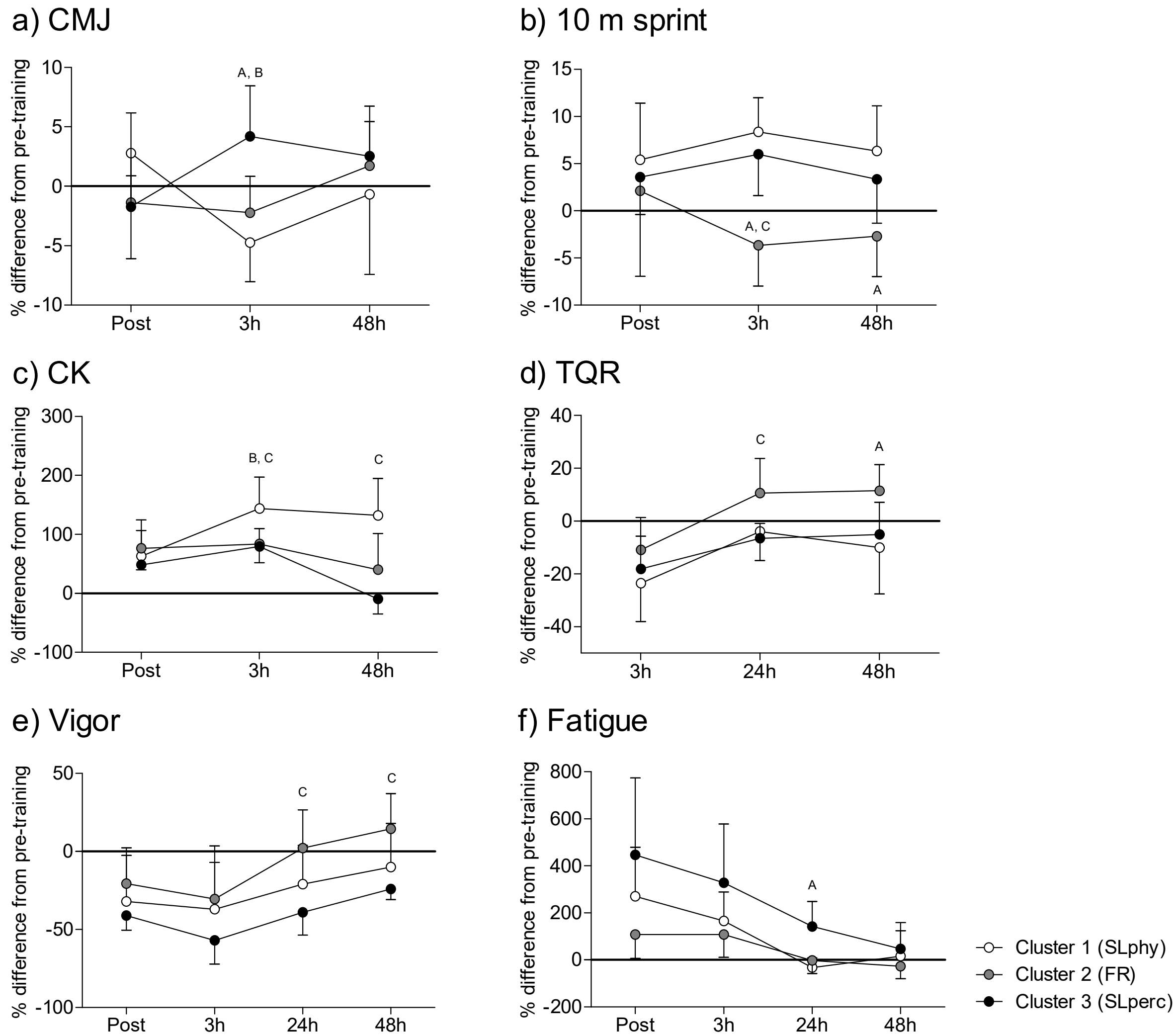

Figure 2. Percentage difference from baseline obtained at each time point (post-training, 3 h, 24 h and 48 h hours post training) of the 3 clusters in each recovery parameter. a) countermovement jump (CMJ), b) 10m sprint, c) creatine kinase (CK), d) total quality recovery (TQR) scale, e) Vigor, e) Fatigue. A = different from SL_{phy}; B = different from FR; C = different from SL_{perc}.

Table 2: Age, anthropometry, physical performance and pre-training measures of the three clusters (mean ± SD).

	Cluster 1 (SLphy)	Cluster 2 (FR)	Cluster 3 (SLperc)	p	ES
Age / Anthropometry					
Age (years)	18.3 ± 1.0	20.8 ± 3.4	24.0 ± 6.5^{A}	0.027	0.89 / -0.55 / 1.03
Body mass (kg)	68.2 ± 10.8	70.0 ± 3.2	70.4 ± 6.1	0.857	0.19 / -0.07 / 0.22
Stature (cm)	174.2 ± 7.1	175.1 ± 7.0	172.7 ± 3.4	0.778	0.12 / 0.40 / -0.24
Physical performance					
VO_2max ($mlO_2.kg^{-1}.min^{-1}$)	48.9 ± 4.0	54.2 ± 4.5	51.9 ± 3.6	0.128	1.13 / 0.52 / 0.70
%VO_2max at VT	43.3 ± 4%	45.5 ± 12%	52.2 ± 14%	0.466	0.23 / -0.49 / 0.76
CMJ (cm)	33.7 ± 4.2	32.7 ± 4.3	30.9 ± 1.4	0.407	-0.22 / 0.51 / -0.79
Sprint 0-10m (s)	1.53 ± 0.06	1.64 ± 0.03^{A}	1.55 ± 0.05^{B}	0.002	1.99 / 1.89 / 0.33
Pre-training measures					
CK (U/L)	198 ± 129	168 ± 89	327 ± 370	0.908	-0.25 / -0.51 / 0.41
TQR	14.7 ± 1.4	13.0 ± 1.3	14.3 ± 1.5	0.099	-1.16 / -0.88 / -0.21
Vigor	11.5 ± 1.8	7.7 ± 2.6^{A}	10.5 ± 2.3	0.035	-1.59 / -1.05 / -0.44
Fatigue	2.8 ± 2.7	4.6 ± 2.4	1.8 ± 1.2	0.105	0.63 / 1.33 / -0.42
Tension	3.0 ± 2.5	2.9 ± 2.5	1.2 ± 1.0	0.279	-0.05 / 0.81 / -0.84
Depression	0.5 ± 0.5	1.0 ± 1.0	0.2 ± 0.4	0.142	0.57 / 0.98 / -0.63
Anger	0.7 ± 1.6	1.1 ± 2.2	0.7 ±1.6	0.867	0.23 / 0.23 / 0.00
Confusion	1.0 ± 1.5	1.7 ± 2.2	0.7 ± 1.2	0.552	0.35 / 0.54 / -0.22
Urine specific gravity	1020 ± 7	1026 ± 7	1026 ± 7	0.321	0.78 / 0.07 / 0.71
Sleep hours	7.5 ± 0.9	7.0 ± 0.9	6.7 ± 1.1	0.387	-0.46 / 0.34 / -0.73
Sleep quality	3.5 ± 0.5	3.0 ± 0.6	3.8 ± 0.8	0.100	-0.83 / -1.14 / 0.46

ES = Effect size, presented in the following order of comparisons: Cluster 1 *vs* Cluster 2 / Cluster 2 *vs* Cluster 3 / Cluster 1 *vs* Cluster 3. SL_{phy} = slower physiological recovery, FR = faster recovery, SL_{perc} = slower perceptual recovery, CK = creatine kinase, CMJ = countermovement jump, TQR = total quality recovery scale, VO_2max = maximal oxygen consumption, %VO_2max at VT = percentage of maximal oxygen consumption at the time the ventilatory threshold was reached. A = different from Cluster 1 (SL_{phy}); B = different from Cluster 2 (FR).

Discussion

This study investigated the identification of faster and slower post-training recovery profiles in elite futsal players, and the distinguishing characteristics between respective groups. The cluster analysis differentiated 3 groups based on 6 recovery parameters (cluster 1 = SL_{phy}; cluster 2 = FR; cluster 3 = SL_{perc}). FR players demonstrated better post-training recovery in 4 of the 6 measures (10m sprint, TQR, vigor, fatigue), showed slower sprint performance and moderate effects for increased VO_{2max}. SL_{phy} players showed poorer sprint performance and higher CK concentrations, despite a tendency to report better perceived recovery (TQR, vigor and fatigue). Conversely, SL_{perc} players were older than SL_{phy}, and reported poorer mood states (vigor and fatigue) despite no overt decrement in any physical performance. Consequently, a multi-parameter classification of recovery state may be possible to differentiate recovery characteristics and guide training and recovery practices.

Given the technical-tactical nature of the session replicating ecologically valid high-intensity training routines, training load was not precisely standardized for all players. However, despite better pre-training TQR of FR players, no differences in training load parameters PL, %HRmax and RPE were between clusters (Table 1). Aligned with these results, comparisons of post-session CMJ, 10m sprint and CK changes from baseline were not significantly different between clusters, supporting previously reported association between training loads and physical performance after a soccer match[23]. Therefore, it is reasonable to infer that factors aside from training loads would explain the distinct recovery profiles.

Discussing the respective groups in isolation, FR demonstrated faster recovery in 10m sprint, TQR, vigor and fatigue than the other groups. We propose this represents a "preferred" recovery profile given reduced extent of post-training fatigue or faster return to pre-testing is considered optimal[1, 4]. Additionally, the aligned response of objective and subjective parameters agrees with integrative models of fatigue[24], supporting recent perspectives of the mechanisms underpinning recovery[2]. Interestingly, defining characteristics of this FR cluster were the slowest 10m time compared to the other clusters and a tendency (moderate ES) towards higher VO_{2max} compared to the other two clusters. Such a finding aligns with previous research reporting that players with higher YoYo performance showed faster post-match recovery following a rugby league match than their counterparts with lower performance[4]. Accordingly, the profile of futsal players who may be considered to have better "recovery capability" may relate to higher aerobic fitness. However, the tendency towards lower $\%HR_{max}$ during the session for FR players compared to SL_{phy} groups raises the question of whether physical capacity or training load may best explain the difference in recovery profile.

SL_{phy} players exhibited the worst AUC for CMJ and CK, based on a decrease in CMJ 3h post-session and the sustained increase in CK up to 48h. This profile represents higher peaks in muscle damage and reduced power during the 48h post-training, which could risk optimal performance at ensuing training/competition sessions during congested schedules, and represent the most important group to intervene to aid recovery[1]. Notably, SL_{phy} presented faster 10m sprint time before training, as well as a tendency (moderate ES) towards lower VO_{2max} than FR. In this case, it is not unexpected that high power athletes with higher proportion of fast-twist muscle fibers may experience greater decrease in power performance and longer time for muscle damage repair[25, 26]. Albeit speculative, this rationale also aligns with the greater decreases in speed previously observed in faster futsal players after a preseason[27]. Accordingly, extra attention to the neuromuscular recovery status of high speed/power athletes during congested schedules can be beneficial.

The SL_{perc} group reported worse fatigue and vigor AUC, representative of worse scores relative to baseline 24h and 48 h after the session. However, these players also despicted better CMJ and CK recovery profiles. These results contradicts our expectations of an overall slower recovery profile, and is likely to represent differences often reported by practitioners between an athlete's perception of recovery and the observed physical performance in a session[28]. The environmental or psycho-physiological factors that affect these perceptions remain speculative, but this profile highlights perception of recovery as an important factor to consider in sub-groups of players. Given these players were older than SL_{phy} participants, it is possible that age and experience affected players' perceptual mood/recovery contributing to the observed mismatch between objective and subjective parameters' timeline of recovery in SL_{perc} and SL_{phy} clusters. As evidence, years of experience in professional Australian football have been associated with higher RPE for a constant external training load[29].

