Guilherme Passos Ramos

PERFIL DA ATLETA DE FUTEBOL DE ELITE NO BRASIL:

características antropométricas, físicas e respostas fisiológicas em treinamentos e competições

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Orientador: Prof. Dr. Cândido Celso Coimbra

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“Os que se encantam com a prática sem ciência são como os timoneiros que entram no navio sem timão nem bússola, nunca direcionam o destino”

Leonardo da Vinci

RESUMO

O objetivo desse trabalho foi determinar as características antropométricas e investigar as capacidades físicas, o desempenho físico das atletas ao longo do jogo e a possível interferência do treinamento na regulação hormônios cíclicos de atletas de futebol feminino das categorias sênior, Sub-20, Sub-17 e Sub-15, pertencentes à seleção brasileira de futebol. Os resultados do estudo-1 mostraram que as atletas da categoria sênior apresentam maior desempenho em todas as avaliações (Salto agachado - SJ, salto contramovimento - CMJ, 20m de sprint e teste de Yo-YoIR1) quando comparadas às outras 3 categorias (ES=0,67-3.06). Foi observado também que a categoria Sub-20 apresenta melhor desempenho no Yo-YoIR1 e nos saltos quando comparada às categorias mais jovens (ES=0,81-3,06). Além disso, é importante salientar que as atletas selecionadas em todas as categorias mostraram melhor desempenho no teste Yo-Yo IR1 quando comparadas às não selecionadas (ES=0,85-1,59). Quando avaliado o desempenho durante partidas oficiais (estudo-2), foi observada uma tendência de aumento na distância total percorrida (ES=0,82-2,04), ações de alta intensidade (corrida de alta velocidade - HIR e sprints) (ES=0,73-2,74) e número total de acelerações e desacelerações (ES=0,71-5,36), quando considerada a categoria. Considerando todas as posições, as atletas sêniores apresentaram melhor desempenho que as Sub-20 quando avaliada a distância total, acelerações e desacelerações durante as partidas (ES=0,82-4,04). Comparadas as Sub-20, as jogadoras de meio campo e as zagueiras da categoria sênior apresentaram maior distância em HIR e em sprint (ES=0,75 a 1,14). Interessante salientar que independentemente da posição tática, as jogadoras sênior mostraram melhor desempenho em todas as variáveis medidas que as atletas Sub-17 (ES=0,88-5,57). Ao longo dos jogos da categoria sub-20 (estudo-3) foi observado que as laterais e atacantes percorreram maiores distância total, distância em HIR e sprint comparado às zagueiras (ES=3,10-0,97). Nos últimos 15 min da partida foi observado uma redução no desempenho quando comparado aos minutos iniciais. O elevado desempenho físico observado no primeiro tempo (distância total, sprint e acelerações) parece resultar em aproximadamente 19% de redução do desempenho no segundo tempo. Por fim, no grupo de atletas da categoria Sub-20, nenhum dos quatro hormônios ciclos avaliados (cortisol, testosterona, estradiol e progesterona) (estudo-4) apresentaram variações importantes ao longo do período de treinamento pré-competitivo. Os resultados do presente estudo apresentam parâmetros de avaliações físicas para atletas de futebol feminino em diferentes categorias e demonstram que os resultados no teste de Yo-Yo IR1 parecem ser importantes na detecção de atletas para a disputa de competições internacionais de futebol feminino. Além disso, o aumento progressivo no desempenho físico de jogo de acordo com a categoria avaliada sugere que o treinamento deve seguir uma carga progressiva de acordo com a categoria. Por fim, carga de treinamento pré-competitivo geralmente aplicada às atletas de futebol parece não constituir um agente estressor que afete o controle dos hormônios cíclicos estudados. De um modo geral, os resultados desse estudo trazem informações relevantes para o futebol feminino, principalmente do Brasil, e podem ser úteis para treinadores ao planejar programas de treinamento para atletas de futebol alto nível.

Palavras-Chave: Futebol feminino. Testes físicos. Jogos oficiais.

ABSTRACT

The main objective of this study was to investigate aspects related to physical performance face official match physical demands and all long the training period of different belonging to the Brazilian soccer team: Under20 (U20), Under17 (U17) and Under15 (U15) categories. In addition, the influence of training load in cyclical hormone regulation of female athletes was evaluated. It was observed in the study-1 that the athletes of the senior category presented higher performance in all the evaluated physical tests (Squat jump - SJ, countermovement jump - CMJ, 20 meters sprint and aerobic capacity - Yo-Yo IR1), compared to U15, U17 and U20 categories (ES=0,67-3.06). In addition, the U20 category performed better in the Yo-Yo IR1 test and in jumps when compared to the younger categories (ES=0.81-3.06). Moreover, higher values were observed in the Yo-Yo IR1 for the selected athletes compared to the non-selected ones (ES=0.85-1.59), in all categories. There was a tendency for an increase in the observed values with the increase of the age of each category in the total distance traveled (ES=0.82 to 2.04), high intensity actions (high intensity running - HIR and sprints) (ES = 0.73-2.74) and total number of accelerations and decelerations (ES=0.71-5.36) during official matches (study-2). For all player positions, the senior athletes presented higher values of total distance, accelerations and decelerations than the U20 (ES=0.59-4.04). Senior’s midfielders and defenders showed greater distance in HIR and sprint than U20 (ES=0,75-1,14). Regardless of the tactical position, the senior players showed higher values in all measured variables than the U17 athletes (ES=0.88-5.57). Throughout the games of the U20 category (study-3) it was observed that the full-backs and forwards covered greater total distance, distance in HIR and sprint compared to the defenders (ES=0.97-3,10). In the last 15 min of the match a reduction in performance was observed when compared to the initial minutes and the accomplishment of a high physical performance in the first time (total distance, sprint and accelerations) resulted in approximately 19% decrement in the second time. Finally, for the U20 athletes, no differences among the pre-competitive training periods were observed for any of the four hormones evaluated (cortisol, testosterone, estradiol and progesterone) (study-4).–The results of this study present parameters of physical evaluations for female soccer players in different categories and demonstrate that performance on Yo-Yo IR1 test seem to be important in the detection of athletes selected for international women's soccer competitions. In addition, the progressive increase in the physical performance of the game according to the category evaluated suggests that the training should follow a progressive training load according to the category. Finally, changes in pre-competitive training load did not alter the cycle of some hormones of female soccer players. Overall, the results of this study provide relevant information to women's soccer, especially in Brazil, and may be useful for coaches in designing training programs for top-level soccer players.

Keywords: Female Soccer. Physical Tests. Official Matches.

SUMÁRIO

1.1 Desempenho físico

Um modelo "ergonômico" para a análise do futebol já foi proposto anteriormente e destaca que o jogo de futebol impõe uma gama de exigências sobre os jogadores que devem desenvolver a capacidade necessária para lidar com essas demandas (REILLY, 2005). Consequentemente, uma compreensão abrangente das demandas de um esporte é a base fundamental para a elaboração de programas de desenvolvimento.

Investigações sobre os padrões de movimento e características físicas de jogadoras de futebol em diferentes faixas etárias, categorias e ligas (HEWITT; NORTON; LYONS, 2014; VESCOVI *et al.*, 2011) são informações imprescindíveis para o planejamento e preparação destas atletas em busca de melhor desempenho. Dados publicados sobre o futebol feminino demonstram que uma elevada capacidade aeróbica é necessária par a prática da modalidade, uma vez que são observadas frequências cardíacas médias entre 84-86% da frequência cardíaca máxima durante partidas oficiais (ANDERSSON *et al.*, 2010; KRUSTRUP *et al.*, 2010), e distâncias médias percorridas entre 9 e 12 km (ANDERSSON *et al.*, 2010; HEWITT; NORTON; LYONS, 2014; KRUSTRUP *et al.*, 2005, 2010; MOHR *et al.*, 2008). Essa distância é semelhante àquela encontrada no futebol masculino (ANDERSSON *et al.*, 2010; BRADLEY *et al.*, 2010; KRUSTRUP *et al.*, 2010; MOHR *et al.*, 2008; MOHR; KRUSTRUP; BANGSBO, 2003b; RAMPININI *et al.*, 2007).

Embora o desempenho individual em jogos de futebol seja associado à capacidade aeróbica, uma vez que a partida oficial possui 90 minutos de duração (BANGSBO; NORREGAARD; THORSOE, 1992; MOHR; KRUSTRUP; BANGSBO, 2003b), ações de alta intensidade tais como correr em alta velocidade, saltar, mudar de direção estão associados aos momentos mais importantes do jogo, como por exemplo aqueles relacionados aos gols (AZIZ; CHIA; TEH, 2000; JULLIEN *et al.*, 2008; LITTLE; WILLIAMS, 2006). Em partidas de futebol feminino as jogadoras oscilam a intensidade da atividade 1326-1379 vezes durante os 90 minutos (MOHR *et al.*, 2008), realizando aproximadamente 20-27 sprints e 125-154 corridas de alta velocidade (MOHR *et al.*, 2008). Isso resulta em uma distância em sprint e corrida de alta velocidade entre 250-460 m e 1.300-1.680 m, respectivamente (MOHR *et al.*, 2008).

Além disso, já foi observado que ao longo de partidas oficiais de futebol ocorre uma diminuição da distância total percorrida no segundo tempo de jogo quando comparado ao primeiro (COELHO *et al.*, 2012), além de redução nas ações de alta intensidade nos minutos finais (MOHR; KRUSTRUP; BANGSBO, 2003b), alterações que podem ser decorrentes do desenvolvimento da fadiga (MOHR; KRUSTRUP; BANGSBO, 2003b). Entretanto, outros autores propõem que a redução nas ações de alta intensidade, não ocorrem em jogadores de alto nível – nível internacional (BRADLEY *et al.*, 2010). Atletas desse nível seriam capazes de regular suas ações totais, reduzindo-as e fazendo com que sejam mantidas as de alta intensidade, consideradas as mais importantes no jogo (FAUDE; KOCH; MEYER, 2012). Dessa forma, parece que a compreensão do desempenho ao longo da partida é um fator importante para entender o processo de fadiga e sua possível influencia na demanda física do jogo.

Além do desempenho ao longo do jogo, já foi verificado que diferentes posições táticas podem gerar demandas físicas distintas (BLOOMFIELD; POLMAN; O'DONOGHUE, 2007). O conhecimento sobre as exigências do jogo e as demandas específicas de cada posição também têm implicações importantes para a adoção de uma abordagem mais individualizada para o treinamento físico. De fato, Bloomfield *et al.* (2007) verificaram que homens jogadores de futebol da posição de ataque podem permanecer até 50% a mais do tempo de jogo realizando ações de alta velocidade quando comparado aos jogadores de defesa. Isso reforça a proposta de que a informação a respeito da demanda física de jogos de futebol deve ser feita com a discriminação da posição tática no jogo (AQUINO *et al.*, 2017).

Nesse sentido, diversos métodos para quantificação da demanda física em jogos oficiais de futebol já foram utilizados nas últimas décadas, incluindo a análise através de sistemas semiautomatizados, computadorizados e por meio de sistemas de posicionamento por satélite (GPS). Essas tecnologias contemporâneas apresentam abordagens eficientes no que diz respeito à análise do desempenho físico de atletas de futebol em jogos oficiais (DI SALVO *et al.*, 2009) e, em sua maioria, são recursos utilizados principalmente nas categorias profissionais.

Parte dos estudos que avaliam a carga externa (ex. distância percorrida, ações de alta velocidade, etc) durante as atividades relacionadas ao futebol feminino utilizando GPS (VESCOVI; FAVERO, 2014) e/ou análises de vídeo (ANDERSSON *et al.*, 2010; GABBETT; SEIBOLD, 2013), mediram a distância percorrida, ou o tempo gasto em velocidades específicas. Estudos recentes incluiem também distância ou o tempo gasto em diferentes faixas de aceleração e desaceleração (AKENHEAD *et al.*, 2015), número de acelerações (RUSSELL *et al.*, 2016) e aceleração média (BRADLEY *et al.*, 2010). O entendimento dessa demanda e estabelecimento de parâmetros para a modalidade parece importante devido à alta frequência com a qual ocorrem em jogos (VARLEY; FAIRWEATHER; AUGHEY, 2012), e a demanda mecânica aumentada que provocam nos grupos musculares envolvidos (STEVENS *et al.*, 2015). Além disso, apesar da maioria das atividades durante partidas de futebol serem realizadas em baixa velocidade (BRADLEY *et al.*, 2014), as ações em alta velocidade e, principalmente, as ações com altas acelerações e com esforços repetidos, são consideradas cruciais para o desempenho do jogo (GABBETT; MULVEY, 2008; MOHR; KRUSTRUP; BANGSBO, 2003b) e estão presentes principalmente em momentos em que o atleta não dispõe de espaço suficiente para alcançar altas velocidades, como disputa a bola e enfrentamento ao oponente.

No entanto, há poucas informações disponíveis na literatura sobre acelerações e desacelerações em atletas de futebol feminino, o que reforça a necessidade de novas pesquisas sobre a modalidade. Além disso, é importante salientar a ausência de informações acerca dessas variáveis especialmente relacionadas a seleções nacionais ranqueadas entre as 10 melhores seleções de futebol do mundo (Ranking FIFA - 2016) e com atletas de nível internacional.

A partir dessas informações, é possível perceber que o jogo de futebol envolve elevada demanda de diferentes capacidades físicas, principalmente se for considerado o alto rendimento. Dessa forma, a avaliação das capacidades física de jogadores, incluindo medidas antropométricas, desempenho de força, velocidade e resistência aeróbica, são importantes em programas de desenvolvimento de atletas de futebol (MANSON; BRUGHELLI; HARRIS, 2014b). Além disso, a caracterização desses níveis de desempenho nas categorias propostas pela FIFA é de grande importância prática para treinadores e pesquisadores que buscam parâmetros para seleção, avaliação, comparação e treinamento de seus jogadores.

Embora a escolha de atletas seja um procedimento complexo devido aos vários fatores relacionados no desenvolvimento de um jogador, estudos anteriores retratam que o conhecimento dos perfis físicos daqueles indivíduos de sucesso constitui um recurso valioso para orientar a seleção dos mais aptos à modalidade (REILLY; BANGSBO; FRANKS, 2000; STOLEN *et al.*, 2005).

De fato, Le Gall *et al.* (2008) investigaram os resultados de desempenho físico de jogadores de futebol de categorias de base franceses e identificaram que jogadores com melhor desempenho físico alcançam níveis competitivos superiores ao atingirem a categoria sênior (nível internacional). Ao contrário, jogadores com pior desempenho físico alcançam níveis competitivos inferiores (nível amador). As diferenças no desempenho físico entre esses níveis competitivos foram verificadas para a capacidade aeróbia máxima, tempo de sprint de 40m e altura de salto contramovimento. Resultados similares já foram observados em outros estudos envolvendo jogadores de futebol masculino (COMETTI *et al.*, 2001; LAGO-PENAS *et al.*, 2011), inclusive relacionando as colocações finais em competições com maiores valores de consumo máximo de oxigênio (LAGO-PENAS *et al.*, 2011).

Nesse contexto, foi encontrado na literatura científica apenas um estudo investigando atletas femininas de futebol, com inferência sobre possíveis diferenças no desempenho físico entre aquelas selecionadas e não selecionadas (MANSON; BRUGHELLI; HARRIS, 2014a). Nesse estudo, foi verificado que atletas neozelandesas selecionadas para competirem internacionalmente pela seleção nacional, 17ª colocada no ranking da FIFA, apresentam maior desempenho no pico de força de membros inferiores e na capacidade aeróbia que aquelas não selecionadas. Os demais estudos que investigaram diferenças físicas entre atletas mulheres de diferentes níveis competitivos, não foram realizados com mulheres atletas de futebol, sendo a maioria com jogadoras amadoras, que geralmente não recebem carga elevada de treinamento. Além disso, na maioria foram trabalhos que abordaram apenas uma única característica física (BRADLEY *et al.*, 2011; CASTAGNA; CASTELLINI, 2013), diferentemente da proposta do presente estudo.

Para alcançar os níveis de desempenho exigidos para atingir elevada performance e serem selecionados para clubes de maior expressão, os atletas de esportes coletivos como o futebol experimentam altas exigências diárias e semanais tais com treinamentos, diferentes competições ao mesmo tempo, em meio a viagens e reuniões de equipe. Treinamentos eficazes que equilibram cuidadosamente o desgaste e a recuperação são fundamentais, uma vez que a carga de treinamento deve ser prescrita de forma adequada para evitar o excesso de treinamento, que geralmente é acompanhado por redução no desempenho e alterações hormonais (KRAEMER *et al.*, 2004). No contexto do futebol, treinamentos que podem integrar aspectos físicos e técnico / táticos são considerados interessantes por representarem uma melhor utilização do tempo disponível para os treinos, representando também situações de jogos.

Dessa forma, o gerenciamento da carga de treinamento para que se possa tentar identificar um equilíbrio entre as exigências e garantir que os atletas se comportem no melhor de seu desempenho físico, tornou-se um grande desafio para treinadores e profissionais do esporte. Já é estabelecido na literatura, principalmente no esporte de alto rendimento, que a carga de treinamento pode influenciar a liberação de hormônios cíclicos do eixo hipotálamo-hipófise-adrenal (HPA) em atletas (KRAEMER *et al.*, 2004).

O treinamento desencadeia respostas no sistema neuroendócrino que promovem a adaptação do organismo para os desafios das demandas do esporte. Neste contexto, os hormônios esteroides (cortisol/testosterona) são considerados bons indicadores do nível da adaptação e remodelação induzidas pelo esforço do treinamento (síntese/degradação proteica) (GLEESON, 2002; HELLHAMMER; WUST; KUDIELKA, 2009). Estudos têm demonstrado alterações nas concentrações de cortisol (hormônio indutor de mobilização de proteínas) e de testosterona (hormônio estimulador da síntese de proteínas) no plasma durante treinamento esportivo. Além disso, a razão T/C pode ser utilizada como marcador de adequação ou excesso da carga de treinamento. É proposto que quando essa relação se apresenta reduzida em aproximadamente 30% ou mais em referência aos seus valores iniciais (AIZAWA *et al.*, 2006; BANFI; DOLCI, 2006) o intervalo de recuperação dos atletas de futebol é considerado inadequado. De fato, aumento nas concentrações de cortisol com concomitante redução na razão T/C tem sido verificado em períodos de acúmulo de jogos destacando que o aumento da demanda física imposta pelos jogos altera a concentração hormonal levando a possíveis desgastes dos atletas (AIZAWA *et al.*, 2006; MILOSKI *et al.*, 2016).

No caso de mulheres atletas, além do ciclo hormonal circadiano, apresentam também um ciclo hormonal mensal denominado ciclo menstrual (MIDDLETON; WENGER, 2006b) onde ambos os ciclos, eventualmente, poderiam ser afetados pela carga excessiva de treinamento. Dessa forma as mulheres atletas de futebol estariam sujeitas, além de possíveis perturbações no eixo hipotálamo-hipófise-adrenal, a variações também cíclicas de hormônios sexuais (por exemplo: estrogênio e progesterona) ligados ao ciclo uterino/ovariano ao longo de seu ciclo menstrual. Estas perturbações poderiam eventualmente causar alterações no seu metabolismo, termorregulação, respostas contrácteis musculares e capacidade aeróbica, entre outras

(JANSE DE JONGE *et al.*, 2001; MIDDLETON; WENGER, 2006a). No entanto, as pesquisas atuais investigando o efeito do ciclo menstrual sobre as qualidades de desempenho físico de atletas são inconsistentes. A maioria dos estudos realizados com atletas mulheres busca investigar a existência de possíveis associações entre as fases do ciclo reprodutivo e o desempenho esportivo (JULIAN *et al.*, 2017; MASTERSON, 1999; MIDDLETON; WENGER, 2006a). Outra área de interesse seria verificar a relação entre a carga de treinamento e a ocorrência de alterações do ciclo menstrual como amenorreias. Ainda há poucos registros na literatura de estudos sistematizados que investigaram o efeito do treinamento na cinética diária de hormônios cíclicos de mulheres (DE SOUZA *et al.*, 2010), e uma carência ainda maior em modalidades esportivas como o futebol feminino.

Os dados literatura destacam que o futebol feminino mudou dramaticamente nas duas últimas décadas (HAUGEN; TONNESSEN; SEILER, 2012). O aumento do profissionalismo no esporte é representado pelo aumento da demanda física de jogo e da capacidade física das atletas, representado pelo aumento da velocidade em sprint e altura de salto contramovimento (HAUGEN; TONNESSEN; SEILER, 2012). No entanto, ainda existem muitas lacunas no que diz respeito às informações de características físicas, características de jogos, monitoramento e alterações hormonais com o treinamento de mulheres jogadoras de futebol, principalmente considerando-se atletas de alto nível, das categorias de base e aquelas pertencentes a seleções nacionais. Desta forma, o presente trabalho tem também como objetivo preencher algumas destas lacunas ainda existentes, focando principalmente na quantificação de capacidades físicas de jogadoras de futebol feminino, na demanda física de jogos internacionais das diferentes categorias, no seu desempenho físico ao longo de jogos oficiais, inclusive verificando se a carga de treinamento imposta em período pré-competitivo poderia influenciar as respostas hormonais cíclicas de mulheres atletas de futebol.

1 INTRODUÇÃO

O futebol é um esporte praticado em todos os continentes e a adesão à modalidade aumenta a cada ano, especialmente entre os jovens, veteranos (REILLY, 1997) e mulheres (MANSON; BRUGHELLI; HARRIS, 2014a). Estima-se que há mais de duzentos e sessenta e cinco milhões de jogadores de futebol em atividade em diferentes países (FIFA, 2007).