Despite the attempt to classify and explain recovery clusters, several limitations need to be further acknowledged. To partially overcome the restricted number of players constituting a futsal team, we evaluated two age/skill level groups in separate sessions; albeit it appears that training load *per se* was not the determinant of the different recovery profiles, the influence on the current findings remains uncertain. We also acknowledge that sample size can still restrict the extrapolation of our findings, as well as the limitation of the physiological dimension to a single muscle damage marker (CK). Moreover, it is important to address that 3 players were not nested to any cluster, showing that not all athletes fit in a general classification of recovery, and therefore the use of this technique to guide training loads and recovery practices can be limited. Finally, we recognise that this study represents responses to one session and the methodological assessment may not be practical to high performance teams.

Practical Applications

Given the distinct timeline of recovery of physical, physiological, perceptual and mood markers, recovery monitoring should include both objective and subjective measures, alongside training load measures to aid appropriate interpretation. Based on such multifactorial recovery timeline, our results provide initial insights to the use of statistical tools as a diagnostic approach, discriminating smaller groups within a team to support the prescription of training and recovery according to main individual needs. Future studies are thus encouraged to adapt more functional approaches for recovery profile assessment.

Conclusions

Differing post-training recovery profiles were evident in futsal players. A faster global (physical and psychological) recovery profile existed, possibly positively affected by higher aerobic capacity. Interestingly, two groups were classified with distinct slower recovery profiles conditioned by responses in either physiological or perceptual parameters, potentially influenced by higher speed/power performance and higher age/experience of athletes, respectively.

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7 ESTUDO 3

Daily perceived recovery in futsal players: influence of recovery profile classification, perceived sleep, acute training load and phase of microcycle

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Keywords:	Fatigue, Recovery monitoring, Pre-season, Team sport, TQR

Abstract:

Purpose: To determine whether daily perceived recovery is explained from a multifactorial single-session classification of recovery type (i.e. faster vs slower), or circumstantial factors such as previous training load, self-reported sleep or phase of training week. **Methods:** During four weeks of pre-season, training load via Player Load (PL), training impulse (TRIMP) and training load based on the perceived exertion (TL-RPE) were monitored in nineteen elite male futsal players. Prior to each day's training, players reported their perception of recovery (total quality of recovery scale, TQR), the number of hours and perceived quality of sleep the night prior. A hierarchical linear mixed model was used to analyse the effect of different recovery profiles (i.e.: slower physiological, slower perceptual and faster,recovery), training load, sleep and phase of the week (i.e.: start, middle, end) on daily TQR. **Results:** The recovery classification of players ($P = 0.20$), training load (TRIMP: $P = 0.32$; PL: $P = 0.23$; TL-RPE: $P = 0.46$) as well as the self-reported hours slept on the night before ($P = 0.45$) did not significantly predict TQR. However, perceived sleep quality ($P < 0.01$) and phase of the microcycle ($P < 0.01$) were significantly associated with TQR ($r^2 = 0.41$). **Conclusions:** Neither acute post-training recovery classification or prior training load predicted perceived recovery during pre-season training. However, higher TQR was evident with higher self-reported sleep quality, whereas lower values were associated with further phases of the training week.

Keywords: Fatigue, recovery monitoring, pre-season, team sport, TQR.

Introduction:

Allowing adequate recovery following training and matches is important to promote positive training adaptations and readiness to perform; however, understanding this fatigue – recovery response is difficult given the multifactorial nature of these processes [1]. In this sense, research on post-match or training recovery timeline provides reference for the expected extent of readiness to perform; for example, 72 h after soccer matches [2] and 24 h after soccer small-sided games training [3]. However, such studies report mean cohort data in single-variable timelines, without incorporation of the diversity of recovery measures and variability of player recovery [4]. To counter this, we recently used a cluster analytical approach to identify multifactorial post-training recovery profiles in futsal players after a high-intensity training session; classifying three groups of 1) faster recovery (FR); 2) slower physiological recovery (SLphy); and 3) slower perceptual recovery (SLperc) [5]. Whilst the abovementioned classifications are novel to recovery research, they were reported from a single training session, hence whether these profiles are reflected in daily monitoring of fatigue and recovery responses commonly used in sports remains unknown.

In the aforementioned study, the respective recovery profiles indicating faster and slower timelines were differentiated based on physical performance (CMJ and sprint), physiological (blood concentration of creatine kinase - CK) and perceptual parameters (perceived recovery and a mood questionnaire) [5]. Further, we observed that individuals with higher aerobic capacity had a tendency to recover to near baseline values faster, and that older players tended to report worse perceptual recovery without physical performance impairment. Whilst understanding distinct profiles and their relation to individual characteristics may be informative for practitioners to assist providing appropriate interventions, these were investigated outside the congested schedule of team sports [6-8]. For instance, 2 rest days were allowed before and after the experimental training session, whereas a typical futsal pre-season routine involves 1-2 on-court and strength training sessions per day [9]. In such contexts, players' responses to daily recovery assessments would expectedly be influenced by factors other than their individual profiles identified in controlled settings; such as the previous training load, sleep and existence of cumulative fatigue [10, 11]. The multifactorial nature of recovery [1] reinforces the concern of whether such timelines apply in chronic and ecologically valid settings. Accordingly, whether these faster or slower recovery classification types are reflected in commonly used measures within athlete monitoring programs in a daily ecological setting remains to be determined.

Further to particular recovery profiles, understanding the situational variables i.e. load, stage of the training week or previous nights' sleep, that influence athletes' perceived recovery is important. Subjective self-reported questionnaires and scales of the load (i.e. rating of perceived exertion - RPE) and recovery status are popular tools in athlete monitoring programs. For instance, the perception of recovery based on total quality of recovery scale (TQR) [12] has been reported to reduce after basketball [13] and youth soccer matches [14]. The sensitivity of TQR to chronic load has also been reported, as scores fluctuated throughout a season in relation to weekly training load in elite volleyball players [15]. Wellbeing scores, an additional indicator of recovery and readiness perception, have also been shown to be affected by the fatigue accumulated within a microcycle. McLean et al. [16] reported that longer training microcycles evidenced higher fatigue and lower wellbeing scores compared to shorter ones in rugby league. Furthermore, sleep is suggested as an important driver of recovery [11], and an increase in self-reported sleep duration was shown to positively influence youth players' [17]. Consequently, understanding what influences players' perception of recovery may improve coaching staff awareness of recovery status and hence their ability to manipulate training and recovery strategies. Therefore, this study aimed to 1) determine whether multifactorial single-session classification of recovery type was reflected on daily perceived recovery and 2) to determine what factors explained daily perceived recovery state in elite futsal players during a pre-season.

Methods

Subjects

Nineteen elite futsal players, members of either the professional or under 20 team of the same first-division Brazilian club agreed to participate in the study (age: 21.0 ± 4.5 years, weight: 69.6 ± 6.7 kg, height: 174.0 ± 5.7 cm). All participants were informed of all the procedures involved in the study and provided written informed consent. The study was approved by the university Research Ethics Committee (50166015.9.0000.5149).

Design

This study is part of a larger project aiming at understanding recovery profiles of elite futsal athletes, and detailed information of the identification of the recovery profiles can be found elsewhere [5]. Briefly, at the start of the pre-season, players underwent a high-intensity training session followed by the assessment of 48 h physical, physiological, and perceptual recovery timelines. Players were then classified into three profiles based on the timeline of recovery of countermovement jump (CMJ) and 10m sprint with change of direction performances, creatine kinase concentration, TQR, vigor and fatigue scores assessed immediately post, 3 h, 24 h and 48 h following the session. These classifications were as follows:

1) Faster recovery group (FR; n = 6)

2) Slower physiological recovery group (SLphy; n = 7)

3) Slower perceptual recovery group (SLperc; n = 6)

The present study used these players' classifications to the recovery and training load monitoring data during the ensuing pre-season training. Specifically, for four weeks during the 2016 pre-season, elite futsal players reported their perception of recovery based on the TQR scale before the first training session of each day, in addition to the duration and quality of their sleep from the night prior. External and internal load from all technical-tactical sessions were also measured.

Methodology

Pre-season training

Training schedules of both U20 and professional teams included a minimum of five technical-tactical and two strength training sessions per week. A detailed schedule of each team during the four weeks is presented in Table 1. Technical-tactical training sessions comprised activities aimed at developing team shape, technical and decision-making skills; and were held on one of the three courts available at the training facilities: 36 × 20 m; 31 × 19 m; or 25 × 15 m. Strength training was performed in the gym; including general upper body, lower body and core exercises aiming for both hypertrophy and explosive strength. Planning and prescription of all sessions were conducted by the respective Head and Strength and Conditioning coaches, with no interference from the researches. For analysis purposes, each microcycle (Mon – Sun week) was divided in three sections (start (first 2 sessions), middle (1 to 3 sessions) and end (last 2 sessions).

Table 1: Schedule of each microcycle of the professional and under 20 teams.

		Week 1		Week 2		Week 3		Week 4	
		Morning	**Afternoon**	**Morning**	**Afternoon**	**Morning**	**Afternoon**	**Morning**	**Afternoon**
Professional	**Monday**		T.T	FT + T.T		T.T		T.T	
	Tuesday	T.T		T.T	Gym	T.T	Gym	T.T	Gym
	Wednesday	Video	Gym	T.T		T.T		T.T	
	Thursday	T.T	T.T	T.T	Gym	T.T	Gym	T.T	Gym
	Friday	OFF		T.T		T.T		T.T	
	Saturday	FT + T.T	FT	T.T		OFF		T.T	
	Sunday	OFF		OFF		OFF		OFF	
Under 20	**Monday**	T.T		FT + T-T	FT	T.T		T.T	
	Tuesday	T.T		FT + T-T	Gym	T.T	Gym	T.T	Gym
	Wednesday	T.T		T-T			T.T	T.T	
	Thursday	T.T			T.T + Gym	T.T	Gym	T.T	Gym
	Friday	T.T			T-T	T.T		T.T	
	Saturday	T.T		OFF		T.T		T.T	
	Sunday	OFF		OFF		OFF		OFF	

T.T = technical-tactical training sessions; FT = fitness testing; Video = video analysis session; Gym = strength training at the gym.

Daily recovery monitoring

All players answered short questionnaires before the first training session of each day, including: 1) perception of recovery, using the TQR [12], ranging from 6 (worse than very, very poor recovery) to 20 (better than very, very good recovery); and 2) how long they slept on the night before and how they would rate the quality of their sleep using a 5-point scale (1 = very bad and 5 = very good).

Training load monitoring

During the technical-tactical training sessions, players wore a Global Positioning Satellite unit coupled with a triaxial accelerometer (SPI ProX2, GPSports Systems®, Australia), and a compatible heart rate receiver (Polar®, Finland). The devices were used in the indoor mode, with which accelerometer and heart rate data were recorded, from which Player Load (PL) [18, 19] and the training impulse (TRIMP) [20] were calculated. Approximately 15 min after the session, players rated their perception of effort relative to the entire session (session RPE; sRPE) using a 10-point scale [21], and the training load based on the sRPE (TL-RPE) was calculated by multiplying sRPE score by the session duration [21].

Statistical analysis

A Kruskal-Wallis test was used to access differences in TQR based on the three recovery classifications (FR, SLphy, SLperc) and the Friedman test was used to access differences amongst the phases of the microcycle (start, middle, end), followed by Wilcoxon's pairwise test when applicable (SPSS® software, version 22).

Importantly, differences in responses for players belonging to the different recovery profiles were tainted by the fact that there were repeated measures within the sample. To overcome this, mixed models were used. Before applying this method, a principal component analysis was run to identify the most suitable training load parameter (PL, TRIMP or TL-RPE) to be used in the model (SPSS® software, version 22). However, results indicated a single component with eigenvalues values lower than 1 for the three variables (TRIMP = 0.789, PL = 0.878, TL-RPE = 0.873), indicating that no variable would explain a higher variance in training load, and therefore all were maintained in the model. To investigate the influence of recovery profile, training load, sleep and cumulated fatigue on athletes' perception of recovery, a hierarchical linear mixed model (HLMM) was performed using TQR as the response variable (R® version x64 3.4.3). A step-up approach was implemented, starting from a null model, and adding variables if 1) their effect on TQR was significant and 2) their inclusion improved the model fit. Predictors (recovery profile, training load parameters, sleep and phase of the microcycle) were assigned as fixed factors, and all models allowed the intercept to vary randomly per player. TQR outliers (n=9) were removed to improve model fit, and the number of observations attained was 261.

Results

Comparison between recovery profiles:

Mean weekly TQR during the 4 weeks of pre-season for FR, SL_{phy} and SL_{perc} were 13.7 ± 1.7, 13.7 ± 1.9 and 13.8 ± 1.1, respectively (equating to qualitative recovery descriptors of poor/reasonable and good); and was not significantly different between the three recovery classifications ($P = 0.350$). In addition, the TQR did not differ between the groups at each stage of the week microcycle ($P = 0.955$; 0.941 and 0.078 for start, middle and end of the microcycle, respectively; Figure 1). However, TQR was higher at the start of the microcycle than in the middle or end of the microcycle, respectively ($P < 0.001$).

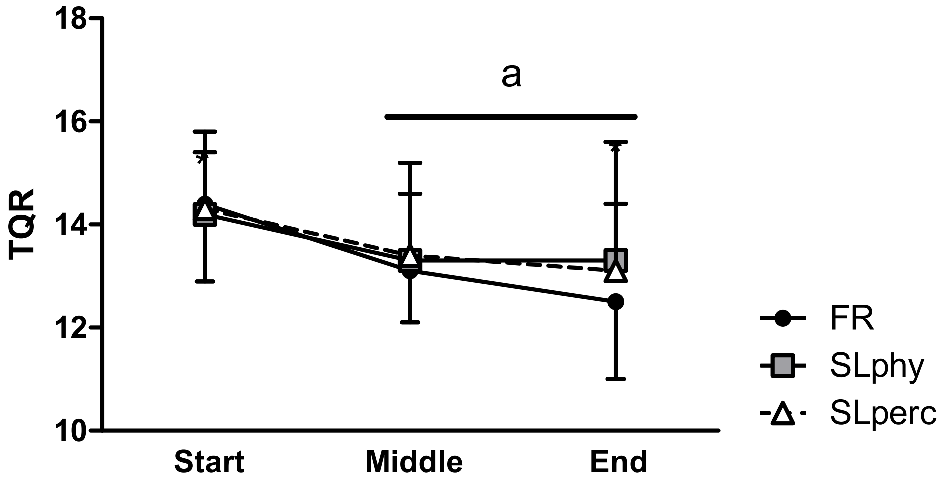

Figure 1: Total quality recovery scores (TQR) of the three recovery classifications at the start, middle and end of each training microcycle. FR = faster recovery; SLphy = slower physiological recovery; SLperc = slower perceptual recovery profiles. [a] different from the start of the microcycle, irrespective of the recovery profile ($p < 0.001$).

Influence of recovery profile, training load, sleep and phase of microcycle on TQR:

When tested both separately and in the full model, the recovery classification of players, training load on the previous day (TRIMP, PL and TL-RPE) as well as the self-reported hours slept on the night before had no significant effect in predicting TQR (Table 2). However, perceived sleep quality and phase of the microcycle significantly influenced TQR, particularly with inclusion of a random intercept for players. The explained variance (r^2) of TQR using this model was 0.41.

Table 2 Linear mixed model parameter estimates for the effect of recovery profile, training load, sleep and moment of the microcycle on TQR.

	Coefficient	Std Error	df	t value	p
Fixed effects					
(Intercept)	12.30	0.93	107.30	13.29	<0.01*
Cluster	-0.28	0.21	16.13	-1.33	0.20
TRIMP	-2.36 x 10-3	0.00	127.70	-1.00	0.32
PL	1.17 x 10-3	0.00	108.50	1.20	0.23
TL-RPE	-4.47 x 10-4	0.00	171.50	-0.74	0.46
Sleep hours	-0.05	0.07	171.60	-0.75	0.45
Sleep quality	0.90	0.18	162.50	5.09	<0.01*
Phase of microcycle	-0.46	0.11	164.10	-4.26	<0.01*

PL = player load, TRIMP = training impulse, TL-RPE = session rating of perceived exertion x session duration. * represents significant effect ($p<0.01$).

Further analysis of the best predictors of TQR (sleep quality and phase of the microcycle) is presented in Table 3 ($r^2 = 0.36$). For each 1-point increase in player's rating of sleep quality, TQR was expected to increase by 0.85 units. When analysed for phase of microcycle, TQR reported in the mid- microcycle sessions was expected to decrease by 0.42 units compared to the first two sessions of the microcycle, and to decrease additional 0.42 units at the end of the microcycle.

Table 3 Parameter estimates of the best-fit linear mixed model based on the effect of sleep and moment of the microcycle on TQR.

	Coefficient	Std Error	df	t value	p
Fixed effects					
(Intercept)	11.43	0.49	270.70	23.49	<0.01*
Sleep quality	0.85	0.11	328.20	7.44	<0.01*
Phase of microcycle	-0.42	0.08	325.70	-5.38	<0.01*

* represents significant effect ($p<0.01$).

Discussion:

Perceived recovery (TQR) in elite futsal players varied irrespective of their recovery classification identified after a single training session at the start of the season. Importantly, perceived recovery was highly individualised, though progressively decreased TQR was evident for the weekly microcycle. Of interest, perceived TQR was positively influenced by improved perceived sleep quality on the previous night, despite no effect of training load from the day prior. Such findings support the notion that when monitoring players' perception of recovery, results should be interpreted individually, considering both sleep and cumulated fatigue.

We had hypothesised that player recovery profile classification determined from an acute recovery bout would persist in chronic recovery status during pre-season training. Previously, a "faster recovery" group presented lower reduction in sprint performance 3 h post-training, alongside improved TQR and vigor scores at 24 h and 48 h post-training [5]. However, recovery classification here was not associated with TQR in a chronic training setting. Explaining this contrast, the recovery profile classification in the former study involved a 48 h recovery timeline of 6 parameters, including physical (CMJ and 10m sprint with change of direction), physiological (creatine kinase concentration) and perceptual (TQR, vigor and fatigue) dimensions. Therefore, it is plausible that TQR alone was not sufficient to reflect this holistic nature of recovery captured in the acute training session classification [1]. Alternatively, the uncontrolled environment of elite teams' routine differs considerably from the controlled post-training recovery timeline study [5]; and other situational variables are likely to affect psychophysiological recovery [2, 22]. This is particularly the case given single-session timelines do not capture intra-individual variability in recovery responses, thus having limited application to ongoing monitoring. Consequently, despite the novel concept of recovery type classification, such acute profiles either are not represented in a daily recovery status of athletes in a professional setting, or are not captured by single-item perceived recovery scales [1, 2].

Hence, further longitudinal studies are required within these environments on recovery profile classification.

Although recovery classification type was not associated with daily perception of recovery, other factors from the training environment were significant in predicting players' perceived recovery. For example, TQR was expected to reduce during the microcycle irrespective of the reported training load on the preceding day. Previous studies have found wellbeing scores to decrease within a season, associating such results to accumulated fatigue [23, 24]. The current study shows a reduction in TQR as the weekly microcyle progresses, though seemingly independent to the effect of prior training load. As an explanation, we speculate that stressors related to maintaining the engagement in the weekly training routine may influence the reduction in TQR over the microcycle. For example, stressful factors include normal demands of being a professional athlete such as attending training, maintaining appropriate diet and dealing with coaches' expectations in addition to the training stress. Such hypothesis is supported by psychology studies showing that peoples' willingness and motivation to dedicate effort that demands self-control can wane over time, irrespective of physical activity [25]. However, it is also suggested that increased motivation can reduce the self-depletion effect, which aligns with models of exercise-induced fatigue [26, 27]. Consequently, whether the phase of the weekly microcycle can predict players' perception of recovery during in-season match weeks, as well as its interrelationship with the training load in such context remain to be elucidated. Regardless, this study shows that the advancement of the microcycle, in the absence of match load, affects perceived recovery irrespective of the previous days' training load.

The lack of influence of preceding training load on perceived recovery was an unexpected result. For instance, negative associations between weekly training load and TQR were found in elite volleyball players [15] and *most likely* small effects of previous days' training load on perception of recovery and muscle soreness were detected in youth scholar athletes [17]. However, Gallo et al. [23] also found no effect of training load on the following day's wellness response of professional Australian Footballers. Differences between ours and the abovementioned studies' approach to analyse the load (i.e. weekly vs daily) and athletes' experience or time of exposure to training (i.e. youth x elite) may partially explain the various findings. Given current literature in futsal suggests 24 h may be sufficient for some athletes to perceive themselves recovered from high-intensity training sessions [5] or match-loads [6], we speculate that the approximate 24 h interval between most technical-tactical sessions can partially explain the lack of association between preceding training load and perceived recovery.

In agreement with a range of studies showing the benefit of sleep in athletes' recovery [28], TQR was positively influenced by perceived sleep quality. This result is also in agreement with the small effect of perceived sleep quality on the perception of recovery reported in youth athletes [17]. It is possible that the predominance of morning training sessions in our study strengthened such effect, due to a dominance of sleep being the primary activity in the hours preceding athletes' response to their perceived state of recovery. In fact, perceptual scales can be influenced by recent events, whether the training intensity or other activities [21]. Future studies on aspects influencing TQR on assessments performed in different times of the day may assist answering this query. Interestingly, the self-reported sleep duration was not a significant predictor for TQR as previously shown [17]. Given the different factors that may be related to sleep quality (i.e. time asleep, wakening time, sleep efficiency [29]), it is possible that sleep hours did not reflect how well players recovered after the night of sleep. Regardless, the subjective assessment of sleep quality may be a useful low-cost and practical solution guiding an understanding of self-reported recovery in the morning prior to training.

It is important to acknowledge that the best-fit model in this study presented a low estimative potential ($r^2 = 0.36$) and a relatively large amount of unaccounted variability (Residual SD = 1.189), strengthening the idea that more and / or different assessments are needed to fully understand TQR. Additionally, the model was developed using a relatively small time-frame, during a pre-season without matches; it is possible that the relationship between the monitoring variables changes during the congested match period of the season. Provided limitations of the model are considered, the reported relationships could be used as reference values to interpret players' daily rating of recovery.

Practical Applications

Findings from this study again highlight the multifactorial nature of recovery and the importance of including various factors in monitoring programs, including self-reported sleep quality. When interpreting perceived recovery (TQR) responses, two aspects are evident: 1) the individuality in players' perception of recovery – and thus the relevance of individual analysis and 2) phase of the weekly microcycle. Accordingly, the impact of off-field factors on recovery further supports benefit of player education regarding sleep hygiene. Future studies are encouraged to investigate whether such relationships are maintained during the congested match period of the season.

Conclusion

Daily perception of recovery during a pre-season was not predicted by players' acute post-training recovery profile determined from a multi-parameter 48 h recovery timeline, nor was by the previous day's training load. However, higher self-reported sleep quality enhanced TQR, whereas players' perception of recovery decreased over the course of the training microcycle.

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8 ESTUDO 4

Can training influence post-session recovery? A case study of Brazilian futsal players before and after a pre-season

Brief running head: Effect of training on post-session recovery in futsal

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Abstract

This study compared the post-training recovery timeline of elite Brazilian futsal athletes before (PrePS) and after (PostPS) a 10-week pre-season period of high-intensity tactical training. At the start and at the end of the pre-season, seven under-20 male futsal players participated in a training session where performance and psycho-physiological measures were recorded before, immediately, 3, 24 and 48h post-session. Measures included countermovement jump (CMJ), 10m sprint with change of direction, creatine kinase (CK), total quality recovery scale (TQR) and Brunel Mood Scale. Magnitude-based inference analyses were used to compare athletes' fitness, pre-training values and difference from baseline values at each time during the recovery timeline for each parameter at PrePS *vs* PostPS. No meaningful differences in maximal oxygen consumption, ventilatory threshold, CMJ and 10m sprint were evident at Post compared to Pre PS (effect sizes = -0.02 to 0.11). Although no changes were evident for 10m sprint recovery timeline, post-session CMJ recovery was improved at 3h, 24h and 48h in PostPS (0.87, 0.55 and 1.27, respectively) and CK was lower at 48h (-1.33) at PostPS compared to PrePS. Perceptual responses were also improved at PostPS: perception of recovery was improved at 3h-post (1.50) and 24h post session (0.92). Further, perception of fatigue was lower at 3h (-0.49 and -0.63) and vigor responses were improved in all post-session assessments (0.59 to 1.13). In conclusion, despite minimal changes in fitness, pre-season training attenuated players' perception of effort and fatigue and improved their recovery profile following high intensity technical-tactical training session.