Com relação ao futebol feminino, na última década, foi observado um rápido aumento do número de praticantes, tornando este esporte um dos mais praticados pelo público feminino e um dos que mais cresce em popularidade no mundo (FIFA, 2015). A Fédération Internationale de Football Association (FIFA) estimou em 2012 que havia mais de 29 milhões de mulheres praticando essa modalidade esportiva, o que representou um aumento de 32% considerando os 10 anos anteriores (FIFA, 2015). Além disso, foram observados resultados econômicos expressivos na Copa do Mundo Feminina da FIFA Alemanha 2011 (COMITÊ ORGANIZADOR LOCAL [LOC], 2011). Recentemente, a Copa do Mundo Feminina da FIFA Canadá 2015 foi considerada o maior evento esportivo feminino do mundo, com número de espectadores próximo a 1,35 milhões de pessoas nos estádios, cobertura de TV atingindo 188 países e com audiência de 25,4 milhões de telespectadores durante a partida final. Essa foi a maior audiência já registrada em todos os tempos de uma partida de futebol feminino e uma das maiores audiências de eventos esportivos nos Estados Unidos (FIFA, 2016).

Dentro do contexto do futebol feminino brasileiro, a Confederação Brasileira de Futebol (CBF) reformulou nos últimos anos os campeonatos do país tanto para o nível profissional quanto para as categorias de base. Na temporada 2016-2017 foi criada a Copa do Brasil feminina e a série A2 do campeonato brasileiro feminino, o que dobrou o número de clubes participantes em campeonatos. Além disso, foi estruturado também o campeonato brasileiro feminino Sub-20, composto por atletas de até 19 anos de idade.

Em uma resolução lançada em 2017, a CBF em conjunto com a Confederação Sul-Americana de Futebol (CONMEBOL), lançou uma normativa para que até 2019 todos os clubes de futebol participantes do Campeonato Brasileiro, tenham parte dos investimentos direcionados ao desenvolvimento do futebol feminino. Portanto, existe a expectativa de que para as temporadas 2017, 2018 e 2019, seja praticamente dobrado o número de equipes de futebol feminino no Brasil, e que mais atletas de futebol, tenham oportunidades de praticar esta modalidade esportiva.

A compreensão das diferentes demandas físicas durante treinamentos e competições relacionadas ao futebol tem atraído o interesse da comunidade científica, podendo ser encontrados 8.292 artigos no PubMed (pesquisa realizada em 05/05/2016 com as palavras-chave "*soccer*"). Entretanto, apesar do elevado número de artigos publicados relacionados ao futebol, ainda há uma grande disparidade na literatura em relação ao número de estudos dedicados a caracterização do desempenho físico de jogadores do sexo masculino, comparado ao sexo feminino (MANSON; BRUGHELLI; HARRIS, 2014a; MUJIKA *et al.*, 2009; VESCOVI; BROWN; MURRAY, 2007). De acordo com essa perspectiva, a partir de pesquisa na base de dados PubMed em 05/05/2016 (utilizando os termos de busca: female soccer e male soccer), observamos que a maioria dos trabalhos de pesquisa sobre os dados fisiológicos (Desempenho Físico e variáveis de jogo 11vs11) são de jogadores de futebol masculinos, sendo menos de 20% dedicados à modalidade feminina.

Com a perspectiva de aumento considerável do futebol feminino assim como a sua importância no país, mais pesquisas precisam ser realizadas para a melhoria do nível desta modalidade e para que a mesma alcance patamares ainda mais elevados em nível internacional.

2 OBJETIVOS

O objetivo principal desse trabalho foi descrever características físicas, a demanda física de jogos oficiais, o desempenho físico das atletas ao longo do jogo e a influência do treinamento pré-competitivo em atletas de futebol feminino das categorias sênior, Sub-20, Sub-17 e Sub-15, pertencentes à seleção brasileira de futebol.

2.1 Objetivos específicos

1 – Descrever e comparar os valores antropométricos, de desempenho físico em testes de saltos, velocidade e resistência aeróbica de atletas de futebol feminino das categorias Sub-15, Sub-17, Sub-20 e profissional;

2 – Comparar o desempenho físico entre grupos de atletas selecionadas e não selecionadas para compor as seleções brasileiras de futebol feminino em competições internacionais;

3 – Comparar as distâncias percorridas em diferentes faixas de velocidade, número de acelerações, desacelerações de atletas de futebol feminino das categorias Sub-17, Sub-20 e Sênior durante torneios internacionais;

4 – Verificar a distância percorrida em diferentes faixas de velocidade e o número de acelerações e desacelerações de atletas Sub-20 de futebol feminino ao longo de 7 jogos oficiais internacionais;

5 – Avaliar as concentrações ao longo do dia dos hormônios cíclicos testosterona, cortisol, a razão entre esses (T/C) e dos hormônios sexuais femininos, progesterona e estradiol, de mulheres atletas de futebol submetidas a um período de treinamento pré-competitivo de 35 dias;

6 – Verificar se a variação na carga de treinamento poderia alterar a regulação de hormônios cíclicos (testosterona, cortisol, estradiol e progesterona) de atletas de futebol feminino.

2.2 Organização do Estudo

Esse trabalho consistiu no desenvolvimento de estudos que serão apresentadas em formatos de artigos, com introdução, método, resultados e discussão na seguinte ordem:

Estudo 1. Determinação das características antropométricas, capacidade física de jogadoras de futebol de elite do Brasil de 15 anos à categoria sênior.

"Comparison of physical fitness and anthropometrical profiles among Brazilian female soccer's national teams from U15 to seniors categories"

***Artigo será submetido** no periódico *International Journal of Sports Physiology and Performance* (Qualis A1)

Estudo 2. Desempenho físico em partidas oficiais de futebol feminino das seleções brasileiras sub-17, sub-20 e sênior durante competições internacionais: Existem diferenças significativas?

"Activity profiles in U17, U20 and senior women's Brazilian National soccer teams during international competitions: Are there meaningful differences?"

***Artigo submetido** no periódico *Journal of Strength Conditioning Research* (Qualis A2 - Processo de segunda correção)

Estudo 3. Determinação do padrão de movimentos de jogadoras de futebol durante partidas internacionais.

"Movement patterns of an U-20 National female soccer team during competitive matches"

***Artigo aceito para publicação** no periódico *International Journal of Sports Medicine* - *In press* (Qualis A1)

Estudo 4. Avaliação das possíveis alterações dos ritmos biológicos de atletas de futebol da seleção brasileira submetidas a condições de treinamento físico

***Artigo em processo de finalização** para submissão em periódico científico a definir

Estudo 1. Determinação das características antropométricas, capacidade física de jogadoras de futebol de elite do Brasil de 15 anos a categoria sênior.

Comparison of physical fitness and anthropometrical profiles among Brazilian female soccer national teams from U15 to seniors categories

*Artigo será submetido no periódico *Journal of Strength Conditioning Research* (Qualis A2)

Introduction

The popularity of women's soccer match has grown worldwide. During the last ten years it has become one of the most popular female sports between young practiced by over than 29 million of players with an increase of 32% (13) . Recently, 2015 Women's World Cup had 24 participating nations, eight nations more than the previous tournament (14). However, although reports identify female soccer as one of the fastest growing sports practicing in the world (21), only a few studies regarding match performance characteristics, training methods and athlete's physical capacities has been done, when compared to male soccer athletes studies.

Recent studies have demonstrated that during a match, professional female players can cover distances around 9-11 km (33,42,43) and perform a range of 130 and 25 high-intensity runs and sprints, respectively (33). More recently, it has been shown that the number of sprints performed during a match varies among playing positions (e.g., central defenders: 10.2 ± 4.1; forwards: 31.9 ± 11.1 events) (1). Hence, sprinting is a significant feature in women's professional soccer with top speeds reaching up to 30 km/h (16,44). Of note, throughout a 90-min match, soccer players rely mainly on aerobic metabolism to sustain their work rate. While aerobic metabolism is the dominant energetic system during a soccer game, anaerobic based actions such as short sprints, jumps, decelerations, tackles, shots and duels are demonstrated to be predominant while creating goal scoring opportunities (12).

Interestingly, physical attributes that influences performance levels may change based on players age. Previous research showed that high-intensity tasks lasting several seconds, short sprint speed and lower limb power performance increases until U13 and U14 players and tend to plateau after mid teenage years (44), whereas aerobic endurance increase in U15 and U16 players (41). In contrast, Mujika *et al.* (35) reported better counter-movement jump and agility tests performances in high level senior compared to youth (16–19 years) female soccer players, which showed that short duration anaerobic performance can be improved in young adults.

Long term athletic development is a dynamic process, and knowledge about female soccer player's physical performances throughout different age categories could assist coaches and sports scientists who use these measures to evaluate players within their national organizations through providing expected values of physical fitness. However there is only a few studies with physical data collected from successful female soccer players nominated for their respective age-specific national teams, specially towards all Federation Internationale de Football Association (FIFA) age brackets (U17, U20 and Senior).

Since player level cannot be determined by assessing a single physical parameter (32,37), an understanding of the qualities needed to be physically successful in the game can provide insight to detect player's potential for long-term success (40). As evidenced in the literature, physical player profile such as the levels of sprint speed, agility, leg power, strength and endurance can distinguish between elite and non-elite youth players (Gissis *et al.*, 2006; Meylan *et al.*, 2010). Selected players routinely achieve higher performance outcomes on these performance tests compared with sub-elite (6) or beginners (30), demonstrating the importance of physical characteristics for player development and this influence on player selection.

Thus, the aim of this study was to compare anthropometric values and power, speed and endurance performance of female soccer athletes from under 15 years old to senior categories (i.e., primary step) from the Brazilian national teams. A secondary aim was compare the physical performance characteristics between groups of selected and non-selected players (i.e., secondary step) to compete in official tournaments for the national team. If physical differences were noted between groups of selected and non-selected players, it would indicate that success in national team player selection depends at least to some degree upon the level of physical conditioning. This study can be of practical value to technical staffs for appropriate training, development and profiling of top-level female soccer.

Methods

Participants

Two hundred and thirty (n = 230) female soccer players from the Brazilian National soccer teams participated in this study that was previously approved by the institutional Research Ethics Committee and was conducted under the rules established by the national Health Council (Resolution 466/2012) for research involving humans. The present data arose as a condition of playing for the National team in which players are routinely physically evaluated before the start of a training period (47). Therefore, because of the posteriori nature of the analyses, signature of the informed consent form was not required; nevertheless, to ensure player confidentiality, all physical performance data were anonymized before analyses.

Forty-six players were members of the under 15 years old team (U15), forty-eight from the under 17 years old team (U17), ninety-eight from the under 20 years old team (U20) and thirty-eight from the senior's National team (Senior). In case of some player being part of two different age teams (e.g., U20 and Senior), she was included only in the youngest group. All the study participating players were nominated by the Brazilian soccer coaches and were officially invited by the Brazilian Football Confederation to be part in at least one entire training camp (e.g., 10-15 days) with the National team, for observation and selection purposes.

All the players were familiarized with the procedures involved in this study due to the testing procedures implemented in their respective clubs and the routines undertaken by the National squads.

Some of the players were selected to represent Brazil within the 2013/2014/2015/2016 calendars in international competitions, including the U15 Portugal's Cup (2014), U17 South American Tournament in Paraguay (2013/14), U17 South American Tournament in Venezuela (2016), U17 World Cup in Jordan (2016), U20 South American Tournament in Uruguay (2014), U20 South American Tournament in Brazil (2015) and U20 FIFA Women's World Cup in Canada (2014), Senior South American Tournament in Ecuador (2015) and Senior Olympic Games in Rio (2016). During the period in which players performed the physical tests, FIFA's official ranking had the Brazilian senior team ranked 8th out of 133 national teams.

Study Design

This is a cross-sectional comparative study aimed at characterizing the physical profile of elite female soccer players with different ages across all FIFA age brackets (U17, U20, and Senior) and the U15. In addition, we compared the findings of selected and non-selected players to be part of the National squad during official international tournaments of each age bracket to determine selection–related differences in physical qualities such as maximal sprint speed, jump height and intermittent running capacity.

All measurements were performed in the morning (between 9:00-12:00-am) at the Training Center of the Brazilian National Soccer Confederation. Athletes from the same age group were evaluated at the same time, but separated from the other groups. After a minimum of 24-h rest and an overnight sleep, sessions started with the measurement of players' body mass, height (Filizolla®, São Paulo, Brazil), and the sum of seven skinfolds (triceps, biceps, subscapular, suprailiac, abdominal, front thigh, medial calf) (Holtain Ltd., Crymych, UK).

Physical tests were complete in the following order: squat jump (SJ), countermovement jump (CMJ), 20 m linear sprint and Yo-Yo Intermittent Recovery Test level 1 (Yo-Yo IR1) (26). All tests were separated by at least 10-min rest. Jump tests were performed on a rigid surface with the players wearing running shoes, whereas all running tests were performed on a natural grass soccer pitch with the players wearing soccer boots. The physical tests used herein are acceptable and have shown high reliability in previous studies (e.g. CV = 3.3%; ICC = 0.97 for SJ; CV = 2.8%; ICC = 0.98 for CMJ; CV = 1.5%; ICC = 0.96 for sprint test; CV = 6.6%; ICC = 0.94 for YR1 test) (11,31,34). Athletes were instructed to freely warm-up for 10-15 min performing general exercises such as jogging, shuffling, skipping, short sprinting, multidirectional movements, and dynamic stretching exercises. During each test all players were verbally encouraged by the team technical staff.

Vertical Jump tests: Vertical jump height was determined using both SJ and CMJ performed on a timing mat (Multisprint, Hidrofit, Brazil). For the SJ, subjects were required to remain in a static squat position with a 90° knee flexion angle for 3-s before jumping with no stretch-shortening cycle before. In the CMJ, the players were instructed to execute a downward eccentric action preceding the power concentric action followed by a complete extension of the legs. Both jump techniques were executed with the hands fixed on the hips. A total of three attempts were allowed for each jump, interspersed by 15-s. All tests were video recorded for posterior analysis to confirm the athlete's correct technique execution and the best attempts of SJ and CMJ were retained. For detailed description of the tests, see Bosco *et al.* (5).

20m Linear Sprint Test: All players sprinted along 20-m straight track on three trials, separated by 3-min passive rest, and the fastest time was considered for analysis. Twenty meters is a common sprint distance observed during matches for female soccer athletes (44). Sprint times were recorded by photocells (Multisprint, Hidrofit, Brasil®) mounted 1-m height.

Yo-Yo Intermittent Recovery Test, level 1: The players completed the Yo-Yo IR1 test as described by Krustrup *et al.* (26). Briefly, each athlete performed repeated 20-m shuttle runs at increasing velocities with 10-s of active recovery between runs. The tests were performed using an audio signal and was terminated when the subjects failed twice to reach the starting line or the participant felt unable to complete another shuttle at the dictated speed. The total distance covered was used as the performance measure.

Statistical analysis

A one-way analysis of variance (ANOVA) was used to examine age group differences in the Yo-Yo IR1, vertical jumps, sprint test performance and anthropometrical variables with the Student-Newman-Keuls post hoc test used when necessary to locate specific age groups differences. Unpaired t tests were used to assess differences in selected and non-selected players within each age group. To determine the magnitude of the differences among age groups and selected and non-selected players, the effect size (ES: Cohen's d) was calculated and values of 0.2, 0.5 and above 0.8 were interpreted as small, medium and large, respectively. The Sigma Stat 12.0 software package (Germany) was used for all analyses. All results were show as mean ± standard deviation.

Results

Table 1 shows the results of anthropometric data across age groups. The U15 players were shorter (p<0.01) than all other age groups and were lighter (p<0.01) than U20 players.

Table 1. Anthropometric characteristics of different age groups of Brazilian's national female football players. Data in Mean (±SD).

Age Group	N	Age (years)	Height (cm)	Body Mass (kg)	Skinfolds (mm)
Under 15	46	14.7 ± 0.5	161.8 ± 7.4	57.3 ± 7.4	100.6 ± 24.4
Under 17	49	16.5 ± 0.5	164.9 ± 7.8[a]	59.2 ± 8.7	97.0 ± 27.3
Under 20	98	18.6 ± 0.6	166.6 ± 7.3[a]	61.1 ± 7.6[a]	90.2 ± 24.9
Senior	38	26.0 ± 2.9	168.0 ± 5.1[a]	60.5 ± 6.1	87.1 ± 24.8
Total	231				

[a] different from Under 15, p<0,05.

Irrespective of jump technique (CMJ or SJ), age group influenced jump performance (p≤0.001). The U20 (31.6 ± 4.3 cm) and senior (33.0 ± 4.1 cm) athletes showed higher CMJ performances than the U15 (27.2 ± 3.1 cm) (ES = 1.19, ES = 1.61, respectively) and U17 (28.1 ± 3.8 cm; ES = 0.86 for U20 and ES = 1.24 for senior) players (Figure 1-A). For the SJ, U20 athletes (29.4 ± 4.2 cm) presented higher jump performance than U15 (25.8 ± 2.9 cm; ES = 1.01) and U17 (26.1 ± 3.9 cm; ES = 0.81) players, while senior athletes (32.1 ± 3.9 cm) presented higher performance than all the other age categories (ES = 1.85 for U15; ES = 1.54 for U17; ES = 0.67 for U20) (Figure 1-B).

Senior athletes were significantly faster (6.2 ± 0.5 $m.s^{-1}$) than all other age categories in linear 20-m sprint test (5.9 ± 0.2 , ES = 0.86; 5.8 ± 0.2, ES = 1.14; and 5.9 ± 0.3 $m.s^{-1}$, ES = 0.75, for U15, U17 and U20 respectively; p<0.01) (Figure 1-C), and also covered the greatest total distance in the Yo-Yo IR1 test (1.51 ± 0.32 km) (ES = 3.06; ES = 2.87; ES = 2.32 for U15, U17 and U20 respectively). In addition, the U20 (0.86 ± 0.24 km) athletes covered higher distance than U15 (0.71 ± 0.21 km; ES = 0.67) and U17 (0.72 ± 0.23 km; ES = 0.60) ($p<0.05$) (Figure 1-D).

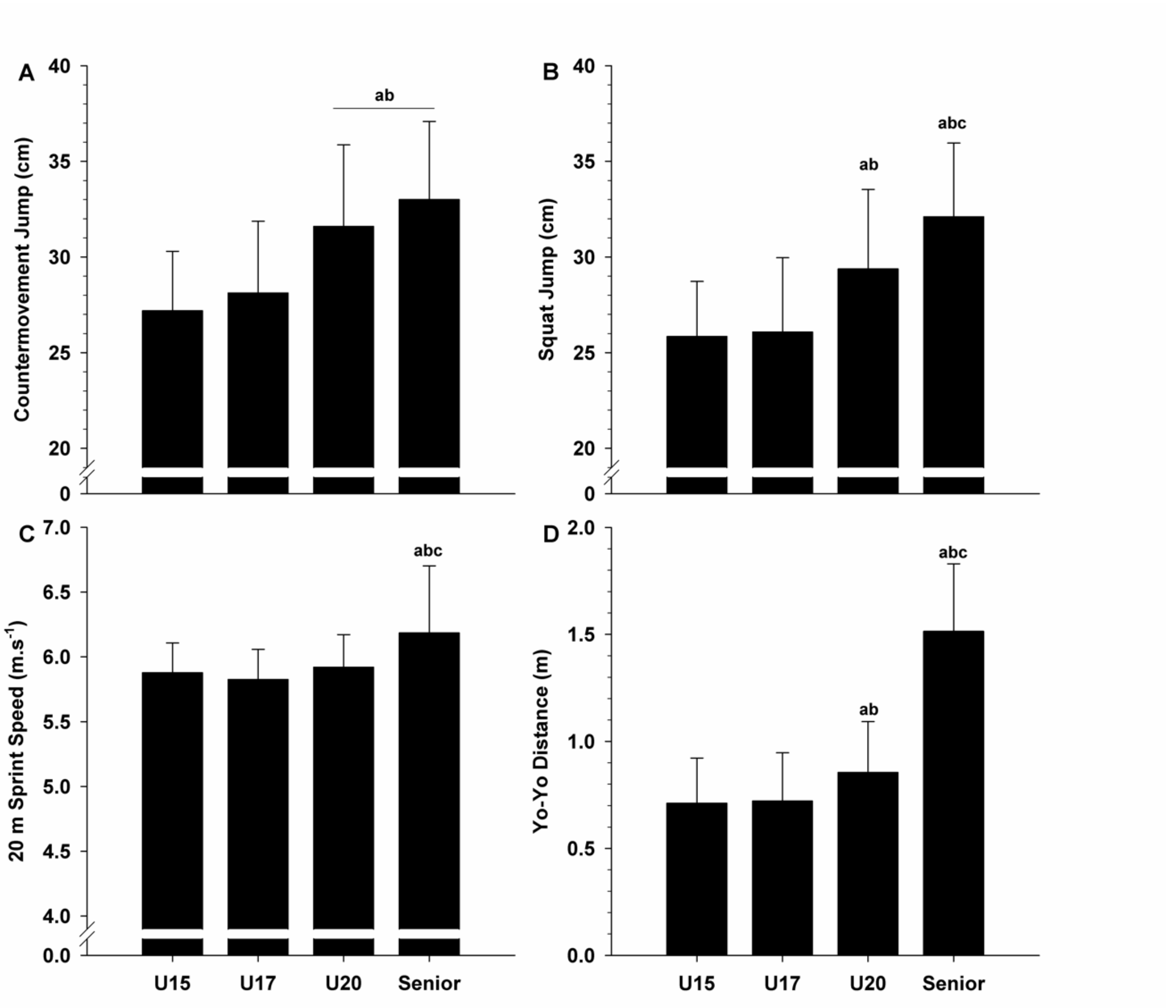

Figure 1. Countermovement jump (A), squat jump (B), 20 m linear sprint speed (C) and total distance covered in Yo-Yo IR1 test (D) in the different age categories.
[a] different from Under 15; [b] different from Under 17; [c] different from Under 20.