Keywords: CMJ, performance, team sport, TQR, training, fitness.

Introduction

High-intensity training and match loads in team sports induce transient physical performance decrements, alongside increased muscle damage and inflammatory markers, and impaired neuromuscular function (1). The congested schedule of training and competition experienced during a season requires players to recover within short intervals to ensure readiness to perform and reduce injury risks (2). Whereas recovery interventions may accelerate recovery to some extent, research has shown that many methods often present minimal benefit, particularly in regards to physical performance (3, 4). Thus, it remains plausible that underlying factors related to individual physical capacities and exercise tolerance may be more relevant to the regulation of the post-exercise recovery timeline. For instance, higher aerobic fitness is associated with short-term recovery from high-intensity intermittent exercise (5). Given training can improve physical fitness (6-8), it is likely that training adaptations can also promote faster recovery (9). Despite such relationships between fitness and recovery reported in team sports in cross-sectional studies (5, 10), the chronic investigation on the effect of training on recovery in ecologically valid settings remain sparse.

The combination of intermittent high-intensity and strength/power training in team sports induces central and peripheral adaptations related to improved aerobic, anaerobic and sprint performance (11, 12). In turn, such adaptations are proposed to reduce fatigue and improve physical performance during matches (10, 13); though the effect of such training on the ability to recover from team sport demands remains presumed. Zghal et al. (14) observed that individuals with higher aerobic capacity showed faster short-term recovery after maximal isometric exercise; suggesting that the improved tolerance to peripheral fatigue resulted in improved post-exercise recovery. However, this is less clear within team sport contexts, where multi-parameter recovery timelines may vary from hours to several days (15). Johnston et al.

(10) showed that players with higher aerobic power (as evident from higher YoYo Level 1 scores) exhibited lower post-match impairment in countermovement jump (CMJ) and plyometric bench press power, followed by faster recovery of respective performances following a rugby league match. Collectively, such findings support the hypothesis that improved physical fitness may positively affect players' recovery. Nevertheless, individual factors related to aerobic power (e.g. age, performance level and playing position) (16, 17) underlying cross-sectional studies limit inferences on the potential effect of training on recovery capacity.

Recovery is particularly important in the sport of futsal since the high number of weekly training sessions (i.e. up to 10) combined with frequent matches (7) places considerable impact on players' readiness to perform. Due to the high number of in-season matches, development of physical performance is often targeted during the pre-season (12); from which aerobic power and repeated sprint ability improvements are observed in under 20 and professional players (7, 8, 18). Collectively, given the importance of players' ability to recover from high psycho-physiological demands within the congested schedules of futsal, it seems reasonable to infer that training may benefit post-exercise recovery ability. Given such timeline is variable-dependent, a multi-parameter investigation of recovery can provide a more comprehensive understanding of the physical, physiological and psychological changes involved in this process (2). Therefore, the aim of this study was to investigate whether a pre-season training period improves recovery from high-intensity futsal training session using a multi-parameter recovery assessment.

Materials and methods

Study design

To investigate the effect of training on player's recovery time course, 14 under 20 (U20) players from a national-level Brazilian futsal team were recruited. At the start of the 2016 pre-season (February - PrePS) and after 10 weeks of training (April - PostPS), they underwent anthropometric and maximal aerobic power (VO_2max) measurements. Within 7 days from these tests, players then undertook a high-intensity technical-tactical training session followed by 48 h post-session recovery assessments (at both PrePS and PostPS). Physical, physiological and perceptual markers were assessed before, immediately and 3, 24 and 48 h after respective Pre and Post pre-season sessions. The two respective testing sessions occurred in the morning, on a standard 38m x 20m indoor futsal court. The adoption of training sessions rather than matches as the recovery testing environment was based on the confounding influence of contextual factors from match demands, such as location, opponent and result (19); as well as the logistical difficulties in implementing complex pre- and post- testing routines performed herein. In the 48 h preceding and following the training sessions used to assess recovery, players refrained from alcohol, caffeine and high-intensity exercise. During PrePS, they were instructed to maintain their habitual diet and record food intake on the 2 days before and during testing, which was later replicated during PostPS testing.

Subjects

Initially, 14 male U20 futsal players from a club competing in the Brazilian national competition agreed to participate in the study. After receiving explanation of all procedures involved in the study, players provided informed consent and were cleared to participate by the team's medical physician. The study was approved by the University Research Ethics Committee (50166015.9.0000.5149) and complies with the Declaration of Helsinki. During the study, 7 players were excluded from the final sample for the respective reasons: 4 athletes were released from the team due to technical proficiency reasons, 2 left the club for personal/career reasons and 1 player did not finish testing due to illness. Therefore, data analysis was conducted on 7 players (age 18.7 ± 0.7 y; body mass 65.0 ± 5.5 kg and stature 174 ± 7 cm). We acknowledge the underpowered nature of the study, and therefore analysed data using practical inference analysis (20).

Procedures

Participants' characterization

Anthropometry and aerobic capacity were measured at the start and end of the pre-season period. Stature, body mass without shoes (MF100, Filizola®, Brazil) and skinfold (plicometer; Lange®, Beta Technology, Seko Dosing Systems Corp., USA) assessments were followed by an incremental test to determine players' VO_2max, maximal heart rate (HRmax) and ventilatory threshold (VT). On a treadmill (HPX 380, Total Health®, Brazil) at 1% gradient, initial speed was set at 6 $km \cdot h^{-1}$ and was continuously increased by 1.0 $km.h^{-1}$ every minute, until volitional fatigue. Oxygen consumption ($K4b^2$, Cosmed®, Italy) and heart rate (HR) (RS801, Polar®, Finland) were measured continuously and recorded every minute, and VO_2 was averaged at every 15 s for analysis. Rating of perceived exertion (RPE; (21) was provided by the players at the end of each stage and at the end of the exercise. The test was completed when at least one of the following criteria was attained: the athlete 1) requested termination of the exercise; 2) failed to maintain the stipulated speed; 3) rated 10 on the RPE scale; 4) showed any signs of dizziness, mental confusion, pallor, cyanosis or nausea. The spirometer was calibrated before each test according to the manufacturer's instructions. The highest value attained during the test on the respective variable was considered as VO_2max and HRmax. Due to technical malfunctions, 6 out of the 7 players completed the test at each stage of the pre-season and comparisons were held only including 5 players that completed both assessments.

Recovery training session

A high-intensity 70 min technical-tactical training session was performed on the 3rd and 12th weeks of the pre-season. To ensure ecological validity, both sessions were conducted by the coaches, who received only two guidelines from the researchers 1) the need for a high-intensity technical-tactical training session and 2) the intensity on PrePS testing session should be replicated at the PostPS session. As a result, whilst activities performed were not identical (Table 1) due to the tactical content of each training phase, training loads and exposure were matched as closely as possible.

During the session, players wore a Global Positioning Satellite (GPS) device coupled with a triaxial accelerometer with a sampling frequency of 100 Hz (SPI ProX2, GPSports Systems®, Australia), which has been shown to be reliable (22), and a compatible heart rate receiver tape (Polar®, Finland). Accelerometer and HR data were recorded continuously using the devices' indoor mode. External training load was assessed by Player Load (23), whereas internal load was quantified using HR and RPE-derived parameters. Mean session HR was calculated as a percentage of the highest value attained in the incremental test (%HRmax), and the training impulse (TRIMP) calculated according to Edward's method (24). Individual absolute values of the session RPE (sRPE) were analysed as an indication of training intensity, and RPE-derived training load (TL-RPE) was used as an overall internal load index by multiplying sRPE by the sessions' duration (21).

Table 1: Description of the training sessions held before (PrePS) and after (PostPS) the pre-season for characterization of the 48 h recovery timeline.

Situation	Activity number	Field players involved / court size	Duration	Rules
PrePS	**1**	4x4 Full court	21 min + 34 min with 8 min interval in between	Similar rules to an official match Free time and number of players` substitutions allowed Short (30s to 120s) pauses during each block for instructions
PostPS	**1**	6x3 Half court	15 min	Similar rules to an official match
	2	2x1 followed by 3x2, 3x3 and 4x4 Full court	5 min	The team that started with the ball possession had to make a fast attempt to score a goal. Irrespective of the result (scored or not), either the goalkeeper or the coaching staff made a quick ball reposition to the opposite team that should perform a counter-attack as fast as possible. This sequence was repeated 4 times without interval. At each time, more players were added to the activity.
	3	4x4 Full court	7 min	Similar rules to an official match
	4	Repeat activity 2	5 min	Same as activity 2

Recovery timeline characterization

Upon arrival, players underwent baseline assessments. Firstly, a capillary blood sample was collected for analysis of CK (Reflotron, Roche®, Switzerland). Then, players answered to a customized wellness questionnaire that included a) sleep quantity and quality (1 = very bad and 5 = very good); b) perception of recovery using the total quality recovery scale (TQR) (25); and c) a Portuguese version of the Brunel Mood Scale (BRAMS) (26, 27).

A 15 min warm-up consisting of different speed running and change of direction drills, and a futsal specific activity including technical and decision-making skills, was followed by two physical tests: CMJ and a 20m sprint test with a 180º change of direction. For the CMJ, players performed hip and knee flexion up to approximately 90º followed by a rapid hip and knee extension to achieve the highest possible height, while maintaining their hands in the waist. Four jumps were performed on a force platform (Ergo System®, Globus, Italy) interspersed by 15-s, and the mean jump height was used for analyses. Previous studies have shown high reliability in the CMJ test (i.e. CV = 2.8%; ICC = 0.98) (28). A 20m sprint test with 180º change of direction at 10 m was used to evaluate players' ability to accelerate, decelerate and change direction. The time to complete 10 m and 20 m were measured by photoelectric cells (Multisprint, Hidrofit®, Brazil) positioned at the start/finish line and at 10 m. Due to technological malfunction, only the first 10 m times were used for analysis and this test is referenced as 10 m sprint.

For both Pre and PostPS sessions, following baseline measurements, the training session was undertaken (see Table 1). Immediately after the end of the session, players repeated the CMJ and 10 m sprint tests and provided a blood sample to determine [CK] (intra-assay coefficient of variation of <3%) (29). Approximately 15min after the end of the session, they reported sRPE and answered a BRUMS questionnaire, as outlined above. To determine the timeline of recovery for each variable, all procedures adopted prior to the beginning of the training session were repeated 3, 24 and 48 h after. During this period, no recovery interventions or training sessions were performed, and participants were instructed to record their diet, abstain from alcohol, caffeine and the practice of high-intensity physical exercises, whilst maintaining their usual personal activities.

Pre-season training

Training schedules during the pre-season included one technical-tactical session per day, from Monday to Saturday, except on public holidays. Training was usually performed in the morning, on one of the three courts available at the training facilities: 36 × 20 m; 31 × 19 m; or 25 × 15 m. Technical-tactical sessions were approximately 90 min long and included mostly situational activities aiming for the development of team shape, technical and decision-making skills on situations of attack, defence and counterattack. Additionally, 5 friendly matches against the professional team of the same club were held during the pre-season to provide specific match stimuli. Weekly routines also included 3 strength training sessions per week at the gym, usually performed in the afternoon. Sessions comprised general upper body, lower body and core exercises aiming manly for hypertrophy and strength. Two coaches and one strength and conditioning coach were responsible for all training planning and prescription, with no interference from the researches.

During the pre-season, training load in all the technical-tactical training sessions were monitored, including players wearing a GPS unit and a HR monitor, as described earlier. Furthermore, between 15 and 20 min following the sessions, players reported their sRPE. Training load parameters (PL, %HRmax, TRIMP and TL-RPE) were individually calculated for each session

Statistical Analysis

To compare pre-training (baseline) measures and training load at PrePS and PostPS time points, magnitude-based inference analyses (MBI) were used (20). The same method was implemented to compare the percentage change from baseline at each time during the recovery timeline (immediately, 3 h, 24 h and 48 h post) between PrePS and PostPS, adding individual differences in TL-RPE (PostPS – PrePS) as a covariate in the comparisons to acknowledge a possible impact of this parameter on players' recovery. Smallest worthwhile differences were assessed using the standardized units multiplied by 0.2. The magnitude of differences was analysed using the standardized differences based on Cohen's d effect sizes (ES), with confidence intervals (CI) set as 90%. Chances of finding differences in the variables tested were assessed qualitatively as: <1%, *almost certainly not*; 1% to 5%, *very unlikely*; 5% to 25%, *unlikely*; 25% to 75%, *possible*; 75% to 95%, *likely*; 95% to 99%, *very likely*; >99%, *most likely*. If the chances of having positive and negative results were both >5%, difference was classified as *unclear*. A *likely* (>75%) difference was the minimum considered to detect meaningful differences (30). All data are presented as mean ± standard deviation (SD).

Results

Training load during the pre-season

During the 10-week preseason, the team performed 54 technical-tactical sessions (6 ± 1 per week) including 5 friendly matches; with an average of 46 ± 9 sessions per player. Mean session duration was 91 ± 19 min, in which PL was 670 ± 174 AU, or 7.8 ± 2.1 AU per minute. Such external load resulted in mean HR of 74 ± 7 %HRmax, sRPE of 4.1 ± 1.2 AU and TL-RPE of 373 ± 139 AU. Mean TQR during this period was 13.8 ± 1.1.

Anthropometry and physical performance responses to preseason training

As shown in Table 2, no meaningful differences were observed in body composition and physical performance after the pre-season. Specifically, there were *very likely trivial* increase in body mass and decrease in 10 m sprint performance, *likely trivial* increase in fat percentage, VO_2max and VT; as well as *most likely trivial* decrease in CMJ performance.

Table 2: Anthropometric measures and physical performance of players before (PrePS) and after (PostPS) ten weeks of pre-season.

	PrePS	**PostPS**	**ES**	**CI (90%)**
Body mass (kg)	65.0 ± 5.5	66.8 ± 6.4	0.10	0.00 to 0.19
Percentage body fat	5.2 ± 2.3	6.0 ± 3.5	0.11	-0.08 to 0.31
VO_2max ($mlO_2.kg^{-1}.min^{-1}$) (n=5)	52.6 ± 3.5	52.8 ± 3.5	0.10	-0.10 to 0.29
%VO_2max at VT (n=5)	47 ± 13%	53 ± 12%	0.10	-0.02 to 0.21
CMJ (cm)	32.6 ± 4.2	32.3 ± 4.2	-0.02	-0.13 to 0.08
10 m sprint (s)	1.57 ± 0.10	1.58 ± 0.07	0.02	-0.12 to 0.17

Data are expressed as mean ± SD. VO_2max = maximal oxygen consumption; %VO_2max at VT = percentage of maximal oxygen consumption at which the ventilatory threshold was attained; CMJ = countermovement jump. PrePS = Before the pre-season, PostPS = after the pre-season, ES = effect size, CI (90%) = confidence interval of 90%.

Baseline characteristics and Training load of PrePS and PostPS recovery sessions

Pre-training and training load measures from the two recovery characterization sessions are described in Table 3. In respect to the baseline assessments for the training sessions used to determine the recovery timeline, whilst most variables were not meaningfully different, there were *unclear* to *very likely trivial* differences in CK, perceived fatigue, hours and quality of sleep and TQR. The training session performed after the pre-season was *very likely* shorter than the one held at the start of the season. Regardless, the time players spent in action (time played; i.e., excluding time between activities and when players were substituted) was only *possibly* lower, and there were *unclear* to *very likely trivial* differences between respective sessions for, PL, PL/min, %HRmax, time spent above 80%HRmax and TRIMP. However, sRPE and TL-RPE were *likely* lower at PostPS compared to PrePS. Therefore, to acknowledge a possible impact on players' recovery, individual differences in TL-RPE (PostPS – PrePS) were further used as a covariate in the comparisons between PrePS and PostPS recovery timelines.

Recovery timeline

Figure 1 shows the percentage difference in objective markers from pre-training values during the respective recovery timelines for PrePS and PostPS. CMJ changes from baseline immediately after the session were *likely worse* at PostPS compared to PrePS (-0.41; -0.65 to -0.16); however, they were *very likely* better than PrePS at 3 h (0.87; 0.32 to 1.43), *likely* better at 24 h (0.55; 0.10 to 1.00) and *most likely* better at 48 h post-training (1.27; 0.65 to 1.89). Changes in 10 m sprint performance immediately, 3 h and 24 h after the session were *unclear* between PrePS and PostPS (ES ranging from -0.12 to -0.05; CI from -0.52 to 0.29). Conversely, performance in 10 m sprint decreased 48 h post-session at both PrePS and PostPS and was *very likely* worse at PostPS (ES = 0.49; 0.49; CI = 0.28 to 0.69). The post-session change from baseline in CK concentration was *very likely* higher int PostPS (1.18; 0.33 to 2.02), though was *most likely* lower 48 h post-training compared to PrePS (-1.33; -1.91 to -0.75).

Table 3: Baseline and training load measures from the testing training session performed before (PrePS) and after (PostPS) ten weeks of pre-season.

	Pre PS	**Post PS**	**ES**	**CI (90%)**
Pre-training measures				
Creatine Kinase (U/L)	216 ± 136	227 ±168	0.03	-0.26 to 0.31
TQR	14.9 ± 1.7	14.1 ± 1.8	-0.13	-0.31 to 0.05
Vigor	10.6 ± 2.7	8.6 ± 4.5	-0.23	-0.42 to -0.04
Fatigue	2.6 ± 2.3	2.9 ± 1.3	0.04	-0.20 to 0.27
Sleep hours	7.2 ± 0.6	6.8 ± 1.3	-0.18	-0.63 to 0.27
Sleep quality	3.6 ± 0.8	3.6 ± 0.9	0.00	-0.16 to 0.16
Training load				
Duration (min)	68 ± 0	63 ± 2	-	-
Time played (min)	28 ± 2	26 ± 3	-0.27	-0.64 to 0.10
Player load (AU)	596 ± 102	534 ± 111	-0.09	-0.23 to 0.05
Player load/min (AU)	9.0 ± 1.6	9.0 ± 1.9	-0.01	-0.15 to 0.13
% HRmax	81 ± 4%	80 ± 4%	-0.06	-0.25 to 0.14
Time >80%HRmax (min)	35.9 ± 7.7	30.1 ± 4.5	-0.02	-0.37 to 0.32
TRIMP (AU)	228 ± 23	204 ± 20	0.10	-0.53 to 0.73
sRPE	6.0 ± 1.4	4.4 ± 1.4*	-0.29	-0.48 to -0.11
TL-RPE (AU)	408 ± 111	280 ± 94*	-0.35	-0.57 to -0.14

Data are expressed as mean ± SD. PrePS = Before the pre-season, PostPS = after the pre-season, TQR = total quality recovery scale, % HRmax = mean heart rate relative to the maximum value, sRPE = session rating of perceived exertion, TL-RPE = sRPE x session duration, ES = effect size, CI (90%) = confidence interval of 90%. * represents a *likely* difference from PrePS.

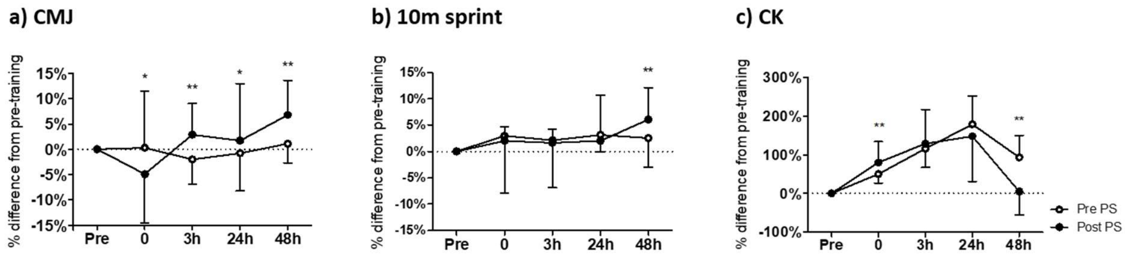

Figure 1: Timeline of objective recovery markers after technical-tactical futsal training sessions held at the start (PrePS) and end (PostPS) of pre-season. Data is presented as percentage change from pre-training values (mean ± SD). a) countermovement jump (CMJ) high; b) 10 m sprint time; c) creatine kinase concentration. * *Likely* different from PrePS ** *Very likely* or *most likely* different from PrePS.

As shown in Figure 2, the decrease in TQR 3 h post-session was *most likely* lower at PostPS compared to PrePS (1.50; 0.88 to 2.12). The subsequent increase in TQR was *likely* higher PostPS (0.92; 0.15 to 1.68), though the difference between both situations was *unclear* at 48 h (0.34; -1.09 to 1.77). The increase in fatigue was also *very likely* lower immediately and 3 h post-session at PostPS compared to PrePS (-0.49; -0.77 to -0.22 and -0.63; -0.95 to -0.31, respectively), though were *unclear* at 24 h and 48 h (0.20; -0.49 to 0.88 and 0.73; -0.42 to 1.89, respectively). Changes from baseline in vigor were improved in PostPS at all time points (immediately after: *likely* 0.59; -0.11 to 1.29; 3 h: *most likely* 0.92; 0.52 to 1.32; 24 h: *likely* 1.13; 0.18 to 2.09; 48 h: *likely* 0.83; -0.05 to 1.72).

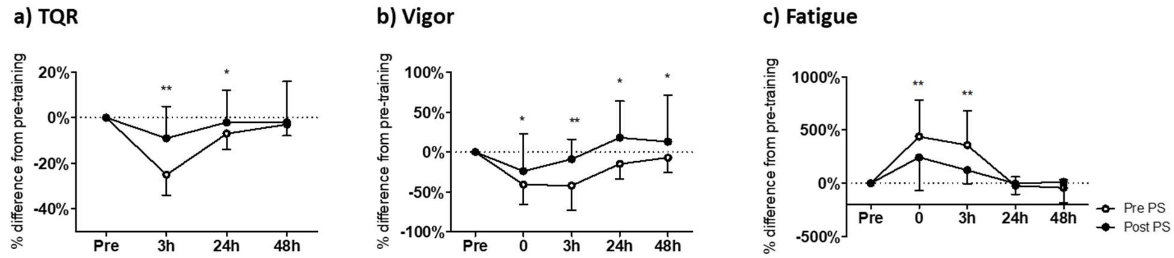

Figure 2: Timeline of subjective recovery markers after technical-tactical futsal training sessions held at the start (PrePS) and end (PostPS) of pre-season. Data is presented as percentage change from pre-training values (mean ± SD). a) total quality recovery scale, b) Vigor (BRUMS) and c) Fatigue (BRUMS). * *Likely* different from PrePS ** *Very likely* or *most likely* different from PrePS.

Discussion

Our results show that despite no improvements in players' lower body power, sprint speed or aerobic power after 10 weeks of futsal pre-season training, an improved recovery timeline existed following a training session of similar load. Specifically, despite greater post-session change in CMJ and CK responses, a faster return to baseline was evident at the end of the pre-season. Furthermore, perceptual responses of TQR, fatigue and vigour were improved in all post-training times at PostPS. Thus, rather than fitness *per se*, we speculate that a greater tolerance to external loads attained from pre-season training resulted in decreased perception of effort, improved post-training perception of fatigue and recovery, as well as improved power and muscle damage recovery profile.