When players from each age category were separated into those selected and non-selected players to participate in international competitions, no differences were found for anthropometric data of height, body mass and sum of skinfolds (Table 1).

In general, selected athletes for all categories showed a higher score than non-selected only during Yo-Yo IR1 test (Figure 2-D), however selected senior athletes presented a higher score for at least three physical tests, SJ, CMJ, and Yo-Yo IR1 when compared with the other categories.

Selected senior athletes showed higher jump performances than non-selected senior athletes for CMJ (34.9 ± 3.6 vs. 31.7 ± 3.9 cm; ES = 0.87) and SJ (33.6 ± 3.6 vs. 31.0 ± 3.8 cm; ES = 0.70) ($p < 0.05$), while non -selected U17 athletes jumped higher than selected U17 athletes in SJ (24.8 ± 3.5 vs. 27.4 ± 3.9 cm; ES = 0.71) and CMJ tests (26.9 ± 3.9 vs. 29.4 ± 3.5 cm; ES = 0.69) ($p < 0.05$) (Figure 2-A and B).

No differences were found between selected and non-selected athletes for linear 20-m sprint test in any of the age groups (Figure 2-C). For total distance covered during Yo-Yo IR1, selected athletes covered a higher distance than non-selected athletes in the U17 (0.85 ± 0.26 vs. 0.69 ± 0.17 km; ES = 0.74), U20 (0.91 ± 0.21 vs. 0.77 ± 0.25 km; ES = 0.62) and senior teams (1.59 ± 0.28 vs. 1.31 ± 0.30 km; ES = 0.98) (Figure 2-D).

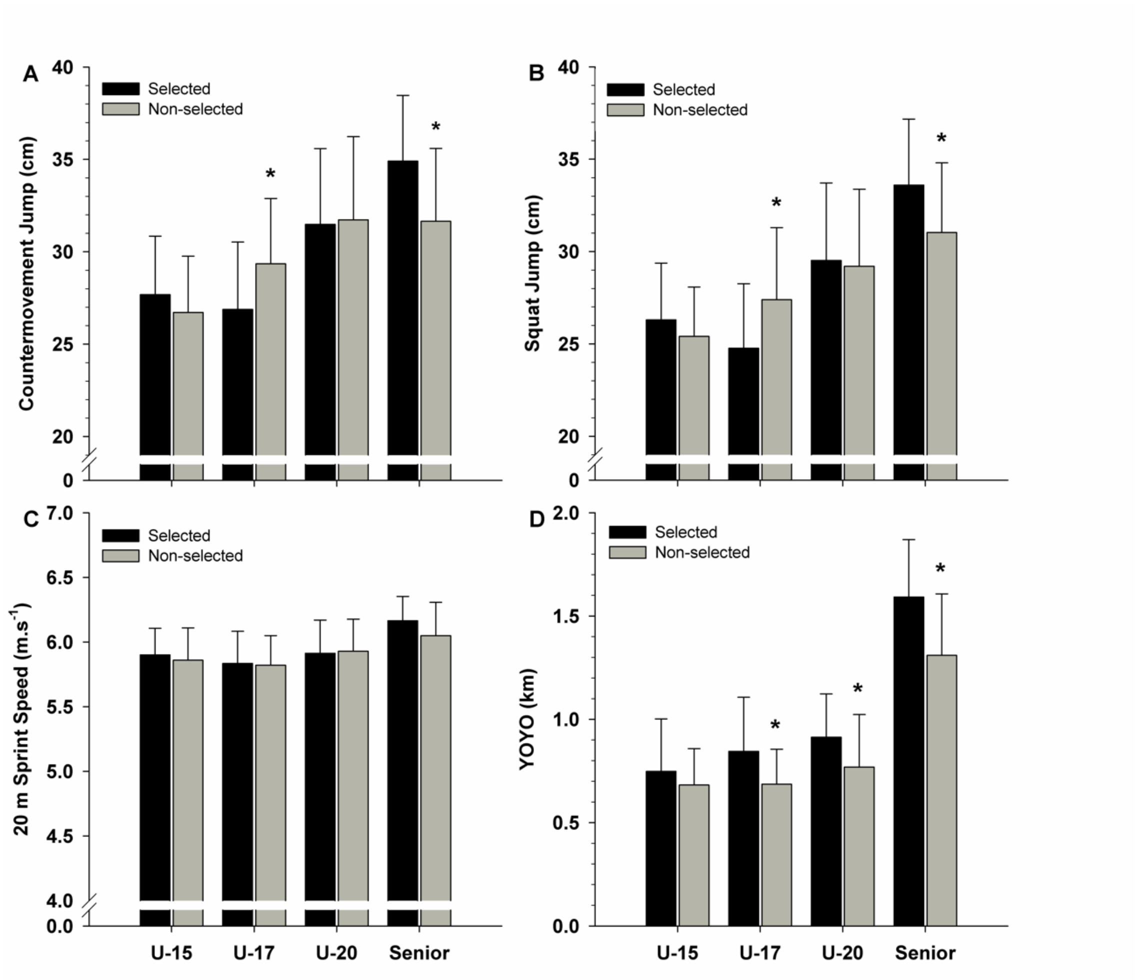

Figure 2. Countermovement jump (A) and squat jump (B), 20 m linear sprint speed (C) and total distance covered in Yo-Yo IR1 (D) test in age categories and for selected and non-selected athletes. * difference between selected and non-selected for same categories

Discussion

The primary purpose of this study was to compare anthropometric parameters and physical performance of female soccer players from different age categories. The secondary purpose was to examine if players selected for participating in an international tournament can evidence differences in physical performances from those not selected to compete for the national team. In general, the U15 and U17 players did not display significant differences in the vertical jump, sprint and specific endurance capacities between each other. However, except for the 20-m sprint, U20 player were better than the younger players in all other tests. Furthermore, the senior players presented superior performance than the younger categories in all tests (excepting the CMJ, in which no difference was detected in comparison to U20).

In respect of player selection, the major finding of this study was the consistently greater distance covered in Yo-Yo IR1 test in U17, U20 and senior selected compared to the non-selected players. These differences were not observed for U15 players. Moreover, selection distinguished jump performances, with selected players jumping higher and lower than non-selected players for senior and U17 categories, respectively.

Our results showed that female player's vertical jump performance discriminate age categories. These results are in accordance with Castagna *et al*. (9), that detected large competitive level effect across female age categories for the SJ and CMJ performances. Similar results were also verified in male players from youth to older teams (17). However, our results are different from those of Vescovi et al (44) that verified improvements in CMJ performance until 17 years old with no further increase in performance until 21 years old players.

Long term athletic development research has demonstrated that an individual will improve physical qualities as they develop through biological maturity (29,39,44), while when a female athlete reach near complete biological maturation around U17 age these biological changes slow down. Therefore, after biological maturation is achieved, a female athlete's ability to continue to improve their physical qualities will be determined by their adaptations to training. One possible reason for the higher jump height between senior and U20 to younger athletes could be the types of training performed by the older groups group. Most U20 players in the national team are part of professional local teams for state and national tournaments, which may undergo higher training and match loads than younger players.

Furthermore, as power is a function of force and velocity, and force is well related to muscle mass (15), the increase in muscle mass (i.e., muscle cross sectional area) can be a significant contributor to the increase in force and power production towards youth to adulthood (i.e., 13-18 years old) (24). Moreover, it also has been reported that increases in stiffness of the musculotendinous unit (28) likewise contribute to developmental changes in jumping performance. However, methods for precise measurement of muscle mass and muscle stiffness were not applied in this study and we encourage future investigations to implement these measurements techniques to deeply investigate physiological mechanisms related to the performance changes in female soccer players over a range of age groups.

It is interesting to note that for SJ, Senior group was significantly greater compared with all younger athletes. Beyond the scope of this study, analyzing senior athletes CMJ and SJ performances it is possible to note that these athletes group presented less differences in reactive strength (calculated as CMJ - SJ height) than U20 players. Considering that comparisons between CMJ and SJ height performances investigate muscle stretching and shortening cycle and involves many complex interactions of neural and mechanical processes (3,4), researchers suggest that a large difference between CMJ and SJ could be expected in subjects that develop force slowly (3) and small difference is expected in subjects who build up force quickly (3). In regard of these mechanisms it could be an explanation why differences between senior and

U20 athletes were observed only in SJ technique and support the better sprint performance in senior athletes than younger age brackets. Therefore, it may be prudent for the U20 players to focus on activities that promote rate of force development (3).

Beside this, the best performance in SJ in senior athletes could also be attributed to the player's level, as in this study senior players appeared to have a relatively better SJ performance when compared to previous studies involving national female soccer players (9,35,38).

Our results somewhat agree with those reported by Vescovi *et al*. (44) who found a plateau in sprint speed performed through 18.2 m, a similar distance to the present study, for female soccer athletes older than 14 years old in. In our study, 20-m sprint speed was not different among U15, U17 and U20 players. However, our senior athletes were faster than the younger players, which it differs from Mujika *et al*. (35) that did not find differences in the 15-m sprint between junior (17.3 ± 1.6 years) and senior (23.1 ± 2.9 years) females, and attributed this lack of difference to the level of the players (elite junior vs. professional senior players). This difference between studies could reflect the "selective pressure" and training process of playing in the very competitive senior team and is consistent with superior match distance in sprint speed observed in national team players "top class" compared to "high level" (professional female soccer players) (33).

Although sprint improvements with training are small in professional players (23), gains of up to 0.8 m in a 10 m sprint for Champions League players have been reported (20), showing a possibility to observe higher sprint physical capacity even in highly trained players. Furthermore, these results underlie that the technical staffs should focus on more effective monitoring and training strategies that could promote a more constant and progressive sprint speed development across the age categories, especially because the ability to sprint has been highlighted as a key physical capacity in the contemporary soccer (12).

In this study, the differences in Yo-Yo IR1 performance observed among age brackets with greater maximal distance covered in Yo-Yo IR1 by senior and U20 players compared to younger age categories are different from maturational studies with non-athlete's girls presenting a stabilization in maximal aerobic capacity (VO_{2max}) after 13-17 years old, with even a decrease in maximal aerobic capacity relative to body mass after sexual maturation (2). However, during growth body mass increases at a greater rate than peak VO_2 and comparative studies expressing peak VO_2 in ratio with body mass favor children and have confused results during growth and maturation (45). When body mass was controlled, girls' peak VO_2 increases from childhood to mid-teens, shows no observable decline into young adulthood (46) and in soccer athletes population an increase in VO_{2max} after initial adulthood to professionalism was also previously observed (18).

In fact, Haugen et al (18) presented that senior female players had 10% higher VO_{2max} than juniors and Mujika et al (35) reported better Yo-Yo IR1 performance for seniors than juniors in a Spanish women's first-division club.

Studies using laboratory VO_{2max} assessments have also found improvements pre- and post- training (10,19) and among different age categories and players levels (18). Helgerud *et al.* (19) and Chamari *et al.* (10) found that soccer player's VO_{2max} improved by 9.6% and 7.5% respectively, after an 8- week aerobic interval training program and Haugen et al (18), presented that senior female players had 10% higher VO_{2max} than juniors. In the current study, Yo-Yo IR1 performance in senior players was almost 45%

higher than in U20 players, which presents higher rates of improvements that previously reported studies measuring maximal aerobic capacity (30). Besides previous researches demonstrates high associations with VO_{2max} and Yo-Yo IRTL1 performance variables for both elite and sub-elite soccer players (r= 0.76-0.73, p<0.01) (22) it seems that Yo-Yo test have greater sensitivity to intervention training and level of player competition than VO_{2max} laboratory tests.

In fact, Krustrup and Bangsbo (25) reported a 23% increase in high intensity work during matches was associated with a 31% increase in Yo-Yo IRTL1 following a 12-week intervention in professional players. Furthermore, Krustrup *et al*. (27) reported that Yo-Yo IRTL1 significantly correlated with the amount of high intensity running performed in the last 5 minutes at the end of each half, the total distance covered and the total amount of high intensity running distance in a soccer match and showing significant correlations with key soccer specific variables (7,26).

In the present study, the almost 45% higher performance observed in Yo-Yo IR-1 distance in senior compared to U20 players was a non-expected result and in part could be attributed to the smaller sample size for senior players that already represents a more specialized group in charge with “selective pressure” of playing in the very competitive senior level. Furthermore, considering Brazilian National senior women’s team and its level in international competitions and FIFA ranking, in this sample only the very best female athletes tended to be part of the senior team.

The within category comparisons in the present study showed that Yo-Yo IR1 test performance presented differences among selected and non -selected players in almost all age brackets evaluated. To our knowledge, this is the first study to report results from a widely used aerobic soccer field test (Yo-Yo IR1 test) among national female soccer players across all FIFA age brackets with specific comparisons between selected and non -selected athletes to compete in international tournaments. Our results agree with previous reports showing that selected U-17, U-20 and Senior players from New Zeland female soccer national team presents respectively 4%, 6% and 7.5% higher maximal aerobic velocity than non -selected players in Buchheit's $30{:}15_{IRT}$ test (8).

In our study, larger ES's (ES from 0.62 to 0.92) were shown for measures between selected and non -selected players in Yo-Yo IR1 test than other physical tests performance with the largest value presented in senior athletes (ES=0.92). The Yo-Yo test is a field based test that estimates maximal aerobic capacity, that presents changes of direction and inter-effort recovery ability, which is more specific to football actions and somehow can have influences of other physical capacities (26). This could justify the greater ES presented in senior selected players as it was the only group also showing better results in SJ and CMJ tests compared to non -selected players.

Beyond these results, regarding a cognitive approach O'Connor *et al.* (36) recently reported that selected male youth soccer players also have better perceptual–cognitive skills in video based tests to measure decision-making performance, compared to the non-selected players (36). The findings suggest that elite youth talent selectors consider multivariate interactions and not just an additive or single factor (36) and reinforces that we cannot disregard the fact that technical, tactical, and cognitive aspects must also be considered within association to physical and match performances for a more holistic player evaluation approach.

In conclusion, these data suggest that there is an increase in physical performance beyond female soccer players age brackets in both jump techniques and Yo-Yo IR1 endurance test through older age categories. Although we consider that player selection is a complex procedure which should take into account a high number of variables, our results demonstrate that Yo-Yo IR1 could discriminate selected and non-selected female players irrespective of the age categories analyzed.

Practical applications

Our results contribute to the literature by providing normative data for coaches, trainers, and clinicians working with elite and international level female soccer players across all FIFA age brackets. Objectively assessment of the female soccer player's physical performance is useful to compare results with the normative data collected and is relevant guiding specific conditioning training activities that develop players for higher level of physical training. Furthermore, it can also help in monitoring changes in performance over time, which is an important process for strength and conditioning professionals and sport scientist.

In addition, our results demonstrate that a field test measure of aerobic capacity (Yo-Yo IR1) could discriminate selected and non-selected female soccer players in different age bracket. These findings suggest that enhancing these physical qualities can be crucial for improving the likelihood of selection into female soccer national teams. Since aerobic and anaerobic performance can all be important to soccer performance, methods aiming to improve both these physical capacities should be used considerably to enhance performance in players.

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Estudo 2. Desempenho físico em partidas oficiais de futebol feminino das seleções brasileiras sub-17, sub-20 e sênior durante competições internacionais: Existem diferenças significativas?

Activity profiles of U17, U20 and senior women's Brazilian National soccer teams during international competitions: Are there meaningful differences?

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ORIGINAL RESEARCH

Activity profiles in U17, U20 and senior women's Brazilian National soccer teams during international competitions: Are there meaningful differences?

Match activity of top-level female soccer players

Authors:

GUILHERME P. RAMOS[1,2], FÁBIO Y. NAKAMURA[3,4], EDUARDO M. PENNA[1,5], LUCAS A. PEREIRA[3], IRINEU LOTURCO[3], LUCIANO CAPELLI[2], FÁBIO MAHSEREDJIAN[2], EMERSON SILAMI-GARCIA[6], CÂNDIDO C. COIMBRA[7]

[1]Federal University of Minas Gerais. School of Physical Education, Physiotherapy and Occupational Therapy, Belo Horizonte, MG, Brazil.

[2]Brazilian National Football Confederation (CBF). Rio de Janeiro, RJ, Brazil.

[3]NAR. Nucleus of High Performance in Sport, São Paulo, SP, Brazil.

[4]The College of Healthcare Sciences, James Cook University, Queensland, Australia

[5]Federal University of Pará, Castanhal, PA, Brazil

[6]Federal University of Maranhão, São Luiz, MA, Brazil

[7]Federal University of Minas Gerais. Institute of Biological Sciences, Belo Horizonte, MG, Brazil.

Abstract

The aim of this study was to compare locomotor activity profiles of Brazilian top-class female soccer players competing at distinct age brackets (U17, U20, and Senior). External match load of 14 U17, 14 U20, and 17 Senior female soccer players competing in full 6-7 official international matches were assessed using global positioning system (GPS). Total distance covered, distance covered in high intensity (HID:15.6-20 $km \cdot h^{-1}$), distance covered in sprints (sprint:>20 $km \cdot h^{-1}$), number of accelerations (Acc)>1 $m \cdot s^{-2}$, decelerations (Dec) >-1 $m \cdot s^{-2}$, and Player Load® generally increased across the age brackets (U17<U20<Senior). For all playing positions, Senior athletes presented greater total distance, accelerations, and decelerations than U20 players. For high-intensity distance and sprints, only central defender and midfielder senior players presented greater values than U20. Senior players demonstrated higher values in all locomotor activities in comparison to U17 players, irrespective of playing positions. Except for central defenders that presented similar total distance, sprint distance, and number of accelerations between U20 and U17, the majority of match external loads evaluated in all playing positions were greater in U20 than in U17 players. These results provide useful information for player development and should be used to establish appropriate match-specific conditioning drills according to age categories.

Key words: Time-motion, football, female athletes, fitness.

Introduction

Scientific interest in women's soccer has increased during the last few years (15). One of the topics attracting more attention in the literature relates to match analysis of locomotor activities performed across different velocity bands (especially at high-intensity) that, to a great extent, reflect the physical demands of competition. Several contextual factors (e.g., team formation and match status) (12) influence the player's work rate during the game; nonetheless, fitness level (24) and playing standard (30) have been considered of great relevance. For instance, Mohr *et al.* (30) compared top-class and high-level female soccer players during competitive matches and showed that the former accumulated longer high-intensity running and sprinting distances, indicating that competitive level is an intervening factor of physical performance. Furthermore, international competitions demanded more repeated-sprint bouts than national-league competitions in elite women Australian soccer players (16). However, the competitive demand differences between age categories in players competing at top-level (i.e., top-ranked National teams during international tournaments) is still a critical gap in the current knowledge. Highlighting meaningful performance dissimilarities would support technical staff responsible for prospective training plans in choosing appropriate and age-specific physical training strategies to optimize players' ability to cope with current women's competition requirements. Additionally, description of current match physical performance would be helpful in establishing standards for comparisons with upcoming evolutions in player kinematics (5).

More recently, a great effort has been made to increase the knowledge related to match physical demands in different team sports due to the possibility of quantifying acceleration/deceleration actions (i.e., changes in velocity), which are calculated via the change in location as measured by the global positioning system

(GPS), and Player Load (i.e., sum of all accelerations performed in the three axes of movement: *x, y,* and *z*; measured by the GPS-embedded accelerometer) (14). When analyzing solely the "traditional" movement patterns (i.e., distance covered in different velocity bands), a great deal of the energetic demand is neglected due to the inability of this type of analysis to detect some high-intensity short actions (33). For instance, Aughey (2) , demonstrated that the number of maximal accelerations is much higher than the number of maximal sprints performed during an Australian rules football match (2). Accordingly, a more detailed analysis of acceleration profiles in elite female soccer matches is necessary due to the high energetic demand and muscle power requirement related to this specific locomotor activity (33).

To date, one previous study (38) evidenced some activity profile differences among female U15, U16, and U17 age brackets competing at national championships. The U15 players presented lower total distance and distances covered across several velocity bands (jogging, moderate speed, and sprinting) than U16 and U17 players. It is still unknown whether and to what extent locomotor activities evolve after the U17 bracket in female players, especially in athletes involved in international competitions and representing their respective age-specific National teams.

Therefore, we aimed to compare the distances covered by top-class female soccer players pertaining to the Brazilian National teams in the U17, U20, and Senior categories during their participation in international tournament matches. Furthermore, owing to the recent interest in the acceleration/deceleration and Player Load profiles of soccer players during official matches (14,35), we also compared these variables among the three different age categories. The working hypothesis was that there would be a progressive increase in high-intensity activities across the age categories due to maturation and, principally, the players' strict commitment to prospective training programs involving soccer-specific fitness development.

Methods

Experimental approach to the problem

A prospective and observational, between-group, study was conducted to characterize and compare the game activity profiles of Brazilian National female soccer teams of different age brackets (under 17, under 20 and Senior players), during official international competitions. Comparisons involved GPS derived variables, including distances ran at different speed ranges, including high-intensity activities, accelerations and decelerations and Player Load. The age brackets and playing positions were considered independent variables, while physical performance indices during the matches were considered the dependent variables.