Session-based external and internal training loads during the 10-week pre-season were similar to previously reported values in soccer training (PL ≈ 523 AU) (31) and futsal in-season sessions (≈ 74% HRmax, TRIMP ≈ 153, sRPE ≈ 5, TL-RPE ≈ 300-500 AU) (32), respectively. Some of the physical fitness outcomes were also consistent with former investigations in futsal whereby a maintenance of jump and sprint performance were evident (7, 8). Such lack of improvement may be explained by the high number of aerobically-dominant technical-tactical training sessions, and the focus on hypertrophy rather than power/speed in the gym sessions in the current program. However, such training characteristics would expectedly improve players' VO_2max and/or VT, which were not observed in this study. The fact that we used an incremental treadmill test aiming at obtaining direct measures of aerobic fitness may partially explain this result given its difference from futsal training and match demands. In fact, performance in more specific on-court tests, which are known to be influenced by other factors related to the movement patterns and match demands (10, 33), would be appropriate and has been shown to improve after futsal pre-season (6, 8, 34). Consequently, following the current 10-week preseason program designed at team technical-tactical proficiency, player physical capacities were not demonstrably improved.

The training session to infer recovery timelines before and after the pre-season showed high training loads, as evidenced by higher PL/min, %HRmax and sRPE when considered in context of the average loads in this pre-season program. Additionally, despite the training activities not being identical at PrePS and PostPS, differences in external load and respective cardiovascular demand were *likely trivial* (i.e. %HRmax) or *unclear* (i.e. TRIMP). However, players perceived the session as less intensive (i.e. lower sRPE and TL-RPE), despite similar external loads. These results support the notion that exposure to training may improve one's perception of the load (35) and thus tolerance to fatigue and discomfort from exercise (14).

When accounting for reduced TL-RPE values, improved changes from baseline in CMJ (from 3 h up to 48 h post-session) and a larger decrease in CK by 48 h at PostPS were evident compared to PrePS. These results indicate that despite no evident fitness changes, pre-season training still resulted in improved neuromuscular recovery profiles in elite level futsal players. Previously, Johnston et al. (10) observed that athletes with higher 3 repetition-maximum back squat and YoYo IR-1 performance exhibited faster CMJ return to baseline and smaller increases in CK on days following a rugby league match, respectively. Whilst similarly improved recovery outcomes are evident in both studies, the cross-sectional nature of the study by Johnston et al. (10), and the absence of both a strength test and a control group here make interpretation of the underpinning factors difficult. However, it is feasible that either fitness capacity improvement or greater tolerance to training exposure are possible mediators of improved PostPS recovery profiles. In fact, exposure to exercise without fitness changes have been reported to decrease muscle damage following subsequent eccentric training sessions (repeated bout effect) (36). However, this phenomenon has been reported in acute settings and such a rationale in ongoing training is speculative; thus further research is required on the factors underpinning training-induced improvements in neuromuscular recovery.

Players also exhibited positive changes in the recovery timeline of perceptual markers after the pre-season, suggesting their attenuated perception of the training load may also reflect in improved recovery profiles. Interestingly, the attenuated perception of load and fatigue immediately post-session allowed players to perceive themselves readier to perform within 3 hours or a day following training, despite performing similar external and cardiovascular loads. This also reinforces the argument of improved tolerance to load following training, potentially via improved psychological ability to tolerate high-intensity efforts (14, 37). Given sRPE score can be influenced by individuals' reference of "maximal effort" (38), it is also possible that similar absolute loads appear easier due to the exposure to high-training and match loads during training. Based on this speculation, it is plausible that players perceived lower physical or mental fatigue at the PostPS session and thus permitted faster recovery PostPS; especially given the focus on technical-tactical sessions during the team's pre-season. As a result, given higher pre-training wellness scores - including ratings of fatigue, stress and mood - have been related to improved subsequent physical performance during ongoing training (39), it can be expected that after the pre-season players will cope better with training and match loads performed 24 h after high-intensity sessions. Such adaptative response can support coaching staff to plan short-duration (~60min) high-intensity on-court sessions more frequently within a microcycle, an/or closer to match days during the in-season, provided previous loads and readiness to perform are carefully monitored.

Understanding athletes' training adaptations in ecologically valid settings is paramount to improve practice and implementation of recovery strategies. However, such studies often result in limitations related to the uncontrolled environment, including the exposure to unexpected data loss and the inability to include a control group of elite level athletes. In this study, although 14 players were recruited, data of only 7 could be used for analysis, increasing the odds of errors and limiting our findings to the population studied herein. Further, the fact that training sessions performed for recovery timeline assessments were not identical at PrePS and PostPS included a co-factor (i.e. training loads) to the effect of the pre-season training in the recovery timeline. Taken this into account, we included the one variable presenting important differences between PrePS and PostPS as a covariate in our analysis, though we acknowledge cinematic and cognitive differences may also be present. Finally, given the difficulty to prevent elite players from training, we appreciate that there is no direct comparison of a control group-though in such circumstances this was an infeasible option.

In summary, 10 weeks of futsal-specific pre-season training attenuated U20 players' perception of effort and fatigue as well as improved the recovery of power and muscle damage markers' up to 48 h after high-intensity technical-tactical training session with comparable load, irrespective of the maintenance of VO_2max, VT, 10 m sprint and CMJ performances. Consequently, monitoring their responses to different training types and loads throughout all phases of the season is warranted to plan ensuing training loads. Further, taken into account the variables used in the study, it seems that apart from sprint time, a combination of CMJ, CK and perceptual responses allow a comprehensive approach to futsal players' recovery timeline. Future studies are encouraged to address which factors can predict improvements in athletes' recovery profile following a training period.

Disclosure of interest

The authors report no conflict of interest

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9 DISCUSSÃO

Após a conclusão dos quatro estudos programados, foi possível caracterizar as linhas do tempo de diferentes indicadores de recuperação de atletas de futsal de alto rendimento, com o retorno dos parâmetros avaliados aos valores pré-sessão de treinamento variando entre 24 h e 48 h, sendo que alguns parâmetros ainda estavam alterados após 48 h. Considerando uma perspectiva multifatorial, observamos a existência de diferentes perfis de recuperação (atletas que se recuperaram mais rápida ou lentamente) que, de forma aguda (i.e., após uma única sessão de treinamento de alta intensidade), foram positivamente influenciados por uma maior capacidade aeróbica. Entretanto, um maior desempenho de velocidade e maior idade comprometeram a recuperação de aspectos físicos e perceptivos, respectivamente. Ao contrário do que se esperava, os diferentes perfis de recuperação não foram capazes de predizer a percepção de recuperação diária dos jogadores durante 4 semanas de pré-temporada. A qualidade do sono, por sua vez, influenciou positivamente o TQR, enquanto que, quanto mais distante do início do microciclo, menor foi a percepção de recuperação, independente da carga de treinamento do dia anterior. Por fim, 10 semanas de treinamento durante a pré-temporada reduziram o tempo de recuperação dos jogadores após um treino de alta intensidade, mesmo sem um aumento evidente nas capacidades físicas avaliadas. Com isso, foi possível aprofundar o entendimento do processo de recuperação de jogadores de futsal de alto rendimento após sessões de treinamento; confirmar sua complexidade e seu caráter multifatorial, além de deixar evidente a necessidade de futuras investigações em aspectos ainda não conclusivos.

Pela primeira vez, caracterizou-se a curva de recuperação pós-exercício específico de atletas de futsal. No caso desse estudo (Estudo 1), investigamos sessões técnico-táticas de alta intensidade com duração aproximada de 70 minutos, contendo exercícios realizados com frequência durante a temporada por uma equipe sub-20 e uma equipe adulta (ambas pertencentes ao mesmo clube). Em relação ao desempenho físico, a altura do CMJ foi mantida ao longo das 48 h nas duas equipes. Apesar do resultado semelhante no sprint de 10 m para o U20, a equipe PROF apresentou uma redução pós-treino, que foi recuperada rapidamente – 3 h após. Essa ausência de queda do desempenho no CMJ após a sessão não era esperada, já que estudos anteriores observaram queda nesse parâmetro no período pós-jogo (TESSITORE *et al.*, 2008; MOREIRA *et al.*, 2015). Entretanto, resposta semelhante já foi observada após sessões de treinamento de outras modalidades esportivas, como o futebol (MALONE *et al.*, 2015). Possíveis explicações seriam: a carga de treinamento aplicada ser habitual aos atletas e, dessa forma, insuficiente para causar efeitos deletérios no desempenho físico em função de fadiga; ou uma limitação do método utilizado para mensuração do desempenho físico devido à maior variabilidade da medida (CV = 5,6%) relativa à variação de desempenho após o treinamento (MALONE *et al.*, 2015) (no caso do nosso estudo, entre 0,8% e 2,9%). Raciocínio semelhante pode ser utilizado para explicar a manutenção do desempenho nos 10 m de sprint para a equipe U20. Por outro lado, o resultado da equipe PROF se assemelha ao encontrado no estudo de (TESSITORE *et al.*, 2008). Estudos demonstram que as capacidades de aceleração, desaceleração e mudança de direção, exigidas no protocolo de sprint adotado neste estudo, são influenciadas pela capacidade máxima de produção de força (DELANEY *et al.*, 2015). Embora não tenhamos utilizado a medida de contração voluntária máxima (CVM), a redução da produção de torque excêntrico dos músculos flexores e extensores do joelho já foi relatada após uma partida de futsal simulada (DAL PUPO *et al.*, 2014). Ainda, reduções mais acentuadas na CVM foram relacionadas a maiores demandas de jogos em esportes coletivos (DUFFIELD *et al.*, 2014), o que pode explicar parcialmente o motivo pelo qual o desempenho do sprint foi prejudicado após a sessão apenas para os jogadores PROF. Apesar do pequeno efeito sobre o desempenho físico, o alto estresse imposto pela sessão de treinamento ficou evidente pelo alto impacto vivenciado pelos jogadores (i.e., player load), assim como no aumento duradouro das concentrações de CK (persistente até 48 h pós-treino para os PROF), consistente com as respostas após uma sessão de treinamento de jogo reduzido (4 x 4) no futebol (SPARKES *et al.*, 2018). Além disso, os escores de TQR, fadiga e vigor foram alterados após a sessão e exigiram pelo menos 24 h para retornarem aos valores de repouso. Este resultado reafirma a sensibilidade dos parâmetros parceptivos a estímulos de treinamento (ROHLFS *et al.*, 2008; DOEVEN *et al.*, 2017; DEBIEN *et al.*, 2018; PAUL *et al.*, 2018) e reforça a sua aplicabilidade em contextos esportivos para o monitoramento da prontidão para o desempenho no esporte (KELLMANN *et al.*, 2018). Baseado nesses resultados, concluímos que um período de recuperação de 48 h parece apropriado para atletas de alto rendimento de futsal após treinamento de alta intensidade com configuração similar àquela aqui estudada, fornecendo um contexto inicial para o planejamento conjunto da carga de treinamento e a subsequente recuperação em microciclos semanais.

Apesar da importância de se caracterizar o tempo médio de recuperação após um estímulo típico de treinamento, a variação de intervalos de tempo de recuperação entre indivíduos de uma mesma equipe é pouco reportada em estudos científicos. Com isso, a transferência dessa informação para contextos esportivos pode ser limitada e, por vezes, direcionar intervenções profissionais imprecisas em relação à recuperação de atletas. Por outro lado, o acompanhamento da recuperação de atletas por meio de medidas que contemplem as diferentes dimensões (ou seja, fisiológica, psicológica e de desempenho) durante uma temporada competitiva é muitas vezes inviável (CARLING *et al.*, 2018). Ainda, mesmo em equipes que se aproximam desse ideal (por exemplo, grandes clubes de futebol que realizam monitoramentos pós-jogos), individualizar as estratégias e o tempo de recuperação também pode ser inviável devido ao caráter coletivo da modalidade. Em esportes com menor recurso financeiro, essa condição é agravada pelo pequeno número de profissionais relativo ao número de atletas, o que inviabiliza tal intervenção individualizada. Com base nesses desafios, utilizamos um método de classificação de grupos (análise estatística de cluster) para entender se seria possível identificar padrões de recuperação em uma equipe, considerando a multifatoriedade desse processo (Estudo 2; WILKE *et al.*, 2019).