Subjects

Fourteen under 17 (U17: 15.6 ± 0.5 years, 164.6 ± 6.4cm, 58.0 ± 4.3 kg and 14.0 ± 1.9 % fat), 14 under 20 (U20: 18.1 ± 0.8 years, 165.9 ± 6.8 cm, 59.9 ± 6.2 kg and 14.0± 2.2 % fat), and 17 seniors (Senior: 27 ± 4.5 years, 186.9 ± 4.8 cm, 60.7 ± 4.5kg and 13.0 ± 2.0% fat) players from the respective age-specific female Brazilian National teams participated in the study. Data were collected during the 2015 South American Championship in Brazil for the U20 team and during the 2016 South American Championship in Venezuela for the U17 team, in which the former investigated team was the winner and the latter finished in 2nd place, respectively. Senior group data were obtained during the Rio 2016 Olympic Games in which the team finished in 4th place. While approval to conduct, the study was granted by the Brazilian Football

Confederation and an Institutional Ethics Committee, the present data arose as a condition of playing for the National team in which players are routinely monitored over the course of a tournament (32). Therefore, because of the *a posteriori* nature of the analyses, signature of the informed consent form was not required; nevertheless, to ensure player confidentiality, all physical performance data were anonymized before analyses.

Procedures

Game movement pattern data were obtained from a total of 7 official matches in youth groups and 6 matches during the Olympic Games, players only being included in the analysis if they completed the entire 90-min of each match. This resulted in 43 player-games for the U17 group (7 for central defenders [CD]; 10 for full-backs [FB]; 17 for midfielders [MD]; and 9 for forwards [FW]), 54 player-games for the U20 group (7 for CD; 10 for FB; 26 for MD; and 11 for FW), and 47 player-games for the Senior group (13 for CD; 8 for FB; 9 for MD; and 17 for FW). All matches were held on outdoor pitches with official dimensions (i.e., 100 × 75 m). GPS units were switched on prior to the warm-up to enable the devices to locate the necessary satellites and the units were fitted to the players' backs (between the shoulder blades) prior to each match.

Match analysis

Match physical activity profiles were obtained using GPS units operating at 10 Hz (MinimaxX GPS units; Team S5, Catapult Innovations, Melbourne, Australia). The GPS contained a tri-axial accelerometer system (100 Hz) which was used to quantify tri-axial body accelerations (Player Load®). Units were fitted to the upper back of each player using an adjustable neoprene harness and were switched on 60 min prior to match commencement. This procedure allowed the connection and acquisition of >12 satellites and horizontal dilution of precision (HDOP) not greater than 1.0 (27). More specifically, the average number of satellites and HDOP (mean ±SD) during match data collection were 12.4 ± 0.5 (range 12 - 15) and 0.75 ± 0.3 (range 0.5 - 1.0), respectively. In addition, the same unit was used by each player in all matches to reduce inter-unit measurement error. Openfield™ software was used to data acquisition which filters the raw GPS velocity data using an exponential filter and GPS acceleration are derived from GPS using the 0.2 s time interval that is fixed within the software data and then filtered further using an exponential filter. For both measurements of acceleration and velocity data acquisition time was fixed at 0.5 sec (Dwell dwell time). The velocity and linear acceleration/deceleration categories were defined based on a previous study in female soccer players (38). Therefore, the match activities were divided into the following categories: total distance covered (TD), distance covered in high-intensity (HID: 15.6-20 $km \cdot h^{-1}$), distance covered in sprints (sprint: >20 $km \cdot h^{-1}$), and number of accelerations (Acc) >1 $m \cdot s^{-2}$ and decelerations (Dec) >-1 $m \cdot s^{-2}$. The validity and reliability of the GPS units used have been extensively reported (37).

The accumulated acceleration data from all three axes (anterior-posterior [front to back], medio-lateral [side to side], and cranio-caudal [up and down]) were integrated to formulate the acceleration vector magnitude. The manufacturers of the MinimaxX accelerometers name this parameter Player Load® (PL). The reliability of the PL measure has been previously reported (CV = 1.6 %) (9).

Statistical analysis

Data are presented as mean ± standard deviation. Due to the large inter-individual variability in all dependent variables of this study, data were log-transformed for the analysis and then back-transformed to facilitate its presentation and interpretation in the results section. The magnitude-based inference (8) method was used to compare the locomotor variables among the three different age categories. The quantitative chances of finding differences in the variables tested among the three different age categories were assessed qualitatively as follows: <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%, almost certain. If the chances of having better and poorer results were both >5%, the true difference was assessed as unclear. A *likely* difference (>75%) was considered as the minimum threshold to detect meaningful differences due to the lower probability of an error occurring in this range of probabilities to find positive/negative effects (19). The magnitudes of the differences for the comparisons across all variables were analyzed using the standardized differences based on Cohen's *d* effect sizes (ES) (13). 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 (20). To be interpreted as meaningful, besides the qualitative change >75%, the associated ES of the difference should be >0.2.

Results

The standardized differences of the match physical activities among the three age categories are displayed in figure 1. *Likely* to *almost certainly* differences among all age brackets for the TD, HID, sprint, number of Acc and Dec, and PL were found (Senior > U20 > U17, ES varying from 0.41 [-0.23- 1.06] to 3.69 [2.63- 4.76]), except for the comparison between U17 and U20 for sprint and between senior and U20 for PL, where the differences were rated as *unclear*.

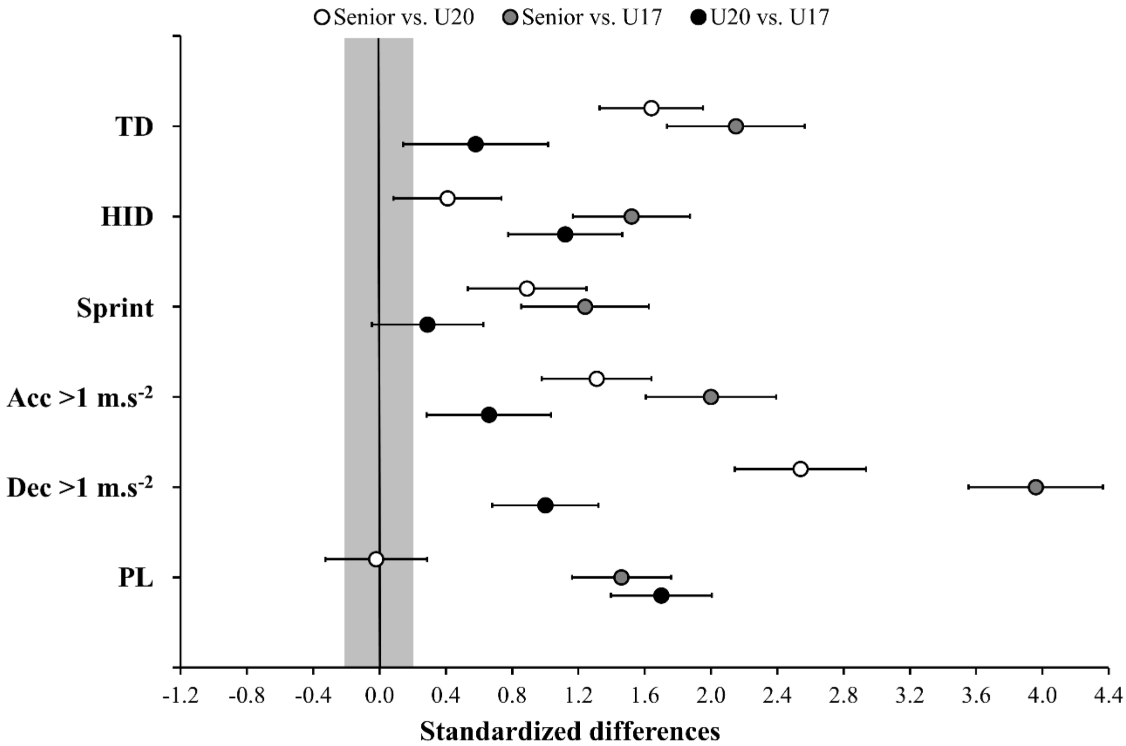

Figure 1. Standardized differences of the match physical activities between the three age categories of top-level female soccer players. TD = total distance; HID: highintensity distance; Sprint: sprint distance; Acc: accerelerations > 1 m.s-1; Dec: decelerations -1 m.s-1; PL = Player Load^{TM}. Error bars represent the 90% confidence interval

Table 1 shows the TD, HID, and sprint among the three distinct age categories for the different playing positions. Senior players presented *likely* to *almost certainly* higher values of TD, HID, and sprint than U20 for CD and MD (ES varying from 0.75 [0.06- 1.44] to 2.04 [1.42- 2.66] and 1.14 [0.52- 1.76] to 1.92 [1.28- 2.56], for CD and MD, respectively). The FB and FW Senior players covered *very likely* to *almost certainly* higher TD than their U20 counterparts (ES = 1.63 [0.95- 2.32] and 0.82 [0.35- 1.29] for FB and FW, respectively). In addition, the Senior players demonstrated *likely* to *almost certainly* higher values in all locomotor activities presented in table 1 in comparison to U17 players in all playing positions (ES varying from 0.88 [-0.15- 1.91] to 2.77 [2.04- 3.50] for CD, 0.90 [0.09- 1.71] to 2.46 [1.55- 3.37] for FB, 1.62 [0.97-

2.26] to 1.94 [1.29- 2.59] for MD, and 1.07 [-0.01- 2.13] to 2.17 [1.20- 3.15] for FW). Finally, U20 players presented *likely* to *almost certainly* differences for TD, HID, and sprint in comparison to U17 in the different playing positions, excepting TD in the CD and MD, and sprint in the CD, where the differences were rated as *unclear* (ES = 2.26 [1.39- 3.13] for HID in the CD; ES varying from 0.73 [-0.16- 1.63] to 2.74 [1.35- 4.13] for FB, ES = 1.25 [0.68- 1.81] and 0.80 [0.22- 1.37] for HID and sprint in the MD, and ES varying from 0.83 [0.02- 1.63] to 2.32 [0.70- 3.95] for FW).

Table 1. Mean (± SD) of the total distance (TD), high-intensity distance (HIR), and sprint distance for the different playing positions among the three age categories of elite female soccer players.

	Playing position	Senior	U20	U17	Senior vs. U20 ES [90% CI]	Senior vs. U17 ES [90% CI]	U20 vs. U17 ES [90% CI]
TD (m)	CD	10003.4 ± 954.0	8201.6 ± 513.6*	7898.9 ± 887.8*	2.04 [1.42; 2.66] *very large*	2.47 [1.63; 3.31] *very large*	0.58 [-0.55; 1.70] *small*
	FB	10237.8 ± 665.1	9072.7 ± 474.5*	8574.7 ± 996.1*#	1.63 [0.95; 2.32] *large*	2.46 [1.55; 3.37] *very large*	1.07 [-0.01; 2.13] *moderate*
	MD	10376.5 ± 981.0	8486.3 ± 702.8*	8545.7 ± 1259.5*	1.92 [1.28; 2.56] *large*	1.91 [1.19; 2.63] *large*	0.01 [-0.65; 0.63] *trivial*
	FW	9825.1 ± 894.2	9055.8 ± 459.7*	8062.3 ± 1407.4*#	0.82 [0.35; 1.29] *moderate*	2.17 [1.20; 3.15] *very large*	2.32 [0.70; 3.95] *very large*
HIR (m)	CD	590.2 ± 103.6	508.8 ± 75.8*	347.9 ± 61.2*#	0.75 [0.06; 1.44] *moderate*	2.77 [2.04; 3.50] *very large*	2.26 [1.39; 3.13] *very large*
	FB	840.1 ± 137.4	859.4 ± 99.1	636.9 ± 226.2*#	0.16 [-0.51; 0.82] *trivial*	1.77 [0.72; 2.82] *large*	2.74 [1.35; 4.13] *very large*
	MD	810.6 ± 207.0	552.4 ± 113.4*	433.8 ± 117.2*#	1.14 [0.52; 1.76] *moderate*	1.94 [1.29; 2.59] *large*	1.25 [0.68; 1.81] *large*
	FW	782.6 ± 250.5	829.8 ± 191.4	520.1 ± 243.0*#	0.23 [-0.31; 0.77] *small*	1.26 [0.58; 1.94] *large*	1.87 [1.02; 2.73] *large*
Sprint (m)	CD	198.8 ± 90.5	113.1 ± 44.1*	138.9 ± 85.0*	1.06 [0.20; 1.91] *moderate*	0.88 [-0.15; 1.91] *moderate*	0.15 [-0.80; 1.09] *trivial*
	FB	379.3 ± 119.4	331.1 ± 94.4	282.8 ± 143.3*#	0.31 [-0.38; 1.00] *small*	0.90 [0.09; 1.71] *moderate*	0.73 [-0.16; 1.63] *moderate*
	MD	298.5 ± 142.0	125.8 ± 47.9*	96.0 ± 46.1*#	1.14 [0.52; 1.76] *moderate*	1.62 [0.97; 2.26] *large*	0.80 [0.22; 1.37] *moderate*
	FW	351.7 ± 124.6	323.1 ± 110.7	247.8 ± 143.3*#	0.20 [-0.43; 0.84] *small*	1.07 [0.28; 1.85] *moderate*	0.83 [0.02; 1.63] *moderate*

Note: CD: central defenders; FB: full-backs; MD: midfielders; FW: forwards; ES: standardized differences based on effect sizes; CI: confidence interval. *Meaningful difference from senior; #meaningful difference from U20.

Table 2 presents the comparisons of the number of Acc and Dec, and the PL among the three different age categories for the distinct playing positions. Except for the comparison of the PL between Senior and U20 players in the CD and FB, where the difference was rated as *unclear*, Senior players demonstrated *likely* to *almost certainly* differences in the analyzed variables in comparison to U20 and U17 players in all playing positions (ES varying from 0.30 [-0.68- 1.28] to 4.04 [3.33- 4.75] for the comparison with U20, and ES varying from 0.39 [-0.31- 1.10] to 5.57 [4.87- 6.28] for the comparison with U17). Excepting the comparison in the number of Acc between U20 and U17 in the CD and FB, where the difference was rated as *unclear*, U20 players demonstrated *likely* to *almost certainly* higher values of Acc, Dec, and PL than the U17 in all playing positions (ES varying from 0.70 [0.07- 1.34] to 3.69 [2.63- 4.76]).

Table 2. Mean (± SD) of the number of accelerations (Acc) and decelerations (Dec), and player load (PL) for the different playing positions among the three age categories of elite female soccer players.

	Playing position	**Senior**	**U20**	**U17**	**Senior vs. U20 ES [90% CI]**	**Senior vs. U17 ES [90% CI]**	**U20 vs. U17 ES [90% CI]**
Acc > 1 m.s^{-2}	CD	217.6 ± 22.4	172.0 ± 10.2*	165.0 ± 21.5*	2.13 [1.56; 2.70] *very large*	2.56 [1.70; 3.43] *very large*	0.71 [-0.65; 2.07] *moderate*
	FB	213.8 ± 34.9	196.8 ± 19.4	199.0 ± 31.8	0.41 [-0.23; 1.06] *small*	0.39 [-0.31; 1.10] *small*	0.03 [-0.82; 0.89] *trivial*
	MD	213.6 ± 16.9	172.0 ± 18.8*	149.7 ± 16.8*#	2.52 [1.83; 3.22] *very large*	4.12 [3.41; 4.84] *nearly perfect*	1.23 [0.76; 1.69] *large*
	FW	209.5 ± 29.4	192.5 ± 29.7*	167.5 ± 34.6*#	0.59 [-0.11; 1.28] *small*	1.58 [0.80; 2.36] *large*	0.83 [0.09; 1.56] *moderate*
Dec > 1 m.s^{-2}	CD	161.1 ± 19.0	108.0 ± 14.0*	85.8 ± 14.9*#	3.37 [2.48; 4.26] *very large*	5.36 [4.32; 6.41] *nearly perfect*	1.57 [0.64; 2.50] *large*
	FB	181.9 ± 23.1	137.7 ± 21.2*	122.0 ± 16.3*#	1.96 [1.15; 2.77] *large*	2.79 [2.07; 3.50] *very large*	0.70 [0.07; 1.34] *moderate*
	MD	178.0 ± 18.8	111.0 ± 16.7*	92.5 ± 13.7*#	4.04 [3.33; 4.75] *nearly perfect*	5.57 [4.87; 6.28] *nearly perfect*	1.11 [0.67; 1.56] *moderate*
	FW	176.1 ± 26.9	145.5 ± 24.7*	105.5 ± 26.9*#	1.15 [0.50; 1.79] *moderate*	3.16 [2.37; 3.95] *very large*	1.87 [1.07; 2.67] *large*
PL (a.u.)	CD	892.2 ± 93.8	866.3 ± 132.2	743.6 ± 66.3*#	0.30 [-0.68; 1.28] *small*	1.62 [0.95; 2.29] *large*	0.93 [0.24; 1.63] *moderate*
	FB	1033.2 ± 92.5	987.9 ± 60.9	780.5 ± 48.2*#	0.44 [-0.23; 1.11] *small*	2.83 [2.19; 3.47] *very large*	3.37 [2.72; 4.03] *very large*
	MD	1011.7 ± 98.5	930.7 ± 130.6*	789.3 ± 62.3*#	0.80 [0.10; 1.50] *moderate*	2.23 [1.60; 2.86] *very large*	1.09 [0.71; 1.46] *moderate*
	FW	893.6 ± 145.1	952.0 ± 78.5*	691.6 ± 120.6*#	0.42 [-0.03; 0.88] *small*	1.50 [0.88; 2.13] *large*	3.69 [2.63; 4.76] *very large*

Note: CD: central defenders; FB: full-backs; MD: midfielders; FW: forwards; ES: standardized differences based on effect sizes; CI: confidence interval. *Meaningful difference from senior; #meaningful difference from U20.

Discussion

This study aimed to compare the locomotor activity profiles of top-level U17, U20, and Senior players from the Brazilian National women's teams competing in international tournaments. As expected, there was a general trend to a progressive increase in TD, high-intensity activities (e.g., high speed running and sprints) and total number of acceleration and deceleration (i.e., >1.0 $m.s^{-2}$ and >-1.0 $m.s^{-2}$, respectively) across the age categories, supporting the notion that training practices need to target increments in soccer-specific fitness components as the players become older.

The TD covered by the Senior players was *almost certainly* greater than attained by the U17 and U20 players, respectively. In the same way, an *almost certainly* difference in HID was found between Senior and U17, and between U20 and U17. We did not find any study comparing the activity profiles of players encompassing the age categories investigated herein (U17, U20 and senior) during official matches in female soccer.

However, the differences observed in TD and HID found in our study are in accordance with previous studies that investigated only youth (39) or only professional female players (30). Vescovi *et al.* (39) showed that U17 players performed higher TD and HID than younger players (e.g., U15) and Mohr *et al.* (30) showed high values of the same parameters for top-level than high-level female soccer players.

In addition, the differences found among the age categories in TD and HID are consistent with an increase in aerobic test performance with age reported in the literature, such as the Yo-Yo Intermittent Recovery Test, level 2 (Yo-Yo IR2) (10), 30-15 Intermittent Fitness Test ($30\text{-}15_{IFT}$) (28) and Yo-Yo Intermittent Recovery Test, level 1 (Yo-Yo IR1) (unpublished observations of our research group). Notably, the performance in intermittent physical tests (e.g., Yo-Yo IR1) were previously shown to be significantly correlated to match TD and HID in male (23) and female (24) soccer athletes.

Our findings are also consistent with the results described by Bangsbo *et al.* (3) showing that 15-16 year old players presented poorer performance in the Yo-Yo IR1 than 17-18 year old players pertaining to the New Zealand National teams. However, in their case, >18 year old players did not display further improvement in the Yo-Yo IR1 compared to the 17-18 year old players. In contrast, larger distances covered in Yo-Yo IR2 were found for senior compared to U20 elite European players (10). Similar results were also found in Brazilian National players, as the Senior athletes presented the better performance in the Yo-Yo IR1 test when compared to the immediately younger age bracket (unpublished observations). These results similarities can be attributed to the high competitive level of the players investigated by Bradley et al (10), who played for two National teams on the top 12 FIFA women's world rankings and competed in the UEFA Champion's League, and the players of the Brazilian National Senior team (top 10 in 2015; 4th place in the 2016 Olympic Games) compared to the New Zealand team (top 20).

Besides this, different training background and long-term player development processes can also play a role, since players involved in the National teams follow training programs designed to improve not only their technical-tactical skills, but also their physical capacities in order to cope with the progressive demands placed as they become older. In Spain, for example, Mujika *et al.* (31) evidenced significantly better Yo-Yo IR1 in Senior females (23.1 ± 2.9 years) compared to Junior females (17.3 ± 1.6 years). Comparative studies among nations placed in distinct FIFA ranking positions concerning fitness levels and motion characteristics are necessary in the future to elucidate their respective influences on competitive results at the top-level. Nonetheless, it appears that aerobic fitness level is one of the most likely explanations for the evolution of TD and HID observed during matches from the U17 bracket to the adulthood.

Interestingly, in most intra-playing position comparisons, the senior players covered greater HID than the younger players (Senior > U20 > U17). The only exceptions were for FB and FW when comparing Senior vs. U20 where the differences were all rated as *unclear*. Of note, these two playing positions presented lower percentage changes in HID from the U17 to the Senior age brackets (31.9 and 50.5%, respectively) than the other positions. Central defenders and MD presented notably high differences between U17 and Seniors (69.6 and 86.9%, respectively). This means that, besides discriminating playing standards (e.g., international vs. national levels), the ability to engage in high-intensity activities during the match can also differentiate between age categories in women's top-class soccer. Hence, prospective players are required to substantially improve physical fitness components related to the ability to engage in repeated high-intensity efforts with low signs of fatigue (24).

A further practical implication of our findings is that the possibility of designating a younger player in the Senior team needs to be carefully examined. It is not an uncommon practice, heavily based on technical considerations. However, if the player does not demonstrate physical conditions to adhere to the tactical scheme proposed by the coach, the potential technical advantage could be lost. With these aspects in mind, we can lend support to the use of tracking technology (e.g., GPS) during soccer matches and training in order to facilitate decision making about the adequacy of a player to the team formation.

Senior players performed *largely* and *moderately* longer distances in the sprinting locomotor category than U17 and U20 athletes, respectively. This increase in the sprint distance during the matches across the investigated youth age categories is in agreement a previous study that demonstrated almost 200% increase in sprint distance from 15 to 17 years old players (39). Previous studies have also found an increase in performance in 5x10 m sprint test with changes of direction from 12 to 16 years old female soccer players (18) and in 36.6 m sprint speed field test in female soccer players from 12 to 20 years of age (40).

These different results between Senior and U17 players is in line with maturational factors involved in 13-16 years old female, as before 17 years old female athletes could not reach full biological maturation, especially in lower limb strength capacity (25), which may justify sprinting ability differences. Although maturation might not explain the differences found in sprint distance covered between senior and U20 players in this study, it is important to highlight that the ability to repeat sprints and high-intensity runs is also related to aerobic performance (36), which can be developed with well-designed training.

Furthermore, higher distance covered in the sprinting category from U20 to Senior transition is consistent with the differences between top-class" (senior National team players) and high level (professional female soccer players) players as previously noted by Mohr *et al.* (30). More specifically, Mohr *et al.* (30) showed that National team players covered more distance sprinting than professionals. This is consistent with the differences observed in the present study, since most of our U20 players (18-19 years) were professionals competing at the Brazilian National Championship, but without taking part of the senior National squad. Once again, this could reflect the "selective pressure" of playing in the very competitive senior team or the training practices implemented with adults in comparison with youth players in the investigated National team.

Of interest, the intra-position comparisons revealed that sprint distances differed from 34.1% in FB to 210.9% in MD between U17 and Seniors. The differences could have been inflated in all player positions by the use of a fixed speed threshold (20 $km{\cdot}h^{-1}$) to define a sprint, possibly favoring the faster (i.e., older) players (32). The use of individualized speed zones based on specific physical fitness (e.g., anaerobic threshold; (22) and/or performance characteristics (e.g., maximal sprint speed (29) has some advantages as the locomotor profile will be representative of specific player status. However, a limitation of this approach also exists, considering one specific physical characteristic adopted (i.e. Maximal speed) it assumes that faster players also have a higher transition speeds into all velocity thresholds and maybe with certain linearity, which may not always be the case.

Beyond the scope of this study, future studies using both arbitrary and individualized speed thresholds in comparison should be conducted to properly compare the distances covered in different speed thresholds throughout age brackets. Nonetheless, the results suggest that the ability to repeat sprints needs to be progressively improved in players involved in top-level competitions from the end of adolescence to early adulthood. For instance, U17 players presented more than 3× the sprint distance of U15 players during official matches (38), although, the authors did not cluster the players per role in the field.

Our results showed that, compared to the other positions, MD are required to develop game-related repeat sprint ability more substantially from <17 years to adulthood in order to achieve the physical performance levels required to succeed as a Senior. The most suitable training method to enhance repeated-sprint ability is still debatable; however, it appears that high-intensity interval training (11) with directional changes (unpublished observations) constitutes an effective option for female team sports athletes.

Seniors performed substantially more accelerations and decelerations than U17 and U20 players (*large* to *very large* ESs). In addition, U20 players performed more accelerations and decelerations than U17 (*moderate* to *large* ESs). The brief explosive concentric and eccentric muscle actions related to accelerating and decelerating are associated with a significant increase in the metabolic demands of running during intermittent sports matches (33), compared to constant velocity running. In addition, it has been estimated that typical acceleration and deceleration activities during soccer matches result in an increase of 28% and 65% in the mechanical load per meter covered (14), respectively, and that 18% of total distance covered during a soccer match is performed whilst accelerating and decelerating (1). It appears then that the ability to repeatedly perform these demanding actions is a pre-requisite to successful soccer practice.

Except for accelerations in the FB, players from distinct positions increase the number of accelerations and decelerations episodes across the age categories from U17 to adulthood, evidencing the need to progressively implement drills in which athletes are required to rapidly increase and decrease running velocity over short distances (17) (i.e., repeated-acceleration ability) (4). In addition, plyometric training can be used as an auxiliary method to enhance not only the number of times players engage in accelerations or decelerations but principally muscle power performance during the acceleration phases of sprints (26,34). Importantly, rapid and repeated decelerations following sprints can be one of the main causes of post-match muscle damage (21). It remains to be established whether Senior players are more prone to post-match delayed recovery due to the severity of muscle damage signs than younger players, or if they are well adapted to the increased deceleration loads.

Finally, Seniors (in all playing positions, except for Senior and U20 CD players) presented *large* differences in PL compared to U17 and U20. This might reflect all the aforementioned discussed differences in the distances covered and performance of accelerations and decelerations. Player Load is a reliable (6,7) accelerometry-based measure of the cumulative load on the musculoskeletal system caused by rate of change in acceleration of the body. Our results underlie that older players, due to their higher fitness levels and ability to engage in high-intensity actions, are also able to accumulate more external loads as measured by a tri-axial accelerometer during the matches. Unfortunately, this study is limited by the lack of quantification of discrete movements that could substantially contribute to PL (e.g., collisions, tackling, and unorthodox movements). These kinds of movements may have contributed to the higher PL observed in Senior players.

In conclusion, there is a general increase in external match load demand in Brazilian female soccer players across all FIFA age brackets, with greatest loads observed in senior athletes. In general, these differences were observed irrespective of game specific positions analyzed. This information is relevant for team staff and coaches for discriminating player's standards and especially in situations where young athletes are selected to play in different age categories in female top-level soccer teams.

Practical applications

The findings of this study can tailor training practices in top-level female soccer teams. From our results, it is evident the need to improve the soccer-specific fitness components as the player progresses across the age categories. Since intermittent exercise endurance and repeated-sprint ability are highly correlated with match performance, especially with the ability to perform high-intensity actions, it is highly recommended the frequent assessment of players using field tests and implementation of training strategies aimed to improve these fitness components (e.g., prescribing high-intensity interval training). Central defenders and midfielders are the playing positions demanding higher improvements in the ability to perform high-intensity activity from the U17 to adulthood. Thus, special attention to players from these playing roles needs to be paid in prospective programs in order to allow for achievement of top-level performance. Furthermore, since Senior players perform larger distances sprinting during the matches than the players from younger age categories, it is necessary to progressively implement training methods designed to enhance the lower limb power and speed capacities. This is challenging, owing to the frequent occurrence of interference effect between strength-power and endurance training adaptations.

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Estudo 3. Determinação do padrão de movimentos de jogadoras de futebol durante partidas internacionais.

Movement patterns of a U-20 National female soccer team during competitive matches: Influence of playing position and performance in the first half

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Movement Patterns of a U-20 National Women's Soccer Team during Competitive Matches: Influence of Playing Position and Performance in the First Half

Authors
Guilherme Passos Ramos[1,4,5], Fábio Yuzo Nakamura[2], Lucas Adriano Pereira[3], Wanderley Brilhante Junior[4], Fábio Mahseredjian[5], Carolina Franco Wilke[1], Emerson Silami Garcia[6], Cândido Celso Coimbra[1,7]

Affiliations
1 School of Physical Education, Physiotherapy and Ocupational Therapy, Federal University of Minas Gerais/UFMG, Exercise Physiology Laboratory, Belo Horizonte, Brazil
2 Departamento de Educação Física, Universidade Estadual de Londrina, Londrina, Brazil
3 Nucleus of High Performance in Sport, None, São Paulo, Brazil
4 Confederação Brasileira de Futebol/ CBF, Youth Athletes, Rio de Janeiro, Brazil
5 Brazilian National Football Confederation/CBF, Rio de Janeiro, Brazil
6 Federal University of Maranhão, CAPES/FAPEMA, Maranhão, Brazil
7 Federal University of Minas Gerais, Biological Sciences Institute/ICB, Belo Horizonte, Brazil

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Correspondence
Guilherme Passos Ramos
Confederação Brasileira de Futebol - CBF Departamento de Fisiologia
Rua Hercílio Ferreira dos Santos
Granja Comary
S/N, Teresópolis
Brazil
Tel.: +55/31/988144081, Fax: +55/21/27418518
guilhermepassosramos@gmail.com

ABSTRACT

The aim of this study was to determine the match locomotor characteristics of a sample of U-20 Brazilian female soccer players. Seven i nternational matches were analyzed during the 2015 U-20 South American Championship, using global positioning technology. During a typical match, fullbacks and forwards covered greater distances in high-intensity running and sprint-ing than central defenders and midfielders (effect size [ES] = 1.42–3.69). In the final 15 min of a game, total and high-intensity running distance and player load were ≈ 20 to 35% (ES = 0.41–3.86) lower than in the first 15 min period for mid-fielders, fullbacks, forwards, and central defenders. Sprinting, and high-intensity running distances, and the frequency of accelerations > 2 $m{\cdot}s^{-2}$ immediately after the most intense 5-min period declined in forwards (ES = 1.78–2.67), fullbacks (ES = 1.96–5.25), midfielders (ES = 1.66–3.77), and central de-fenders (ES = 1.50–4.22). Maintaining 'high' levels of activity in the first half resulted in ≈ 19 % reductions in the second half for sprinting distance and frequency of accelerations > 2 $m{\cdot}s^{-2}$ (ES = 0.43 and 0.88), while increases in these locomotor activities were observed in situations with 'low' levels of activity (ES = 0.64 and 1.12, for sprinting and accelerations > 2 $m{\cdot}s^{-2}$, respectively) (within-subject analysis). The data demonstrate that high-intensity efforts are reduced during various phases of international matches and overall activity patterns vary among playing positions. This information could be useful in the development and prescription of sex- and age-specific training regimes.

Introduction

Male soccer players are probably the most prevalent population of athletes investigated in sport sciences. The physical characteristics of these players and match-related physical and physiological loads at different ages and competitive levels have been widely examined in the literature over a long period [11]. On the other hand, female soccer investigations have been increasing at a high rate in recent years [14], resulting in new knowledge about game movement patterns, enabling coaches to design specific training strategies to develop the required qualities of physical fitness in this cohort of athletes. Several studies have been published on the movement patterns of female soccer players in different age-categories and leagues [18,27,28]. However, there are few reports on match characteristics of different age-group national teams, especially in traditional and top-ranked teams.

For instance, Hewitt et al.[18] tracked the Australian national female team across 13 international friendly matches, demonstrating that players covered 9 630 ± 175 m in total, and presented a 26 % reduction in high-intensity running distance in the final 15 min of the match compared to the first 15-min period. In addition, playing position determined physical performance, as highlighted by the fact that midfielders covered more distance in high-intensity runs than attackers and defenders. However, to our knowledge, there are no systematic observations with national teams (including younger age categories) playing in official competitions. This could be partly due to the fact that wearable technology has only been allowed in official matches since 2015. The number of scientific papers using these devices to analyze the motion characteristics of top-level teams tended to increase following this change in policy. Such descriptions could serve as the basis to characterize contemporary top-level women's soccer match play, and establish future improvements in players' physical condition, especially as the distance covered at high intensities has increased across consecutive seasons, at least in elite level men's leagues [3]. Of note, this analysis should be conducted using age category as an independent variable, since match physical performance changes as players become older and more experienced [27,28].

Although temporary fatigue is a well-recognized phenomenon during matches (i.e., reduction in the work rate from the peak 5 min of activity to the next 5 min), it is still debatable whether enduring fatigue (i.e., decrement in work rate throughout the match duration) ensues in top-level soccer matches, particularly in highly disputed games played during official international competitions [1,7,24]. This is an important source of information for fitness staff to develop specific training strategies aimed at minimizing fatigue within and across matches, considering position-specific performance characteristics. Furthermore, this knowledge would support the evaluation and training of fitness components which are strongly correlated with the ability to maintain high work rates during matches, with low signs of fatigue [2].

Therefore, the aims of this study were to: (1) characterize the movement patterns of a top-level under 20 (U-20) national female soccer team during an official age-specific international competition; (2) determine match-related temporary and enduring signs of fatigue (i.e., analyzed from the game movement patterns during specific periods of the matches); and (3) differentiate playing positions in terms of game movement patterns in this highly select group of athletes. Based on several studies describing the game movement patterns of male and female soccer players from different competitive levels, it was hypothesized that this cohort of top-level players would show signs of temporary and enduring fatigue during the matches (or pacing changes), and that there would be differences in the movement patterns among the different playing positions.

Materials and Methods

Design

This is a longitudinal study describing game movement pattern data (with special reference to high-intensity activity, accelerations, decelerations, and player load [described below]) collected from a total of 7 official matches (total number of matches during the competition referenced). Each match was split into 15-min discrete periods to allow quantification of possible signs of performance decrements (as per Hewitt et al. [18]). In addition, the most intense discrete 5-min of the game was compared with the subsequent and average discrete 5-min periods, in order to detect temporary fatigue, added to which the movement patterns of specific playing positions were compared using the full-match data. We also performed an analysis aimed at quantifying the possible effects of performing a highly intense first half compared to a less intense first half on performance during the second half. For this, the matches in which each player traveled the highest (high) and lowest (low) total distance were retained for analyses. In each condition, high-intensity running, sprint distance, accelerations, decelerations, and player load in the first half were compared with the respective values obtained in the second half of the match. This analysis was performed to verify whether second half performance is influenced by the extremes of first half performance.

Participants

12 female players from the U-20 Brazilian national women's team participated in the study (age: 18.0 ± 0.7 years, stature: 167 ± 5.8 cm and body mass: 62.0 ± 6.2 kg). Data were collected during the 2015 U-20 South American Championship, of which the team investigated was the winner. Prior to the study, all players and their parents (for players < 18 years old) signed an informed consent form, and all procedures were approved by an Institutional Ethics Committee. The current study also adhered to the standards of the International Journal of Sports Medicine described by Harriss and Atkinson [17].

Competition characteristics

The first phase of the competition consisted of 4 matches, from which the 4 best teams were classified to play in the second and final phase that consisted of 3 matches. All matches were interspersed by at least 2 days of rest and final scores were: first phase 3 wins (2-1, 1-0, and 4-0) and one draw (2-2); second phase 2 draws (both 0-0) and one win (3-1).

Procedures

All matches were performed on outdoor pitches with official dimensions (i.e., 100 × 75 m). Match activity profiles were obtained using global positioning system (GPS) units operating at 10 Hz (MinimaxX GPS units; Team S5, Catapult Innovations, Melbourne, Australia). Units were switched on 60 min prior to match commencement and were fitted to the upper back of each player using an adjustable neoprene harness. This procedure allowed the connection and acquisition of > 12 satellites and horizontal dilution of precision (HDOP) not greater than 1.0. More specifically, the average number of satellites and HDOP (mean ± SD) during match play data collection were 15.5 ± 0.5 (range 12–17) and 0.75 ± 0.3 (range 0.5–1.0). Furthermore, the same unit was used by each player in all matches to reduce inter-unit measurement error [21,22].

Match analysis

The GPS contained a tri-axial accelerometer system (100 Hz), which was also used to quantify body accelerations. The velocity and acceleration categories during the matches were selected based on a previous study of female soccer players [27]. Therefore, the match activities were divided into the following categories: 15.6–20 km·h⁻¹ (high-intensity running), >20 km·h⁻¹ (sprinting), number of accelerations >2 m·s⁻², and decelerations > −2 m·s⁻². The validity and reliability of the GPS units used have been extensively reported [26].

The data accumulated from all 3 axes (anterior-posterior [front to back], medio-lateral [side to side] and cranio-caudal [up and down]) of the MinimaxX were integrated to formulate the acceleration vector magnitude. The manufacturers of the MinimaxX accelerometers call this parameter player load. The reliability of the player load measure has been reported previously (CV = 1.6 %) [5].

Statistical analysis

Data are presented as mean ± standard deviation. Due to the large inter-individual variability in all dependent variables of this study, data were log-transformed for the analysis and then back-transformed to facilitate its presentation and interpretation in the results section. Magnitude-based inference [4] was used to test the differences in the game movement patterns between the different playing positions. In addition, this approach was also used to compare physical performances between the first and second halves, between the most intense 5-min period of the match with the following 5-min period and the average of the remaining 5 min periods in the match, as well as across the six 15-min periods during the matches. The quantitative chances of finding differences were assessed qualitatively as follows: <1 %, almost certainly not; 1–5 %, very unlikely; 5–25 %, unlikely; 25–75 %, possible; 75–95 %, likely; 95–99 %, very likely; >99 %, almost certain. If the chances of having better and poorer results were both >5 %, the true difference was assessed as unclear. A likely difference (>75 %) was considered as the minimum threshold to detect meaningful differences. The magnitudes of the differences for the comparisons across all variables were analyzed using Cohen's d effect size (ES) [13]. 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 [19].

Results

The comparisons of the match physical locomotor activities between the different playing positions are displayed in ▶ **Table 1**. The central defenders demonstrated likely to almost certain differences in all tested variables, except for the accelerations >2 m·s⁻², in comparison to the fullbacks (central defenders < fullbacks; ES = 0.88–3.10), very likely to almost certain differences in all variables in comparison to the forwards (central defenders < forwards; ES = 0.63–2.77), and a likely difference in decelerations > −2 m·s⁻² in comparison with the midfielders (central defenders > midfielders; ES = 0.87). With the exception of accelerations >2 m·s⁻², the fullbacks demonstrated likely to almost certain differences from the midfielders in all the other variables (fullbacks > midfielders; ES = 0.97–3.59), and were likely different from the forwards in the decelerations > −2 m·s⁻² (fullbacks < forwards; ES = 0.80). The midfielders were likely to almost certainly different from the forwards in all tested variables with the exception of player load (midfielders < forwards; ES = 0.58–2.21).

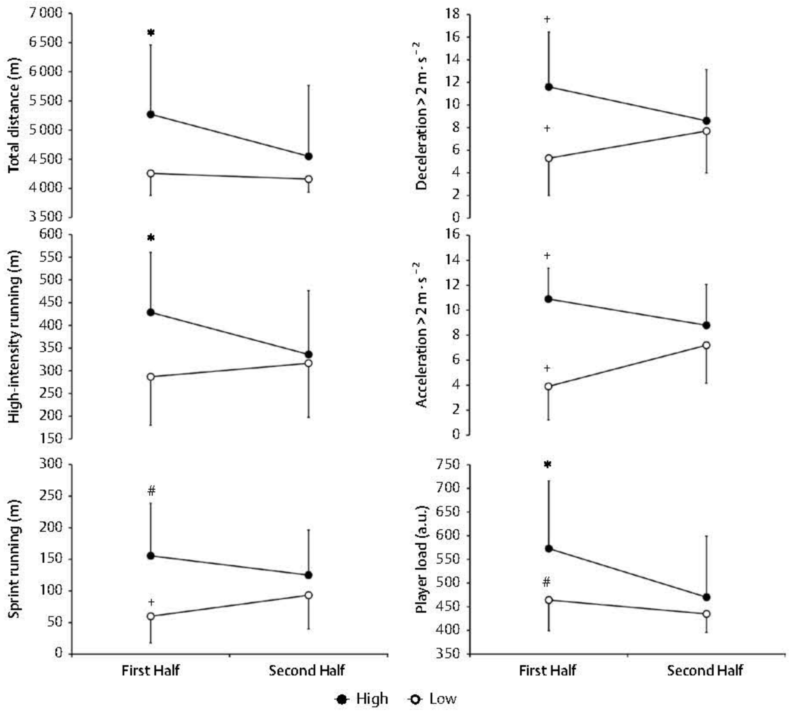
▶ **Fig. 1** depicts the comparisons of the game movement variables between the first and second halves of the matches. When players performed their individually highest values of total distance, player load, and high-intensity running in the first half, there was an almost certain decrease in the respective variables in the second half of the match (ES = −0.76, −0.84, and −0.86, respectively). Meanwhile, the number of accelerations >2 m·s⁻² and decelerations > −2 m·s⁻² were very likely higher in the first half in comparison to the second half (ES = 0.88 for both variables), and the sprinting was likely decreased in the second half compared to the first half (ES = −0.43). When the players performed their individually lowest values of player load in the first half, there was a likely decrease in this variable in the second half (ES = −0.38). In addition, the sprinting distance and number of accelerations >2 m·s⁻² and decelerations > −2 m·s⁻² were very likely higher in the second half (ES = 0.64, 1.12 and 0.66, respectively) compared to the first half under this condition. The differences between halves regarding total distance and high-intensity running were rated as unclear.

▶ **Table 2** demonstrates the game movement activities across the match split into 15-min periods for the different playing positions. Likely to almost certain differences were noted in the total distance, player load, and high-intensity running across the 15-min match periods (ES = 0.41–2.62, 0.34–3.11, and 0.41–3.86 for total distance, player load and high-intensity running, respectively) for all playing positions. No meaningful differences were observed for the number of accelerations >2 m·s⁻² and decelerations > −2 m·s⁻² across the match periods for the different playing positions.

▶ **Table 1** Comparison of movement activities between the different playing positions.

	Central defender	Fullback	Midfielder	Forward
HIR (m)	508.8 ± 75.8 * +	859.4 ± 99.1#	552.4 ± 113.4+	829.8 ± 191.4
Sprint (m)	113.1 ± 44.1 * +	331.1 ± 94.4#	125.8 ± 47.9+	323.1 ± 110.7
Total distance (m)	8201.6 ± 513.6 * +	9072.7 ± 474.5#	8486.3 ± 702.8+	9055.8 ± 459.7
Deceleration > −2 m·s⁻²	13.6 ± 3.0 * #+	18.5 ± 7.4#+	11.4 ± 4.4+	24.7 ± 9.2
Acceleration >2 m·s⁻²	12.9 ± 3.4+	15.2 ± 6.1	13.5 ± 4.8+	16.6 ± 5.7
Player load (a.u.)	866.3 ± 132.2 * +	987.9 ± 60.9#	930.7 ± 130.6	952.0 ± 78.5

Note: HIR: high-intensity running; meaningful difference from * FB; #MD; +FW



▶ **Fig. 1** Comparisons of locomotor activities between first and second halves of the matches. High: individually highest first half distance covered; Low: individually lowest first half distance covered. Symbols represent meaningful differences from *, #, + Second half.