Diferente da nossa expectativa inicial de encontrar dois perfis de recuperação (atletas que apresentassem recuperação mais rápida e atletas que apresentassem recuperação mais lenta); identificamos três grupos de jogadores. O primeiro grupo foi composto por atletas que se recuperaram mais rapidamente considerando as três dimensões mensuradas (desempenho físico, psicométrica e de dano muscular), e foi denominado de "recuperação mais rápida" (faster recovery – FR). A resposta alinhada de parâmetros objetivos e subjetivos vai ao encontro de modelos de fadiga integrada, que sugerem que o exercício desencadeia respostas dos diferentes sistemas de forma proporcional à sua intensidade e duração (ST CLAIR GIBSON *et al.*, 2018). De forma semelhante, a recuperação também tem sido descrita como um fenômeno que mobiliza o sistema nervoso central e respostas periféricas conjuntas para o reestabelecimento da homeostase (MINETT e DUFFIELD, 2014). Uma característica "chave" deste cluster é apresentar uma tendência a um VO_2máx mais alto, corroborando achados anteriores de que indivíduos com maior capacidade aeróbica se recuperavam mais rapidamente (TOMLIN, 2001; JOHNSTON, GABBETT, JENKINS, *et al.*, 2015).

O segundo grupo de atletas - denominado de "recuperação fisiológica mais lenta" (slower physiological recovery – SLphy) - teve como característica uma recuperação mais lenta do aumento da concentração de CK pós-treino (concentração elevada até 48 h pós-treino), embora as respostas às escalas de fadiga e recuperação não tenham apresentado o mesmo padrão lento. Partindo do pressuposto de que uma maior proporção de fibras musculares rápidas é um dos fatores determinantes para o desempenho de ações que demandam altos valores de força e potência (KOMI, 2006), a característica de melhor desempenho no teste de sprint e a tendência a uma menor capacidade aeróbica desses atletas ajuda a justificar o dano muscular mais prolongado. Esse resultado sugere que profissionais do esporte devam ter atenção à recuperação de jogadores com melhor desempenho de força e potência e, quando possível, utilizem marcadores de dano muscular para caracterizar e acompanhar esse processo de recuperação, dado que o desempenho físico de curta duração é restaurado mais rapidamente que um indicador de alterações estruturais na musculatura.

Por fim, apesar de exibir os melhores perfis de recuperação de CMJ e CK, um grupo de atletas apresentou os piores escores de fadiga e vigor em relação aos valore pré-treino ao longo das 48 h; este terceiro grupo foi denominado de "percepção de recuperação mais lenta" (slower perceptual recovery – Sl_{perc}). Dado que estes jogadores eram mais velhos do que os participantes do SLphy, é possível que a idade e a experiência tenham afetado o estado de humor / recuperação dos jogadores, contribuindo para o descompasso observado entre os parâmetros objetivos e subjetivos. De fato, existem relatos verbais de profissionais do esporte de que atletas mais velhos tendem a se queixar mais de treinamentos intensos do que os mais novos. Como evidência, mais anos de experiência no futebol profissional australiano foram associados a maiores PSE para uma mesma carga externa de treinamento (GALLO *et al.*, 2015). Por outro lado, apesar de apenas especulativo, é possível também que jogadores mais velhos realizem uma "autorregulação" do seu processo de recuperação: devido a um maior autoconhecimento da sua capacidade de desempenhar fisicamente em diferentes contextos, podem reportar menor recuperação com o intuito de se "pouparem" para momentos de maior demandada por resultado (ou seja, durante jogos). Por fim, é importante considerar que, nesse estudo, 3 jogadores não foram locados em nenhum cluster, mostrando que nem todos os atletas se encaixam em uma classificação geral de recuperação e, portanto, o uso dessa técnica para orientar cargas de treinamento e práticas de recuperação pode ser limitado.

Especialmente no caso de equipes com capital financeiro e humano que permitam monitorar jogadores em situações de jogos e treinamentos utilizando múltiplos parâmetros que permeiam as três dimensões utilizadas no nosso segundo estudo, acreditamos que os resultados diários possam auxiliar diretamente na tomada de decisão acerca da carga de treinamento e intervalo/estratégias de recuperação dentro de cada microciclo. Entretanto, essa é uma realidade de poucas equipes e, para entender se os diferentes perfis agudos de recuperação podem ser utilizados como base de interpretação de programas de monitoramento da recuperação mais simples durante um período de treinamento, verificamos a sua influência na percepção de recuperação reportada diariamente (via TQR) pelos jogadores (estudo 3). Ao contrário da expectativa inicial, a classificação aguda de recuperação não foi capaz de predizer o TQR dos jogadores durante 4 semanas de pré-temporada. Uma possível explicação para esse resultado é que a classificação do perfil agudo de recuperação envolveu 6 parâmetros (CMJ e 10m sprint com mudança de direção, CK, TQR, vigor e fadiga), sendo provável que, sozinha, a escala de TQR não seja suficiente para refletir a natureza holística da recuperação. Outra possível explicação é a diferença no controle de fatores externos entre investigações agudas da recuperação (como, por exemplo, a fadiga acumulada por treinos consecutivos; reduzida no estudo 2 pela ausência de treinos 48 h antes e após a sessão experimental), e o monitoramento de treinamentos e jogos sucessivos, adotado por equipes esportivas. Ainda, uma única sessão não é capaz de capturar a variabilidade intraindividual nas respostas de recuperação, tendo, portanto, transferência limitada ao se realizar um monitoramento contínuo.

Diferentemente do perfil de recuperação, a qualidade do sono e o estágio da semana foram significativos na predição do TQR em nosso estudo. O primeiro resultado (qualidade do sono) corrobora resultados anteriores que demonstraram a influência do sono na recuperação de atletas (FULLAGAR *et al.*, 2015). O segundo (estágio da semana), apesar de remeter à ideia de um acúmulo de carga de treinamento (e, consequentemente, fadiga) (DEBIEN *et al.*, 2018; SAWCZUK *et al.*, 2018), foi independente da carga de treinamento na sessão de treinamento anterior. Como explicação, especulamos que, além de aspectos relacionados com a fadiga física e mental, fatores relacionados à manutenção da rotina de treinamento podem influenciar a redução da TQR ao longo da semana. Por exemplo, ser pontual, executar todas as tarefas indicadas pela comissão técnica, manter uma dieta apropriada, lidar com as expectativas dos treinadores e evitar comportamentos "não atléticos" requer autocontrole, uma habilidade psicológica que é deprimida após "esforços" de autocontrole consecutivos, independentemente da atividade física (BAUMEISTER *et al.*, 2007). Essa redução na disposição das pessoas em realizar esforços consecutivos é relatada em estudos da psicologia e recentemente foi relacionada a modelos teóricos que tentam compreender a fadiga induzida pelo exercício (EVANS *et al.*, 2016; INZLICHT e MARCORA, 2016). Embora um consenso sobre a explicação mais apropriada para esse fenômeno de "ego-depletion" ainda não tenha sido alcançado, existe um entendimento comum de que a motivação pode ser um modulador (EVANS *et al.*, 2016; INZLICHT e MARCORA, 2016). Portanto, é possível que a relação entre o número de sessões de treinamento e o TQR durante semanas que incluam jogos oficiais seja diferente daquela verificada em nosso estudo – semanas de pré-temporada compostas exclusivamente por sessões de treinamento.

Ainda referente ao estudo 3, é importante reconhecer que o modelo de melhor ajuste (incluindo apenas o sono e a fase do microciclo como preditores do TQR) apresentou um baixo potencial estimativo (r^2 = 0,36) e uma quantidade relativamente grande de variabilidade não explicada (DP Residual = 1,189), reforçando a interpretação de que mais e / ou diferentes avaliações são necessárias para entender completamente o score do TQR reportado por atletas.

Por fim, o último objetivo desse trabalho foi verificar se quatro semanas de treinamento durante a pré-temporada melhorariam a capacidade de recuperação pós-treino de atletas de futsal de alto rendimento. Ao contrário do esperado, não observamos melhorias na capacidade de potência de membros inferiores (CMJ), na aceleração e desaceleração (sprint de 10 m) e na capacidade aeróbica (VO_2máx e limiar ventilatório). Mesmo assim, foi observada melhor recuperação pós-treino ao final da pré-temporada. Para chegar a essa conclusão, dado que a PSE-sessão referente à sessão de treinamento realizada ao final da pré-temporada foi maior do que àquela realizada no início da temporada, essa diferença foi incluída na análise como um co-fator interveniente no resultado. Com esse tratamento, observamos que as diferenças percentuais em relação aos valores de repouso foram melhores no CMJ (de 3 h até 48 h pós-treino) e que houve maior redução da CK 48 h após a pré-temporada em comparação ao seu início. Anteriormente, Johnston, Gabbett, Jenkins*, et al.* (2015) observaram uma resposta de recuperação mais rápida do CMJ pós-treinamento em atletas com melhor desempenho de força máxima de membros inferiores (3 repetições máximas de agachamento), além de recuperação mais rápida das concentrações de CK em atletas com melhor desempenho no YoYo IR-1 nos dias subsequentes a uma partida da *rugby league*. Por outro lado, Hyldahl *et al.*, (2017) relataram que a exposição repetida a um exercício de força excêntrica diminuiu o dano muscular após as sessões (denominado de efeito protetor), mesmo sem causar alterações de condicionamento físico. Analisando os dois estudos em conjunto, é possível que tanto a melhoria das capacidades físicas quanto a maior tolerância à exposição ao treinamento sejam possíveis mediadores de melhores perfis de recuperação após o treinamento. Em nosso estudo, sugerimos que a exposição ao treinamento influenciou a melhoria na resposta de recuperação pós-treino. No entanto, esse foi o primeiro estudo de nosso conhecimento que investigou o efeito de um período de treinamento na recuperação de atletas, enquanto os estudos citados investigaram situações agudas e, portanto, ainda não existem evidências fortes para se aplicar tal raciocínio ao treinamento contínuo. Assim, mais pesquisas sobre os fatores que influenciam as melhorias na recuperação neuromuscular induzidas pelo treinamento são necessárias.

Mudanças positivas na linha do tempo de recuperação também foram observadas nas variáveis perceptivas após a pré-temporada, sugerindo que a percepção atenuada da carga de treinamento (menor PSE ao final da pré-temporada) possibilitou que os jogadores se percebessem mais dispostos (ou preparados) 3 horas ou um dia após o treinamento, mesmo realizando cargas externas e apresentando demandas cardiovasculares semelhantes nas duas sessões. Esse resultado pode ser parcialmente explicado por uma melhora da capacidade psicológica de tolerar esforços de alta intensidade (ZGHAL *et al.*, 2015; O'LEARY *et al.*, 2017) após as quatro semanas de treinamento. Por exemplo, uma vez que a pontuação indicada na PSE é influenciada pela referência de "esforço máximo" dos indivíduos (BORG, 1982), é possível que cargas absolutas similares sejam percebidas como mais fáceis após o treinamento devido à exposição a cargas elevadas de forma repetida, permitindo um aumento mais rápido da percepção de recuperação ao final da pré-temporada. Tal especulação é baseada em um estudo que demonstrou que, maiores pontuações de bem-estar reportadas antes de uma sessão de treinamento (incluindo fadiga, estresse e humor) estavam associados a um melhor do desempenho físico durante a sessão (GALLO *et al.*, 2016). Dessa forma, pode-se esperar que, ao final da pré-temporada, os jogadores lidem melhor com cargas de treinamento e jogos realizados 24 h após sessões de alta intensidade em comparação ao início da temporada.