For central defenders, likely higher sprinting distance was noted during 60–75 min compared to 0–15 min (ES = 0.65) and during 75–90 min compared to 45–60 min match periods (ES = 0.72). Meanwhile, likely to almost certainly higher sprint distance at the beginning of the second half (45–60 min), compared to 60–75 min and 75–90 min, was observed in midfielders (ES = 0.40 for both comparisons). For fullbacks, sprinting distance was likely lower at 75–90 min than at the 0–15 min match period (ES = 0.57). At the end of the match, differences regarding sprints for forwards were rated as unclear.

▶ **Table 3** shows the comparisons of the different locomotor activities between the most intense 5 min (peak 5 min), the next 5 min, and the average of the remaining 5-min periods in the entire match at the different playing positions. The peak 5 min was almost certainly higher in all variables tested than the next 5 min and the average 5 min (ES = 1.74–3.89) for all playing positions. When comparing the 5 min following the peak 5 min (next 5 min) and the average 5 min of the entire match (average 5 min), the number of accelerations $>2\ m{\cdot}s^{-2}$ were likely different for central defenders and midfielders. The number of decelerations $> -2\ m{\cdot}s^{2}$ were likely and very likely different for the forwards and midfielders when comparing the "next 5 min" and the "average 5 min" (ES = 0.35 and 0.96, respectively). Finally, a likely and very likely difference in the total distance and player load comparing the "next 5 min" and the "average 5 min" were demonstrated for fullbacks (ES = 0.93 and 0.91, respectively).

Discussion

The main results of this study showed that: (1) female U-20 soccer players covered a total distance of 8 674.9 ± 663.1 m; (2) in general there was reduction in total distance, high intensity distance and player load, across the match periods (15 min each and halves) regardless of the player position; and (3) fullbacks and forwards covered greater total distances in high-intensity running and sprints ($>15.5\ km{\cdot}h^{-1}$) than the central defenders and midfielders. Importantly, matches demanding higher total distance, player load, and high-intensity running in the first half resulted in decreases in the respective variables in the second half; and matches with lower player load in the first half resulted in increased sprinting distance and number of accelerations $>2\ m{\cdot}s^{-2}$ and decelerations $> -2\ m{\cdot}s^{-2}$ in the second half. These results are partially in accordance with our initial hypotheses that female soccer players would experience signs of temporary and enduring fatigue during matches and that there would be differences in game movement patterns between the different playing positions. However, other than fatigue, contextual factors (e. g., score line) [10] and pacing strategy [8] cannot be ruled out as possible explanations for the reduction in player load, total distance, and high-intensity running observed at the end of the match in all studied player positions. Reductions in running performance, and in particular high-speed running, may not always reflect fatigue or suboptimal preparation of the match participants, but may also be a reflection of a slower tempo of match play.

▶ **Table 2** Game movement activities across the split in match periods of 15 min for the different playing positions.

		0–15 min	15–30 min	30–45 min	45–60 min	60–75 min	75–90 min
High-intensity running (m)	CD	105.7 ± 32.3	77.3 ± 34.7 *	83.3 ± 34.1 *	78.9 ± 4.61	94.7 ± 28.2	68.0 ± 34.0 * ‡
	FB	190.3 ± 56.1	146.9 ± 52.0 *	130.7 ± 28.4 *	166.3 ± 52.7 +	137.1 ± 71.7 *	142.5 ± 52.9 * †
	MD	109.9 ± 43.0	97.2 ± 43.7 *	87.8 ± 30.2 *	91.2 ± 35.4 *	95.8 ± 48.2 *	73.8 ± 37.9 * # †‡
	FW	162.9 ± 45.6	115.7 ± 39.5 *	129.3 ± 42.0 *	146.6 ± 52.9 *	150.3 ± 56.3	105.0 ± 28.8 * †‡
Sprint (m)	CD	12.0 ± 8.91	16.1 ± 13.9	16.1 ± 19.7	13.6 ± 12.8	33.4 ± 22.8 *	25.0 ± 14.0†
	FB	72.1 ± 34.5	41.7 ± 17.8 *	60.5 ± 28.5 #	56.6 ± 26.5	55.2 ± 46.1	47.9 ± 26.8 *
	MD	20.9 ± 18.5	18.3 ± 16.9	20.8 ± 18.5	28.3 ± 22.0 #	19.7 ± 23.7†	15.5 ± 14.9†
	FW	63.9 ± 28.7	50.5 ± 41.3 *	53.4 ± 31.7	44.8 ± 25.8 *	62.9 ± 29.3	59.1 ± 36.2
Total distance (m)	CD	1527.8 ± 123.3	1377.3 ± 146.5 *	1347.1 ± 132.6 *	1383.1 ± 59.5 *	1342.1 ± 162.0 *	1185.1 ± 160.4 * #+ †‡
	FB	1800.4 ± 385.9	1671.1 ± 461.8 *	1630.7 ± 379.5 *	1717.8 ± 406.0 *	1504.9 ± 422.1 * †	1456.3 ± 356.6 * #+ †
	MD	1583.0 ± 189.8	1461.4 ± 167.9 *	1401.7 ± 161.7 *	1459.4 ± 132.1 * #	1370.1 ± 166.4 * †	1241.5 ± 160.0 * #+ †‡
	FW	1674.4 ± 146.5	1542.2 ± 164.7 *	1496.1 ± 121.8 *	1558.4 ± 99.9 * #	1441.0 ± 156.9 * †	1325.9 ± 101.2 * #+ †‡
Deceleration > $-2\ m{\cdot}s^{-2}$	CD	2.33 ± 0.82	1.50 ± 1.38	1.83 ± 1.72 #	2.17 ± 1.60	2.50 ± 1.22	2.50 ± 1.05
	FB	3.64 ± 1.50	3.18 ± 2.23	2.82 ± 1.78 *	3.09 ± 2.63	2.36 ± 1.80	3.18 ± 1.54
	MD	2.00 ± 1.67	1.73 ± 1.15	1.58 ± 1.27	2.08 ± 1.57	2.15 ± 1.54	1.65 ± 1.26
	FW	4.90 ± 1.45	3.70 ± 1.95 *	4.70 ± 3.50	3.90 ± 2.28 *	5.80 ± 2.62†	3.60 ± 2.50 * ‡
Acceleration > $2\ m{\cdot}s^{-2}$	CD	2.33 ± 1.63	2.33 ± 1.21	2.17 ± 1.83	1.67 ± 1.51	1.50 ± 1.38	1.83 ± 1.17
	FB	2.55 ± 1.69	3.27 ± 1.49	2.09 ± 1.51 #	3.09 ± 2.55	2.45 ± 2.11	2.45 ± 1.86
	MD	2.12 ± 1.56	2.73 ± 1.54	1.88 ± 1.28 * #	2.19 ± 1.58	2.19 ± 1.55	2.46 ± 1.50
	FW	2.70 ± 1.64	2.30 ± 2.06	3.40 ± 1.43 * #	2.60 ± 1.35 +	2.70 ± 1.49	3.70 ± 3.37
Player load (a.u.)	CD	162.7 ± 14.4	140.2 ± 15.9 *	135.4 ± 11.3 *	140.9 ± 9.93 *	134.3 ± 16.4 *	116.5 ± 12.8 * #+ †‡
	FB	205.2 ± 41.5	185.2 ± 50.3 *	178.0 ± 40.2 *	188.1 ± 41.5 *	157.8 ± 46.6 * †	152.2 ± 34.6 * #+ †
	MD	183.7 ± 31.3	163.2 ± 29.5 *	153.6 ± 27.4 *	161.1 ± 24.7 * +	147.9 ± 25.6 * †	132.9 ± 24.1 * #+ †‡
	FW	186.9 ± 16.5	157.8 ± 22.5 *	152.1 ± 18.8 * #	164.0 ± 15.6 * +	147.9 ± 20.4 * †	131.8 ± 12.6 * #+ †‡

Note: CD: central defenders; FB: fullbacks; MD: midfielders; FW: forwards; symbols represent meaningful differences from * 0–15 min; # 15–30 min; + 30–45 min; †45–60 min; ‡60–75 min

▶ **Table 3** Comparisons of game movement activities between the most intense 5 min (peak 5 min), the next 5 min, and the average of the remaining 5 min periods of the entire match in the different playing positions.

	Peak 5 min	Next 5 min	Average 5 min
Central Defenders			
HIR (m)	68.9 ± 15.5	27.4 ± 19.0 *	30.5 ± 9.4 *
Sprint (m)	37.1 ± 15.3	5.9 ± 7.9 *	6.2 ± 3.8 *
Total distance (m)	601.4 ± 56.9	459.2 ± 125.8 *	463.0 ± 38.1 *
Deceleration > $-2\ m{\cdot}s^{-2}$	2.56 ± 0.53	0.67 ± 0.71 *	0.71 ± 0.22 *
Acceleration > $2\ m{\cdot}s^{-2}$	2.11 ± 0.60	1.11 ± 0.78 *	0.59 ± 0.17 * #
Player load (a.u.)	68.4 ± 12.1	50.7 ± 10.6 *	48.7 ± 7.0 *
Fullbacks			
HIR (m)	100.0 ± 15.7	47.1 ± 24.6 *	44.8 ± 5.7 *
Sprint (m)	57.4 ± 16.9	21.4 ± 19.1 *	15.4 ± 5.1 *
Total distance (m)	653.4 ± 40.9	529.9 ± 66.2 *	495.0 ± 24.6 * #
Deceleration > $-2\ m{\cdot}s^{-2}$	3.36 ± 0.81	0.91 ± 0.54 *	0.91 ± 0.38 *
Acceleration > $2\ m{\cdot}s^{-2}$	3.00 ± 0.89	0.73 ± 0.47 *	0.71 ± 0.32 *
Player load (a.u.)	74.5 ± 5.2	57.7 ± 6.9 *	53.6 ± 3.2 * +
Midfielders			
HIR (m)	71.3 ± 17.1	33.4 ± 17.0 *	28.0 ± 6.1 *
Sprint (m)	36.4 ± 13.6	4.8 ± 8.1 *	5.3 ± 2.4 *
Total distance (m)	593.6 ± 51.4	470.3 ± 83.1 *	464.3 ± 39.0 *
Deceleration > $-2\ m{\cdot}s^{-2}$	2.19 ± 0.57	1.08 ± 0.89 *	0.52 ± 0.21 * +
Acceleration > $2\ m{\cdot}s^{-2}$	2.42 ± 0.81	1.04 ± 0.72 *	0.65 ± 0.25 * #
Player load (a.u.)	69.5 ± 9.8	51.6 ± 11.9 *	50.7 ± 7.2 *
Forwards			
HIR (m)	91.5 ± 27.8	48.2 ± 22.8 *	42.4 ± 11.9 *
Sprint (m)	60.7 ± 14.6	17.5 ± 14.7 *	17.2 ± 5.5 *
Total distance (m)	623.2 ± 58.3	503.7 ± 81.9 *	489.3 ± 25.7 *
Deceleration > $-2\ m{\cdot}s^{-2}$	3.89 ± 1.05	0.89 ± 0.78 *	1.30 ± 0.56 * #
Acceleration > $2\ m{\cdot}s^{-2}$	3.44 ± 1.13	1.22 ± 0.83 *	0.88 ± 0.27 *
Player load (a.u.)	70.1 ± 8.8	52.5 ± 8.4 *	51.0 ± 4.4 *

Note: HIR: high-intensity running; * Almost certainly different from Peak 5 min; #Likely different from next 5 min; +Very likely different from next 5 min

Top-level male soccer players who covered larger total, high-intensity running (14.4 to 19.8 $km{\cdot}h^{-1}$), and very-high intensity running (19.8 to 25.2 $km{\cdot}h^{-1}$) distances during the first half decreased the respective distances in the second half [25]. On the other hand, players covering shorter distances in the first half did not decrease performance in the second half. Actually, the very-high distance running increased in the second half compared to the first half in these players. Although interesting, these findings were based on a median split technique separating players with "high" and "low" total distances covered in the first half. In our case, the same female players were analyzed in matches during which they covered high and low distances in the first half using within-subject analysis. In partial agreement with Rampinini et al. [25], in the "high" match, the total distance, high-intensity running, and player load were almost certainly, while the number of accelerations > $2\ m{\cdot}s^{-2}$ and decelerations > $-2\ m{\cdot}s^{-2}$ were very likely higher in the first half compared to the second half. Additionally, the sprint distance presented a likely small decrease. In contrast, in the "low" match, the total distance and high-intensity running did not differ between halves, player load presented a likely small decrement, and sprinting distance was very likely higher in the second half. In addition, the number of accelerations > $2\ m{\cdot}s^{-2}$ and decelerations > $-2\ m{\cdot}s^{-2}$ was also very likely higher in the second half. Therefore, it appears that performing at a higher pace during the first half is associated with a reduction in certain performance metrics in the second half, while performing at a lower pace in the first half allows maintenance of overall performance with the potential to increment acceleration actions and sprinting, which are highly associated with goal scoring opportunities [16]. Our findings suggest the relevance of using real-time monitoring of distances covered by players, especially to allow for substitutions at half-time in order to maintain or even increase the work rate of players during the second half [6]. This possibility should be tested in future interventional studies.

In the present study, high-intensity running, total distance, and player load observed in all 15-min period intervals were lower compared to the first 15 min of the match, irrespective of player position. This may have occurred because of a high match tempo at the beginning, as a strategy to establish team tactical superiority considering the importance of international matches and the analyzed team's favoritism (latest championship winner). This is in agreement with previous studies that observed decrements in high-intensity running in all 15-min periods compared to the first 15 min of the match (0–15 min)[9]. Furthermore, throughout the match, the decrease in high-intensity running was generally most pronounced in the final 15-min period of the game, being 25–35 % lower for the 4 playing positions investigated. The decrement in high-intensity running from the first to the final 15-min period was somewhat similar to that observed by Hewitt et al. [18], investigating professional female soccer players and with those reported by the classic study of Mohr et al. [24], who used video-based time-motion analysis, and found a reduction of 14–45 % in high-intensity running in the final 15 min of the match compared to the first four 15-min periods in top-class players. In contrast, Bradley et al. [7] reported that only male domestic players reduced their very-high intensity distance (≥ 19.8 km.h-1) in the final 15 min of the first and second halves compared to the first 15-min period of the game, while international players did not show such a reduction. This observation may be related to the tactical differences and playing strategies, as domestic leagues are notoriously more dependent on high tempo than on retaining ball possession [7]. In this sense, the U-20 female players in our study possibly presented a playing pattern more similar to domestic players than to the international players of the study by Bradley et al. [7], despite competing at international level while representing their age-specific national team.

Finally, it is important to note that female players playing in international games perform more high-intensity and sprinting distances than when playing in domestic games [1, 27]. It is likely that special preparations are needed to improve the ability to perform at high intensities when players are recruited to their national teams, requiring specific and time-efficient training strategies [20]. Possibly, fatigue accumulation over the match, combined with contextual factors and pacing strategy [8, 10], in general led to decrements in the total distance, player load, and high-intensity running measured, particularly at the end of the match (final 15-min interval), which was observed for all players' positions. Furthermore, our results agree with others found in women soccer players playing in international games (including competitive matches for their national team) that show a reduction in similar physical performance parameters over the match duration [1, 18].

In general, irrespective of player position, sprinting distance was relatively unchanged across the match using these time frames. However, player positions showed different patterns when comparing the 60–90 min period to the first 15 min. Fullbacks presented a reduction of 33 % in sprint distance during 60–90 min compared to the first 15 min, while no difference was observed for forwards or midfielders, and central defenders demonstrated an increase of around 100 % observed during the final 30 min of the match. Fullbacks presented the highest sprint distance over the match, which may have contributed to the reduction in performance in the final minutes (i. e., signs of fatigue). On the other hand, central defenders presented the lowest sprint distance throughout the match, which may have allowed an increase in this type of action towards the end. These results may also be attributed to contextual factors (e. g., score line) [10], as over the 7 matches investigated, 5 could have presented different final results (e. g., lose or draw) if the opponent team had scored one goal. The authors believe that such situational factors may impose an increase in high-intensity physical efforts for the defensive players towards the end of the match. In fact, it is suggested that players do not always use their maximal physical capacity through the entire match, as previous research proposes that players modulate their efforts by employing pacing strategies to conserve energy for later in the match [15].

It was demonstrated that there was a nearly 53 % reduction (with range of 47–60 %, according to player position) in high-intensity running in the 5-min period following the most intense 5 min of the match in our sample of U-20 female players. This result is comparable to those previously demonstrated in male soccer players [7]. This could be explained by substantial mobilization of the anaerobic metabolism. This large reduction may be critical for the tactical organization of the team (less compact), allowing more spaces and favoring the loss of ball possession due to reduced engagement in locomotor activities. Accordingly, specific training strategies aimed at improving the ability to sustain high-intensity activities and reduce fatigue during the match are necessary in soccer [20].

In general, the fullbacks and forwards covered higher total distance, and distance at high-intensity and sprinting, and accumulated a higher player load than the central defenders and midfielders. The results in the present study are partially in accordance with the study of Vescovi [27] that showed higher sprinting in the forwards in comparison to the midfielders, but no difference in defenders (combining central defenders and fullbacks). However, they are in contrast with other previous studies that demonstrated higher total distance and high-intensity distance in the midfielders in comparison with defenders (combining central defenders and fullbacks) and forwards during international level contests [1] and during high-level matches and top-class female soccer players [23]. In the study by Vescovi [27], players had a similar age to the present study, which could partially explain the diverging findings compared to adult professional players [1]. Also in our study, we opted to divide the defenders into central defenders and fullbacks due to the differences in tactical roles of these playing positions, and as demonstrated in our results, due to large differences in game movement patterns performed during matches. Different from several previous studies analyzing both male and female soccer players, the forwards covered greater distances than the midfielders and central defenders. The higher physical demands presented by the fullbacks and forwards may be related to the characteristics of the team studied and the quality of the opponents during the competition, which may have required more involvement in playing actions for these specific playing positions (i. e., offensive team). Finally, from the 7 matches analyzed, only 2 were won by a difference of 2 or more goals, attesting to the higher level of competitiveness of the teams that participated in this international championship.

Some studies have shown the importance of situational parameters on players' physical performance [10, 12]. Therefore, more studies are necessary to verify whether the "fatigue effect" shown in the present study can be consistently observed in other teams with different competitive levels and tactical formations, and matches of different results in female soccer, taking into account and specifically investigating the role of the context (e. g., match score status). It is important to emphasize that the previous studies were conducted with male soccer players, and that sex differences may be evidenced in future studies.

In conclusion, the present study showed that U-20 top level female soccer players covered an average of 8674.9±663.1 m during international matches and the fullbacks and forwards covered a higher total distance, and distance at high-intensity and sprinting than the central defenders and midfielders. This study investigated, for the first time, fatigue (or pacing changes) during high-standard U-20 female official soccer matches. It was verified that some selected locomotor activity decrements occur throughout the match, and performance decrements are influenced by the pace performed in the first half of the match. This provides a novel insight to guide appropriate training among top-level U-20 players, and choose positional strategies and match interventions to minimize the performance decrement outcome. In practical terms, female top-level U-20 fullbacks and forwards need to implement more high-intensity training strategies to cope with their playing roles. In addition, coaches need to consider substituting a player when high distances are covered at high-intensity during the first half, since performance decrement can be expected in the second half of the match.

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Estudo 4. Avaliação das possíveis alterações dos ritmos biológicos de atletas de futebol da seleção brasileira submetidas a condições de treinamento físico

Avaliação das possíveis alterações dos ritmos biológicos de atletas de futebol da seleção brasileira em diferentes períodos de treinamento físico

*Artigo em processo de finalização para submissão em periódico científico a definir

Introdução

O esporte competitivo apresenta uma variabilidade de fatores estressores (pressões externas e internas não controladas pelos atletas) que podem desestabilizar física e psiquicamente o esportista ao longo período de treinamento e/ou competição.

Durante o período de treinamento, a carga de treinamento aplicada ao atleta visa promover adaptações que tenham como consequência a sua melhora no desempenho esportivo. No entanto, a aplicação inadequada da carga de treinamento, sem respeitar o tempo mínimo necessário para recuperação, pode levar a uma série de alterações fisiológicas que estagnam ou até mesmo reduzem o desempenho esportivo (HALSON; JEUKENDRUP, 2004; HYNYNEN *et al.*, 2006). Dessa forma, a avaliação do estado de treinamento de atletas e da carga de treinamento são temas amplamente discutidos e nas ciências do esporte (BURGESS, 2017; MURRAY, 2017; THORPE *et al.*, 2017).

Já é estabelecido na literatura sobre o esporte de alto rendimento, que a carga de treinamento pode influenciar a liberação de hormônios cíclicos do eixo hipotálamo-hipófise-adrenal (HPA) em atletas (KRAEMER *et al.*, 2004). O treinamento desencadeia respostas no sistema nervoso endócrino que causam adaptações no organismo para os desafios do esporte, sendo os hormônios esteroides considerados bons indicadores do nível de estresse/recuperação ou ainda desgaste/aperfeiçoamento no contexto desportivo (GLEESON, 2002; HELLHAMMER; WUST; KUDIELKA, 2009). Estudos têm demonstrado alterações nas concentrações dos hormônios cortisol (C) e testosterona (T), e da razão T / C, em atletas de futebol que apresentam níveis elevados de treinamento. Além disso, a razão T/C pode ser utilizada como marcador da adequação da carga de treinamento onde baixa recuperação em atletas de futebol parece estar relacionada a uma relação (T/C) reduzida a 30% ou mentos em relação aos seus valores iniciais (AIZAWA *et al.*, 2006; BANFI; DOLCI, 2006).

De fato, já foi demonstrado que as concentrações de cortisol aumentam após jogos oficiais de futebol com consequente redução na ração T/C, sinalizando um possível desgaste (SILVA *et al.*, 2013), com aumentos subsequentes até 48 horas durante o período de recuperação, sinalizando a adequação ou não da recuperação (SILVA *et al.*, 2013). Bouget *et al.* (2006) verificaram que o aumento na carga de treinamento pode ocasionar um aumento na produção de cortisol e redução nas concentrações de testosterona salivar com consequente redução na razão entre esses hormônios (T/C) em mulheres treinadas. Aizawa *et al.* (2006) observaram um padrão similar de aumento das concentrações de cortisol e redução na razão T/C em jogadoras de futebol submetidas a jogos consecutivos. Nesse estudo, atletas profissionais participaram de 6 jogos internacionais oficiais em dias consecutivos, o que evidenciou um aumento na demanda física e o possível desgaste dessas atletas.

Quanto ao período de recuperação pré-competitivo (polimento), destinado à chamada supercompensação (MUJIKA, 2010), geralmente ocorre redução na carga de treinamento a qual atletas são submetidos. O objetivo desse período é atenuar o desgaste induzido pelo treinamento intenso e possibilitar a recuperação dos atletas (MUJIKA, 2010). A redução da carga de treinamento pode ser realizada através de várias modificações, como a redução na frequência de treinamento (menor número de sessões), no volume de treinamento (menor duração das sessões) e/ou redução na intensidade do treinamento (MUJIKA, 2010).

De fato, Freitas *et al.* (2014) verificaram que a redução da carga de treinamento pode atenuar a produção de cortisol devido a uma adaptação do eixo HPA ao estresse do treinamento. Essas alterações nas concentrações hormonais no período destinado à recuperação dos atletas, estariam associadas à uma menor suscetibilidade a infeções do trato respiratório superior e ao aumento no desempenho esportivo (COUTTS *et al.*, 2007; FREITAS *et al.*, 2014).

Dessa forma, parece que monitoramento da carga de treino em conjunto com possíveis oscilações nas concentrações hormonais de T e C, seriam parâmetros importantes de avaliação das adaptações fisiológicas decorrentes do treinamento, para que seja possível o alcance de melhoras no desempenho esportivo.

Em mulheres atletas praticantes de esportes de alto nível, o treinamento físico, além de influenciar na produção cíclica de T e C, pode alterar a regulação dos hormônios do ciclo reprodutivo, como por exemplo nas concentrações dos hormônios folículo estimulante (FSH), luteinizante (LH), estradiol e progesterona sexuais (CHROUSOS; TORPY; GOLD, 1998). Estudos sugerem a existência de inibição em nível hipotalâmico da produção do hormônio liberador de gonadotrofina (GnRH) pelo hormônio liberador de corticotrófica (CRH) e pela ação do cortisol tanto em nível hipotalâmico, hipofisário, gonodal e em tecidos alvo, o que acarretaria em consequente redução na produção hipofisária dos hormônios sexuais (CHROUSOS; TORPY; GOLD, 1998).

Além disso, já foi demonstrado que o desempenho físico pode ser modificado de acordo com a fase do ciclo menstrual (JULIAN *et al.*, 2017; MIDDLETON; WENGER, 2006). O ciclo reprodutivo de mulheres possui entre 26-35 dias, aproximadamente, dividido em duas fases: folicular e lútea. A fase folicular é caracterizada por alta concentração de hormônio folículo estimulante (FSH) e um aumento gradual nas concentrações de estrógeno, que é secretado prioritariamente pelos ovários. A fase lútea é caracterizada pelas altas concentrações do homônimo luteinizante (LH) com aumento nas secreções de estrógeno e progesterona pelo corpo lúteo (DAWSON; REILLY, 2009). Julian *et al.* (2017) verificaram que jogadoras de futebol apresentam alteração do desempenho em testes para avaliar a capacidade aeróbia de acordo com a fase do ciclo, e resultados similares foram observados no estudo de Middleton *et al.* (2006) em relação ao desempenho de Sprint repetidos de 6-s em cicloergômetro (MIDDLETON; WENGER, 2006). Em ambos os estudos, os resultados observados estavam associados às concentrações hormonais de estrógeno e progesterona, sendo especuladas ações de aumento do metabolismo de lipídios e manutenção dos estoques de glicogênio por ação do estrógeno (OOSTHUYSE; BOSCH, 2010) e possível aumento da temperatura corporal por ação da progesterona.

Grande parte dos estudos científicos realizados com atletas mulheres buscam investigar se existem associações entre fases do ciclo reprodutivo e o desempenho esportivo (JULIAN *et al.*, 2017; MASTERSON, 1999), ou mesmo se o treinamento pode provocar a ausência (amenorreia) ou presença da menstruação (eumenorréia). No entanto, ainda há poucos registros na literatura de estudos que investigaram se o treinamento físico e a manipulação da carga treinamento pode modular diretamente ou indiretamente (por meio de alterações nos hormônios do eixo HPA e hipotálamo-hipófise-gonodal - HPG) os ritmos biológicos de mulheres atletas de futebol submetidas ao treinamento (DE SOUZA *et al.*, 2010). Essa carência ainda é evidente quando se trata de modalidades esportivas com menor apreço da mídia nacional, mesmo quando largamente praticado, como no caso do futebol feminino (FIFA, 2015).

Partindo do pressuposto de que atletas sujeitas ao treinamento físico apresentam maior frequência de ocorrências de distúrbios no ciclo reprodutivo (oligomenorréia e/ou amenorreia) (DE SOUZA *et al.*, 2010), e que a carga de treinamento poderia alterar a produção dos hormônios cíclicos circadianos como testosterona e cortisol, é interessante investigar se a variação na carga de treinamento aplicada a atletas de futebol, o período pré-competitivo, poderia influenciar a concentração desses hormônios.

Objetivo

O objetivo desse estudo foi avaliar os efeitos da carga de treinamento aplicada às mulheres atletas de futebol ao longo do período preparatório de 35 dias para uma competição internacional na regulação dos hormônios cíclicos circadianos (cortisol e testosterona) e/ou dos hormônios ovarianos cíclicos (estradiol e progesterona). Para isso, foram analisadas concentrações salivares das atletas ao longo do dia em quatro momentos durante o treinamento. A razão entre esses (T/C) foi também calculada para avaliar a adequação da carga de treinamento e a relação entre a demanda/recuperação do esforço exigido das atletas durante o período pré-competição.

Método

Sujeitos

Participaram deste estudo 09 jovens atletas de futebol feminino pertencentes à categoria de base (Sub-20) da Seleção Brasileira de Futebol. Para serem incluídas no estudo todas as atletas deveriam estar dentro dos seguintes critérios: 1) idade entre 18 e 19 anos; 2) ser jogadora de linha em qualquer posição; 3) não apresentar lesões musculoesqueléticas e/ou alterações metabólicas que impossibilitassem a prática do futebol durante o período de treinamento; 4) não ter feito uso de anticoncepcionais orais ou suplementação hormonal nos últimos seis meses; 5) ser integrante da equipe durante todo o período de preparação para a competição internacional.

Delineamento da Pesquisa

Esse experimento foi realizado em um período de 2 meses, em que todas as atletas passaram por quatro períodos distintos de treinamento como integrante da seleção brasileira de futebol feminino visando sua preparação para o torneio internacional organizado pela Confederação Sul-americana de Futebol (Conmenbol).

Previamente à participação no estudo, todas as atletas passaram por uma avaliação médica para a liberação para a prática de exercícios físicos e, posteriormente, por avaliações físicas para a caracterização do seu nível de condicionamento físico. No período de treinamento, as atletas foram submetidas a sessões de treinamento específicas da modalidade, sendo todas monitoradas quanto à carga de treinamento. Além disso, durante esse período, ao término de cada período de treinamento, as atletas forneceram voluntariamente 4 amostras diárias de saliva nos dias referentes a 7ª, 4ª, 2ª de treinamento anteriores à competição e 4 amostras diárias na semana que antecedeu o início da competição. Estas amostras de saliva foram estocadas para análise posterior das concentrações hormonais de cortisol, testosterona, estrógeno e progesterona.

Avaliações Preliminares

Todas as atletas foram avaliadas quanto à composição corporal, desempenho em teste de salto contramovimento, salto agachado, sprint de 20 metros e capacidade aeróbia estimada pelo teste Yo-Yo IR1. As avaliações físicas realizadas são de rotina e estão descritas no estudo 1 desse trabalho.

Treinamento

As atletas que participaram desse estudo passaram por quatro períodos distintos de treinamento no centro de treinamento da seleção brasileira. Os dois primeiros períodos (T1 e T2) tiveram duração total de 10 dias cada, e os dois últimos (T3 e T4), duração de 7 dias cada, totalizando 34 dias de exposição aos treinamentos com a seleção brasileira.

Após o término de T1 e de T2 todas as atletas se ausentaram da seleção brasileira e retornaram aos seus clubes por 10 dias para participarem dos campeonatos regionais por seus clubes. Nesses campeonatos, cada atleta jogou de 3 a 4 partidas. Entre T3 e T4, todas as atletas continuaram em treinamento sem interrupção, não havendo período de liberação para retornarem aos seus respectivos clubes.

Nos primeiros 3 períodos de treinamento foi realizado um maior número de sessões de treinamento (8-9 sessões) priorizando os jogos em campo com dimensões reduzidas e treinamentos técnico-táticos. Todos os treinamentos consistiram em: 1) Aproximadamente 10 minutos de atividade preparatória que incluía exercícios gerais preparatórios e de fortalecimento, "*core*" training; 2) 40 a 90 minutos de treinamento físico-técnico e técnico-tático, em sua maioria simulações de jogos e pequenos jogos com número variado de atletas e diferentes instruções de comportamento técnico e tático; 3) 5 a 10 min de atividade de "volta à calma" com exercícios de baixa intensidade, em sua maioria alongamentos sem intuito de ganho efetivo de amplitude de movimento. Todos os treinamentos foram realizados em campo oficial de futebol (100-70 m). Além disso, em cada um desses períodos foram realizadas 2 sessões de treinamento de musculação com duração aproximada de 50-60 minutos, sendo realizados 6 a 10 exercícios com 6 a 12 repetições.

No último período de treinamento (1 semana antes do início da competição) o número de sessões de treinamento foi reduzido com o intuito de diminuir em aproximadamente 50% a carga de treino. A manipulação da carga de treino foi feita para reduzir do volume total de treinamento. Isto é, foi feita redução apenas na frequência (número) das sessões de treinamento realizadas, para o total de 5 sessões de treino em campo com características similares às descritas anteriormente. Nesse período, foi realizado apenas 1 sessão de treinamento de musculação com duração aproximada de 60 minutos, totalizando 6 sessões totais de treinamento. Nesse último período, na 3ª e 4ª semanas, por um dia as atletas não realizaram nenhuma sessão de treinamento.

Todos os quatro períodos de treinamento ocorreram antes do início da competição e foram divididos de acordo com os objetivos da comissão técnica em relação ao desenvolvimento físico, técnico e tático das jogadoras (FIGURA 1).

Todas as sessões de treinamento em campo foram monitoradas quanto à duração total da sessão, sendo considerado o tempo total de exposição da atleta à situação de treinamento, o momento de início da primeira atividade ao término da última atividade. Após 15 a 20 minutos do final de cada sessão de treinamento, foi realizada a seguinte pergunta à atleta "Como foi a sua sessão de treino"? A resposta foi aferida a partir da escala de percepção subjetiva de esforço de Foster *et al.* (1996) de 10 pontos (CR-10), sendo o valor máximo (10) considerado o maior esforço físico experimentado pelo atleta e, o valor mínimo, a condição de repouso absoluto (0). Foram considerados tanto os valores inteiros quanto os decimais.

A carga de treinamento foi calculada a partir da multiplicação da duração do treinamento em minutos pelo valor apresentado na escala de PSE em cada sessão de treinamento, de acordo com o método proposto por Foster *et al*. (1996):

$$PSE_{sessão} = PSE\ (CR\text{-}10) \times volume\ de\ treino\ (minutos).$$

Para cada período de treinamento foi calculado a carga média de treinamento, considerada a soma da carga individual de treinamento em todas as sessões do período, dividido pelo número de sessões de treino, além da carga total de treinamento, considerada a somatória da carga de treino de todas as sessões daquele período.

Coleta de saliva e análise hormonal

Amostras de saliva foram coletadas ao término de cada um dos quatro períodos de treinamento em 4 momentos ao longo do dia: às 8, 12, 19 e 22 horas.

Na coleta realizada no primeiro horário as atletas estavam em estado de jejum (sem comer por 7-9 horas antes da amostragem) e a última sessão de treinamento havia ocorrido há pelo menos 12 horas antes. As amostras foram coletadas em tubos eppendorf (2,5 ml) estéreis pelo método de salivação passiva. Para isso as participantes sentavam-se, com os olhos abertos, a cabeça inclinada ligeiramente para a frente e fazendo um mínimo movimento orofacial. Em seguida os tubos foram estocados em freezers à -80ºC e posteriormente foi feita avaliação das concentrações hormonais de testosterona, cortisol, progesterona e estradiol (Figura 1). Nos dias em que houve coletas de saliva, foi realizada apenas uma sessão de treinamento pela manhã. Nos demais dias as atividades seguiram a rotina normal de treinamentos.

As concentrações salivares de cortisol, testosterona, estradiol, progesterona foram determinadas por kits de ensaio enzimático (Salimetrics®, Diagnostic System Laboratories) através do método de imunoabsorção enzimática (ELISA) em duplicatas e de acordo com o método proposto pelo fabricante e em conformidade com estudos prévios (MOREIRA *et al.*, 2013b). O valor médio de cada duplicata foi considerado para análise dos resultados.

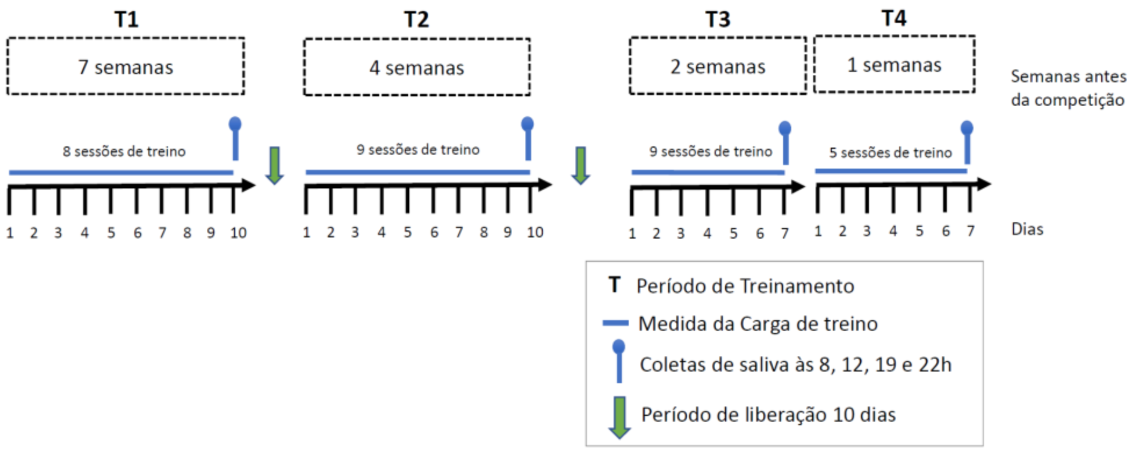

Figura 1: Resumo do delineamento experimental do estudo.

Análise Estatística

Utilizou-se uma análise de variância com dois fatores de variação (ANOVA-2WAY) para verificar as diferenças entre as concentrações hormonais ao longo dos diferentes horários do dia e em relação ao período de treinamento em que foram coletadas as amostras. No caso das comparações entre a carga de treinamento e as concentrações hormonais avaliadas apenas ao longo dos diferentes períodos de treinamento, foi utilizada uma análise de variância com apenas um fator de variação (ANOVA-1WAY) sendo esse fator considerado o período de avaliação. Quando necessário, em ambas as análises, foi utilizado um post hoc de Tukey para identificação das diferenças. Para serem consideradas diferenças foi adotado um nível de significância de $p<0,05$. O software Sigma Stat 12.0 (Alemanha) foi utilizado para todas as análises. Todos os resultados são apresentados como média ± desvio padrão

Resultados

Na figura 1 estão representadas as cargas de treinamento em unidades arbitrárias nos 4 períodos de treinamento. Quanto à carga média de treinamento, foram observados menores valores nos períodos T2 e T4 quando comparado a T1. No entanto, a somatória das cargas observada foi maior no período T2 quando comparada a T1. Durante a semana anterior ao início da competição (T4) foram observados os menores valores de somatória de cargas comparada aos outros períodos analisados.

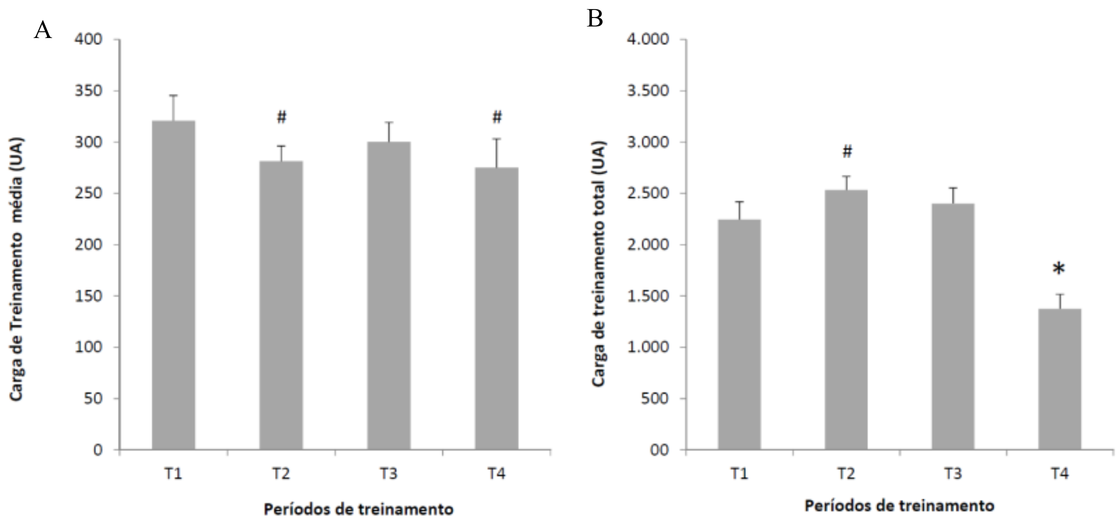

Figura 1: Carga de treinamento media (A) e somatória da carga de treinamento (B) expressas em unidades arbitrárias (UA) ao longo dos períodos de treinamento. # Diferente de T1 ($p < 0.05$); * diferente de todos os outros períodos ($p < 0.05$), $p<0,05$.

Na figura 2 estão apresentadas as concentrações de cortisol em cada um dos períodos avaliados ao longo do dia (A) e a média das concentrações dos períodos em cada um dos horários avaliados (B). As concentrações do hormônio na saliva mostram uma variação circadiana diminuindo ao longo do dia sendo observados menores valores a noite (19 e 22 h), quando comparado aos períodos da manhã (8 e 12 h).

A figura 3 representa a média da área sob a curva desse hormônio nos quatro períodos de treinamento. Para a área sob a curva, não foram identificadas diferenças na intensidade de secreção deste hormônio ao longo dos diferentes períodos de treinamento.

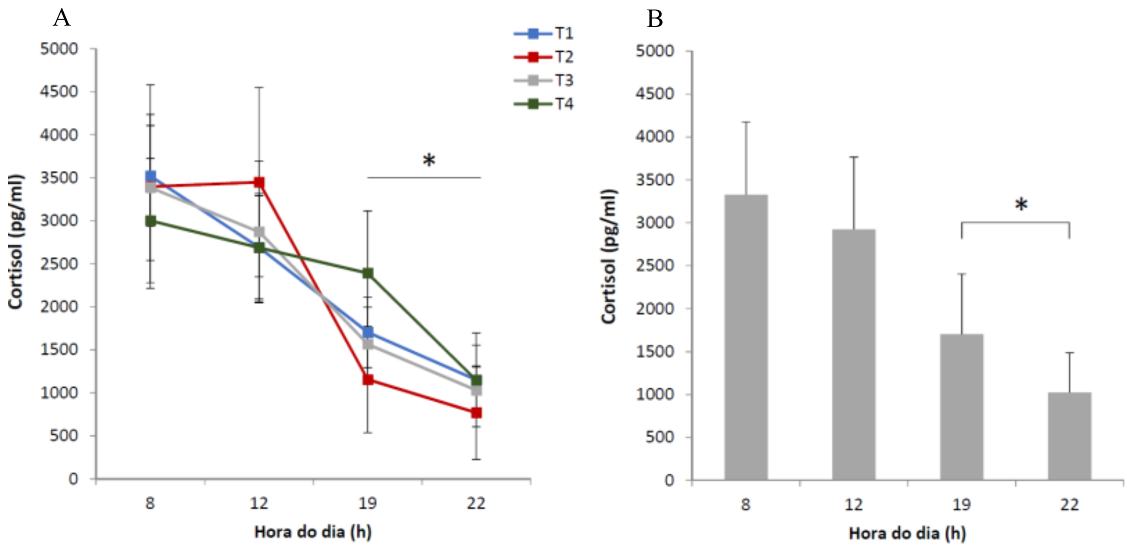

Figura 2: Concentrações de cortisol ao longo do dia (A); médias das concentrações nos quatro períodos ao longo do dia (B). *Significa diferença entre o período da noite (19 e 22 h) comparado ao período da manhã (08 e 12h), $p<0,05$.