Embora este estudo forneça informações valiosas para os profissionais que trabalham no futsal, certas limitações devem ser reconhecidas. Em relação às situações experimentais de treinamento, seguidas de avaliação da recuperação dos jogadores por meio de coletas em diferentes horários até 48 h pós-treino, houve limitações relacionadas à nossa limitada capacidade de modificar as rotinas de treinamento das equipes, um aspecto comum à pesquisa com equipes de alto rendimento. Como consequência, a necessidade de quatro dias dedicados à coleta de dados limitou-nos a uma situação experimental com cada equipe, que possuíam planejamentos de treinamento específicos em cada momento (no início e no fim da pré-temporada). Portanto, a variabilidade intra-individual não pôde ser avaliada e a generalização dos resultados é limitada. Além disso, a parcela faltante de CMJ, sprint e CK 24 h após o treinamento da equipe PROF impediu a obtenção do perfil completo de recuperação deste grupo. A ausência de estímulos de treinamento durante as 48 h após a sessão experimental, estabelecida para controlar fatores intervenientes na recuperação, não reflete o cronograma habitual das equipes e, portanto, também limita a extrapolação dos nossos resultados para cronogramas congestionados. Em relação ao poder estatístico do trabalho, reconhecemos o número limitado de participantes dos estudos como consequência do esporte escolhido como meio de investigação da recuperação. Por exemplo, o número de jogadores de linha das equipes do clube no período estudado foi de, no máximo, 13 atletas, e foi reduzido ao final da pré-temporada. Para superar parcialmente essa limitação, avaliamos dois grupos de idade / habilidade diferentes em sessões separadas, o que pode ter influenciado os resultados. Ainda, apesar do número inicial de participantes ter sido de 24 jogadores, dados de apenas 7 puderam ser usados para análise no estudo do efeito do treinamento, aumentando as chances de erros estatísticos e limitando nossos achados para a população aqui estudada. Por fim, outra limitação metodológica foi o fato de as sessões realizadas antes e após a pré-temporada não terem sido idênticas; apesar de a análise estatística ter sido adequada para corrigir a diferença na carga de treinamento encontrada, reconhecemos que diferenças cinemáticas (por exemplo: número e distância de sprints, corridas de alta intensidade e mudanças de direção) e cognitivas (por exemplo: nível de complexidade das orientações táticas dos treinadores) também podem ter ocorrido.

Mesmo com todas as limitações supracitadas, esse projeto resultou em novas informações a respeito do tempo necessário para recuperação pós-treinos de jogadores de futsal antes e após um período de treinamento de pré-temporada, a sugestão da aplicação de um método de classificação para identificação de perfis de recuperação de atletas, além da identificação da influência de diferentes fatores no monitoramento diário da recuperação de atletas por meio do TQR. Além do caráter inédito dessas informações, acreditamos no valor das mesmas para a contribuição de uma prática profissional baseada em evidências científicas, dada a validade ecológica do estudo.

10 CONCLUSÕES

Após uma sessão de treinamento técnico-tático de futsal realizada em alta intensidade e com duração aproximada de 70 minutos, o desempenho físico dos jogadores foi pouco modificado, enquanto a percepção de recuperação retornou a valores basais após 24 h. No entanto, a CK e alguns parâmetros de humor permaneceram elevados até 48 h após a sessão. Além disso, o tempo de recuperação variou entre as faixas etárias, sendo que a equipe PROF apresentou melhor resposta de recuperação na maioria dos parâmetros em comparação à equipe U20. Portanto, nossos dados indicam que 48 h são suficientes para a recuperação pós-treino de alta intensidade de futsal no início da temporada.

A variação interindividual do tempo de recuperação e da sincronia ou divergência desse tempo entre as dimensões física, fisiológica e perceptiva, resultou na identificação de três perfis de recuperação. Os jogadores com perfil de recuperação global (físico e psicológico) mais rápida foram possivelmente influenciados positivamente pela sua maior capacidade aeróbica. A classificação dos outros dois grupos de atletas com perfis de recuperação mais lenta foi condicionada por respostas nos parâmetros fisiológicos ou perceptivos, potencialmente influenciados pelo maior desempenho de velocidade / potência e maior idade / experiência dos atletas, respectivamente.

Ainda que a proposta de classificação dos perfis de recuperação de atletas da mesma equipe seja atraente do ponto de vista prático, os perfis encontrados em uma situação aguda de treinamento não diferenciaram a percepção de recuperação diária desses jogadores, o que fortalece ainda mais o conceito multifatorial do processo de recuperação. Por outro lado, esse trabalho confirmou a influência do sono na recuperação de atletas, mesmo quando relatado subjetivamente por meio de uma escala de qualidade do sono; além de demonstrar que a percepção de recuperação reduziu ao longo da semana, sem que houvesse relação com a carga de treinamento do dia anterior.

Por fim, demonstramos pela primeira vez uma melhoria na cinética de recuperação pós-exercício em marcadores perceptivos, fisiológico e de desempenho físico, como consequência de um período de treinamento esportivo, mesmo com a manutenção do desempenho físico de potência de membros inferiores e velocidade. A redução da média de tempo de recuperação de 48 h para aproximadamente 24 h após a pré-temporada sugere que seja possível que sessões com carga semelhante às utilizadas nesse estudo possam ser prescritas com maior frequência dentro de um microciclo, ou mais próximas a um jogo após o período de pré-temporada.

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ANEXO

UNIVERSIDADE FEDERAL DE MINAS GERAIS

PARECER CONSUBSTANCIADO DO CEP

DADOS DO PROJETO DE PESQUISA

Título da Pesquisa: Influência de diferentes fatores na recuperação de atletas de futsal após sessões de treinamento antes, durante e após um período de pré-temporada

Pesquisador: Samuel Penna Wanner

Área Temática:

Versão: 1

CAAE: 50166015.9.0000.5149

Instituição Proponente: Escola de Educação Física da Universidade Federal de Minas Gerais

Patrocinador Principal: Financiamento Próprio

DADOS DO PARECER

Número do Parecer: 1.338.627

Apresentação do Projeto:

O futsal é considerado um esporte intermitente de alta intensidade. Durante partidas oficiais, jogadores percorrem entre 3 e 6 km em ações que incluem sprints, corridas de alta intensidade e mudanças de direção. Tais características geram um elevado estresse fisiológico nos atletas, caracterizado pelo aumento de marcadores inflamatórios e de dano muscular após jogos oficiais. Para atender às demandas das partidas, jogadores de futsal são submetidos a sessões de treinamento diárias que incluem atividades com características semelhantes às de jogos oficiais e que permitem o desenvolvimento capacidades físicas específicas à modalidade.Trata-se de estudo com característica observacional analítica, uma vez que os pesquisadores não realizarão procedimentos de intervenção, apenas realizarão o acompanhamento do objeto de estudo (recuperação de atletas). Busca-se investigar a influência de diferentes fatores psicofisiológicos na recuperação de atletas de futsal após sessões de treinamento, e verificar se esses fatores podem definir grupos de recuperação rápida (responders) e lenta (nonresponders). Em adição, pretende-se verificar se o aumento de capacidades físicas induzido pela pré-temporada modifica a cinética de recuperação após uma sessão de treinamento. Participarão do estudo 24 jogadores de futsal do sexo masculino, com idade entre 18 e 35 anos, que disputarem a Liga Futsal e/ou Taça Brasil das categorias adulta ou sub-20, no ano de realização do estudo.

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Objetivo da Pesquisa:

Objetivos Primários:

- Investigar a influência de diferentes fatores psicofisiológicos na recuperação de atletas de futsal após sessões de treinamento.
- Verificar se esses fatores podem definir grupos de recuperação rápida (responders) e lenta (non-responders).
-Verificar se o aumento de capacidades físicas induzido pela pré-temporada modifica a cinética de recuperação após uma sessão de treinamento.

Objetivos Secundários:

O projeto será dividido em três estudos de acordo com os objetivos específicos descritos abaixo:

Estudo 1

- Investigar se a idade, as capacidades físicas e as variáveis perceptivas influenciam a cinética da recuperação de atletas de futsal após uma sessão de treinamento.
- Verificar se os fatores idade, capacidades físicas e variáveis perceptivas podem definir grupos de recuperação rápida e lenta após uma sessão de treinamento.

Estudo 2:

- Investigar se a idade, as capacidades físicas, as variáveis perceptivas e a carga de treinamento influenciam a cinética de recuperação de atletas de futsal entre sessões diárias de treinamento durante o período de pré-temporada.

Estudo 3:

- Investigar se o aumento de capacidades físicas de jogadores de futsal, induzido pelo treinamento no período de pré-temporada, modifica a cinética de recuperação desses indivíduos após uma sessão de treinamento.

Avaliação dos Riscos e Benefícios:

Riscos:

- Associados ao exercício físico, como lesões músculo-esqueléticas, distúrbios e incômodos causados pelo cansaço físico. No entanto, todos os voluntários serão atletas acostumados com a prática da modalidade esportiva avaliada. Além disso, todos os procedimentos a serem realizados durante o experimento são rotineiros no treinamento da equipe em questão. Ademais, em todas as situações de exercício físico, os voluntários estarão acompanhados de um médico disponível para qualquer atendimento emergencial.

-Em relação à punção venosa: flebites, infiltrações, hematomas, desconforto e infecções associadas ao procedimento. No entanto, para minimizar qualquer uma dessas complicações esse procedimento será realizado por um profissional treinado que realizará a devida higienização do local a ser puncionado e sempre fará uso de materiais estéreis e descartáveis. Com esses cuidados, o único risco possível é um leve desconforto gerado pela punção.
-Associados à coleta de amostras de saliva: constrangimento por parte dos voluntários no momento da colheita passiva de amostra; no entanto, esse procedimento será realizado em ambiente privado e apropriado, o que minimiza esse possível desconforto.

Benefícios:
-Os atletas terão acesso aos resultados dos testes físicos realizados, os quais indicarão a sua condição física e auxiliarão na programação das cargas de treinamento.

Comentários e Considerações sobre a Pesquisa:

O projeto segue as recomendações éticas e apresenta objetivos e metologias bem delineados, além de um cronograma dentro dos prazos estipulados.

Considerações sobre os Termos de apresentação obrigatória:

Foram apresentados:
-Projeto no formato da Plataforma Brasil e detalhado
-Folha de rosto devidamente preenchida e assinada pelo pesquisador responsável e vice-diretor da Escola de Educação Física, Fisioterapia e Terapia Ocupacional
-Carta de concordância no apoio à execução do projeto pelo Departamento de Integração das Ciências do Esporte do Minas Tênis Clube.
-TCLE
-Parecer consubstanciado e com anuência do Departamento de Educação Física

Recomendações:

Em relação ao TCLE, deve-se garantir que o participante e o pesquisador rubriquem as folhas anteriores à das assinaturas. Pode ser criado até um espaço para as rubricas.

Conclusões ou Pendências e Lista de Inadequações:

Diante do exposto, SMJ, sou pela aprovação do projeto.

Endereço: Av. Presidente Antônio Carlos,6627 2º Ad Sl 2005
Bairro: Unidade Administrativa II **CEP:** 31.270-901
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UNIVERSIDADE FEDERAL DE MINAS GERAIS

Continuação do Parecer: 1.338.627

Considerações Finais a critério do CEP:

Aprovado conforme parecer.

Este parecer foi elaborado baseado nos documentos abaixo relacionados:

Tipo Documento	Arquivo	Postagem	Autor	Situação
Informações Básicas do Projeto	PB_INFORMAÇÕES_BÁSICAS_DO_PROJETO_602638.pdf	13/10/2015 19:36:27		Aceito
Projeto Detalhado / Brochura Investigador	Wilke_CF_Projeto_COEP.pdf	13/10/2015 19:35:46	Samuel Penna Wanner	Aceito
TCLE / Termos de Assentimento / Justificativa de Ausência	Wilke_CF_TCLE.pdf	13/10/2015 19:33:53	Samuel Penna Wanner	Aceito
Outros	Wilke_CF_Carta_de_concordancia_da_instituicao.pdf	13/10/2015 14:05:56	Samuel Penna Wanner	Aceito
Outros	Wilke_CF_Parecer_departamento_de_Educacao_Fisica.pdf	13/10/2015 14:05:25	Samuel Penna Wanner	Aceito
Folha de Rosto	Wilke_CF_Folha_de_rosto.pdf	13/10/2015 14:04:57	Samuel Penna Wanner	Aceito

Situação do Parecer:
Aprovado

Necessita Apreciação da CONEP:
Não

BELO HORIZONTE, 26 de Novembro de 2015

Assinado por:
Telma Campos Medeiros Lorentz
(Coordenador)

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