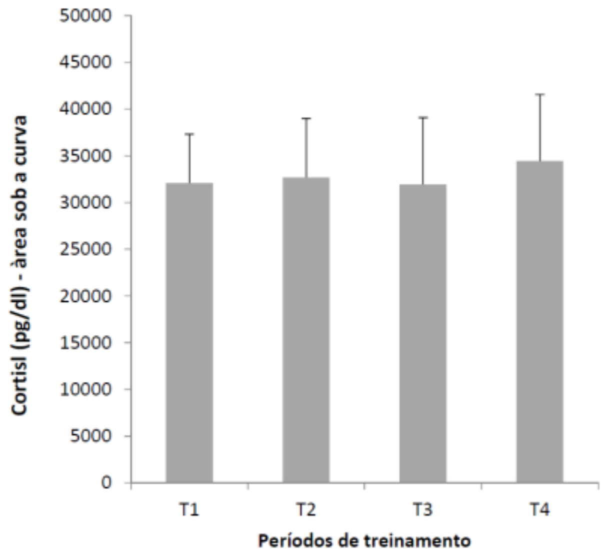

Figura 3: Área sob a curva das concentrações de cortisol nos quatro períodos de treinamento.

Na figura 4 (A e B) estão apresentadas as três fases do ritmo circadiano de secreção da testosterona avaliadas pelas medidas da concentração do hormônio na saliva. Como pode ser observado, o ciclo circadiano está claramente preservado durante todos os períodos de treinamento pré-competição, isto é, apresentando maiores concentrações pela manhã e decaindo ao longo do dia com menores valores no período noturno, quando os valores atingem níveis 52.1% menores quando comparados com os da manhã. Estas variações circadianas ocorreram independente do período e da carga de treinamento (A).

A figura 5 representa a média da área sob a curva da testosterona nos quatro períodos de treinamento. É interessante observar que os maiores valores na intensidade da secreção de testosterona foram encontrados nas últimas duas fases do treinamento quando as atletas já haviam se adaptado a rotina estabelecida.

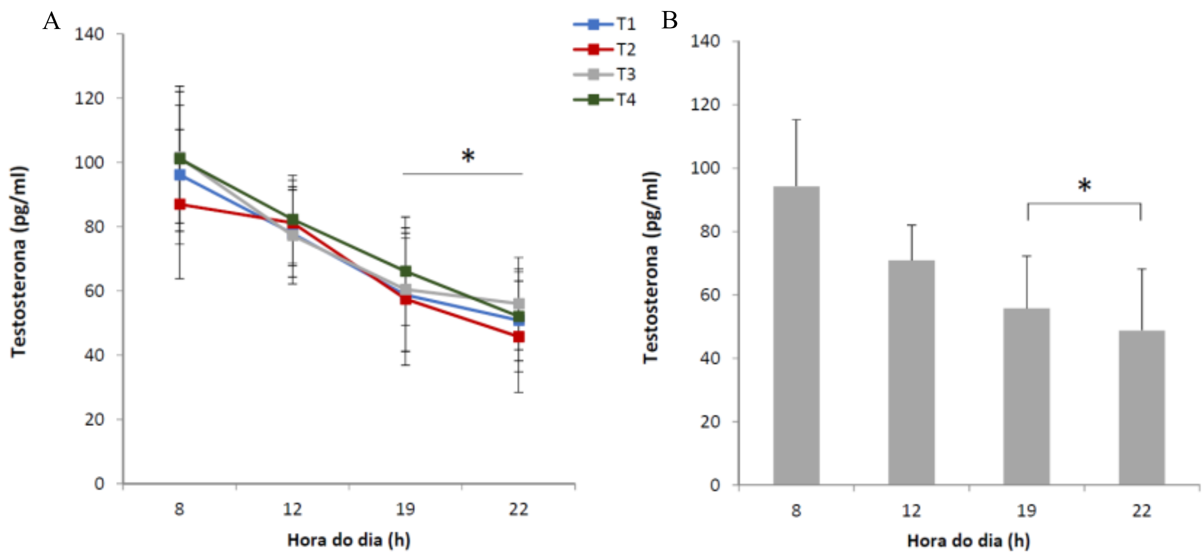

Figura 4: Concentrações de cortisol ao longo do dia (A); médias das concentrações nos quatro períodos ao longo do dia (B). *Significa diferença entre o período da noite (19 e 22 h) comparado ao período da manhã (08 e 12h), p<0,05.

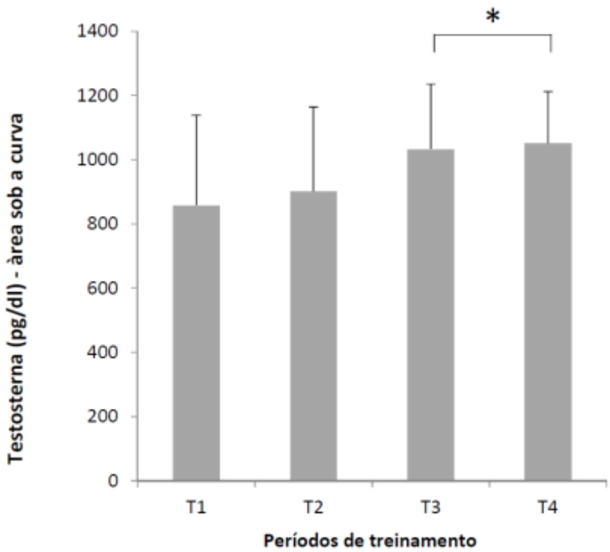

Figura 5: Área sob a curva das concentrações de testosterona nos quatro períodos de treinamento. *Significa diferença entre T1 e T2, p<0,05.

Interessante constatar que os maiores valores da relação testosterona/cortisol (T/C) foram observados no período noturno (19 e 22 h) horário de descanso e recuperação das atletas onde a predominância de um hormônio anabólico poderia contribuir para a recuperação dos desgastes causados pelo treino (FIGURA 6 A). Não foram verificadas diferenças na razão entre os hormônios testosterona e cortisol ao longo dos períodos de treinamento avaliado pela média da área sob a curva da secreção diária (FIGURA 5 B).

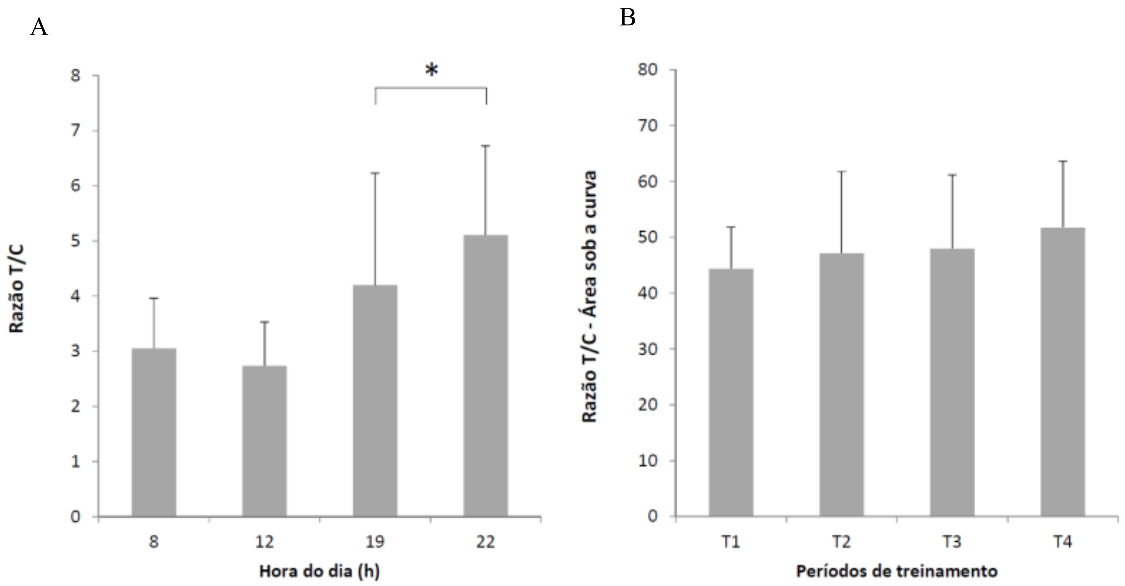

Figura 6: Razão testosterona/cortisol ao longo do dia (A); área sob a curva da razão T/C nos quatro períodos de treinamento (B). *Significa diferença entre o período da noite (19 e 22 h) comparado ao período da manhã (08 e 12h) e diferente de T1 e T2, $p<0,05$.

Na figura 7 são apresentadas as concentrações do hormônio estradiol ao longo do dia nas 4 situações avaliadas (A) e a média da área sob a curva desse hormônio nos quatro períodos de treinamento (B). Não foram encontradas diferenças em nenhum momento para as concentrações de estradiol independente da fase ou da carga de treinamento.

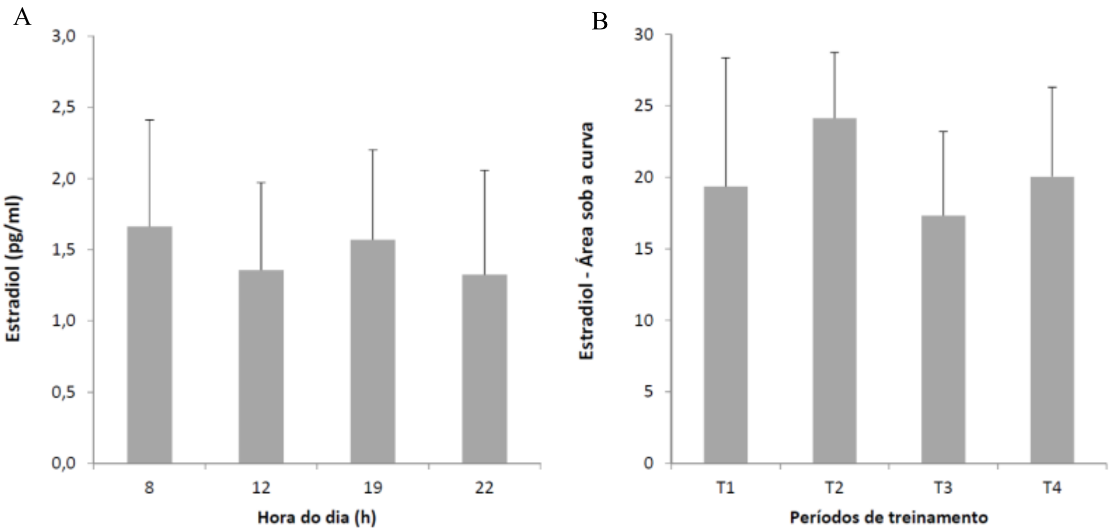

Figura 7: Concentração de estradiol ao longo do dia (A); área sob a curva da concentração de estradiol quatro períodos de treinamento (B).

Na figura 7 são apresentadas as concentrações do hormônio progesterona ao longo do dia nas 4 situações avaliadas e a média da área sob a curva desse hormônio nos quatro períodos de treinamento. Foi constatada diferença nas concentrações desse hormônio apenas em T2 quando comparado ao primeiro período de treinamento, não sendo verificada diferenças ao longo dos horários do dia.

A

B

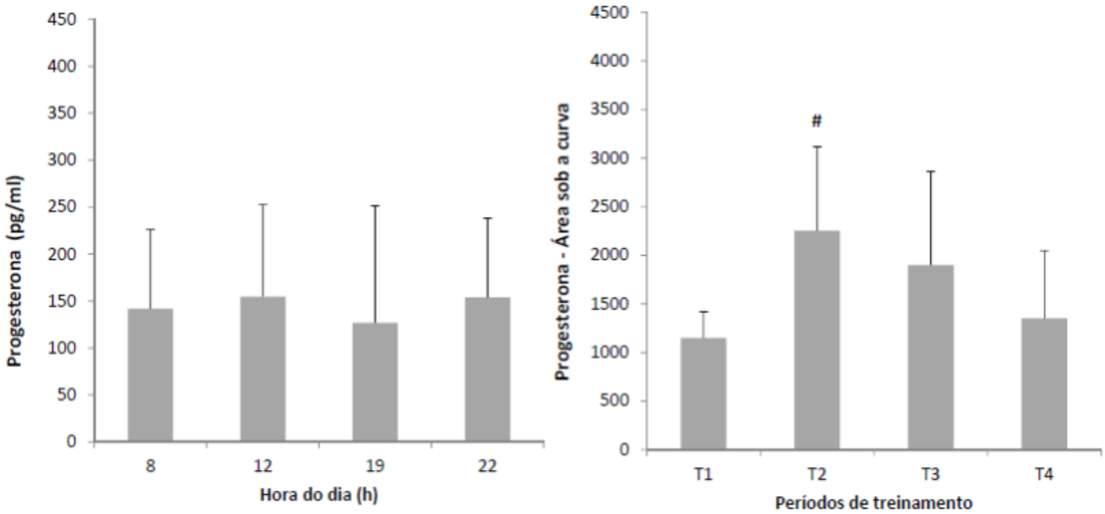

Figura 8: Concentrações de progesterona ao longo do dia (A); área sob a curva das concentrações de progesterona nos quatro períodos de treinamento (B). # Significa diferença de T1, p<0,05.

Discussão

O principal objetivo desse estudo foi verificar se atletas de futebol feminino sofrem perturbações do ciclo circadiano de secreção dos hormônios C e T, quando submetidas ao treinamento pré-competição. A escolha especificamente destes hormônios está ligada a suas ações de remodelação muscular sendo o cortisol um hormônio que mobiliza proteínas e a testosterona um hormônio que favorece a síntese de proteínas e a hipertrofia muscular. Desta forma, a preservação do ritmo circadiano de ambos seria importante para atingir os objetivos de adaptar o atleta aos estímulos produzidos pela carga de treinamento. Os resultados mostraram que a carga aplicada ao longo do treinamento não perturbou a regulação do ciclo com ambos os hormônios apresentando maiores concentrações pela manhã que foram diminuindo ao longo do dia chegando aproximadamente a metade da concentração observada pela manhã. De maneira interessante a relação entre eles se modifica ao longo do dia elevando a relação T/C durante o período noturno de descanso onde seria favorecida a síntese proteica, não só pela diminuição da demanda metabólica como também com uma maior proporção de um hormônio anabólico (testosterona) associado a este período. Estes resultados indicam uma adequação da carga de treinamento que não iria interferir na recuperação das atletas durante o período de descanso.

Nesse estudo, não foram verificadas alterações nas concentrações dos hormônios cíclicos em atletas submetidas ao treinamento de futebol, durante o período prévio à competição. Como pode ser verificado nas figuras 1 à 8, independente do período de treinamento, ou seja, sua proximidade com o início da competição, houve uma manutenção no comportamento da produção diária hormonal, sendo similar o ciclo circadiano dos hormônios em todos os períodos de treinamento, principalmente para T e C, que normalmente apresentam variação diária em suas concentrações (PIRO *et al.*, 1973).

Nossos resultados mostram que ao contrário dos estudos que verificaram aumentos nas concentrações do hormônio cortisol com a proximidade de competições esportivas, devido ao efeito antecipatório do estresse competitivo (BATEUP *et al.*, 2002), observamos a manutenção não só do ritmo circadiano quanto da intensidade da secreção dos hormônio. Este resultado poderia indicar uma melhor preparação das atletas que venceram a competição sem apresentar os efeitos antecipatórios de ansiedade que é caracterizado por uma elevação nos níveis desse hormônio circulantes nos momentos que antecedem a competição (BATEUP *et al.*, 2002; MOREIRA *et al.*, 2013a). Entretanto, a maioria dos trabalhos que verificaram maiores concentrações de C com a proximidade da competição, verificaram essas alterações no dia ou momentos antes da atuação do atleta (BATEUP *et al.*, 2002; EDWARDS; WETZEL; WYNER, 2006; MOREIRA *et al.*, 2013a), diferente da situação observada nesse estudo.

Quando avaliados ao longo do dia, apesar da redução nas concentrações de ambos os hormônios T e C, podemos observar que foi verificada maior razão T/C nas análises feitas no período da noite quando comparado aos períodos da manhã. Esses resultados estão de acordo com estudos prévios que demonstram que indivíduos saudáveis apresentam um padrão similar na razão T/C (HAYES *et al.*, 2012). Essa maior razão T/C no período tarde/noite, sugere que esse período possa ser mais interessante para o treinamento, uma vez que existem evidências de que os ritmos biológicos podem influenciar melhorando o desempenho físico (FACER-CHILDS; BRANDSTAETTER, 2015; TEO; NEWTON; MCGUIGAN, 2011). Além disso, já foi demonstrado que quando o exercício é realizado no período da tarde as concentrações de cortisol tendem a se reestabelecer mais rápido aos seus níveis normais (ERDEMIR *et al.*, 2013) possibilitando o retorno mais rápido ao estado "anabólico".

No presente estudo, mesmo com a redução de aproximadamente 50% na somatória da carga interna no último período de treinamento, verificada pelo índice $PSE_{sessão}$, também não foi possível observar alterações nas concentrações de nenhum dos hormônios avaliados nos diferentes horários do dia, assim como não houve diferença na área sob a curva entre os períodos de treinamento para C e estradiol. No entanto, quando comparada a área sob a curva nos diferentes períodos de treinamento, foram verificados maiores valores de testosterona em T3 e T4 comparado aos dois primeiros períodos de treinamento, e maior valor de progesterona em T2, quando comparado ao primeiro período de treinamento.

Em parte, esses resultados são diferentes daqueles observados por Freitas *et al.* (2014) que encontraram redução nas concentrações de cortisol salivar em jogadores de futebol, concomitante à diminuição na da carga de treinamento nas duas semanas antecedentes à competição. Nesse estudo, os atletas foram submetidos a 4 semanas consecutivas de treinamento, sendo que a partir da segunda semana foi reduzida a carga total, seguido de 50% de redução na terceira semana e, aproximadamente, 75% na última semana de treinamento. Possivelmente, a elevada carga aplicada na primeira semana de treino (*overload*), somada à magnitude de redução das cargas nas semanas subsequentes possibilitou a atenuação nas concentrações de cortisol devido à redução na necessidade de mobilização de substratos.

No presente estudo, houve redução da carga total de treinamento apenas no último período (aproximadamente 50%), sendo ainda observada maior carga em T2 que em T1, fatores que podem ter influenciado a manutenção da secreção de cortisol no último período de treinamento. Além disso, apesar de termos verificado aproximadamente 50% de diferença entre o último e os três primeiros períodos de treinamento, os valores de carga interna encontrados nos 3 primeiros períodos de treinamento são similares aos encontrados anteriormente em atletas profissionais de futebol (ALEXIOU; COUTTS, 2008).

Nossos resultados vão de encontro àqueles verificados por Coutts, Wallace e Slaterry (2007). Nesse estudo, triatletas foram divididos em dois grupos submetidos a programas distintos de treinamento, sendo um com aumento na carga habitual e outro com manutenção da carga de treinamento, sendo esta carga manipulada através do volume de treino. No grupo com aumento no volume de treinamento (290% superior ao grupo de manutenção), mesmo após duas semanas de redução da carga foram observados valores de cortisol salivares aumentados. Em contrapartida, nos atletas em que a carga de treino não sofreu aumento significativo, as concentrações desse hormônio foram mantidas em níveis normais, independente das duas semanas subsequentes em que houve redução significativa na carga de treino.

É proposto na literatura que, exercícios repetidos podem induzir a adaptação do eixo HPA (DUCLOS; GOUARNE; BONNEMAISON, 2003). Uma possível justificativa para isso seriam os níveis reduzidos de receptores de glicocorticoides em indivíduos treinados e/ou a diminuição da sensibilidade tecidual a esses glicocorticoides (DUCLOS; GOUARNE; BONNEMAISON, 2003). Essas são possíveis adaptações que podem ter ocorrido nas atletas do presente estudo.

No entanto, independente das alterações nas concentrações hormonais, devemos levar em consideração que durante todos os períodos em que foram realizadas as coletas salivares pelo menos uma sessão de treinamento foi realizada. Ao verificarmos que a carga interna média de cada sessão não foi diferente, podemos considerar que a sessão de treino do dia em que a coleta foi realizada, também possa ter algum grau de influência na resposta de produção de cortisol, independente da carga total do período de treinamento avaliado.

Nesse estudo, apesar de ter sido verificado um aumento significativo nas concentrações de testosterona nos dois últimos períodos de treinamento, não foi observada alteração na razão T/C com a redução da carga de treino em T4. Reduções nas concentrações de testosterona, em conjunto com o aumento nas concentrações de cortisol, já foram verificadas em períodos de treinamento extenuante em atletas de futebol e outras modalidades esportivas (KRAEMER *et al.*, 2004; MOREIRA *et al.*, 2016). Esta é a razão pela qual a razão T/C foi proposta como sendo um índice útil da relação entre estresse e recuperação em resposta à uma determinada carga de treinamento (URHAUSEN; GABRIEL; KINDERMANN, 1995). Entretanto, apesar das alterações nessa razão poderem ser consideradas como indicativo indireto de um estado de *overreaching*, ela não necessariamente representa o estado de *overtraining*. No presente estudo, a ausência de alteração (redução ou aumento) na razão T/C, em todos os períodos de treinamento mesmo após a maior carga total de treinamento em T2, e a grande redução da carga em T1, sugere que o estímulo de treinamento realizado no presente estudo não representou uma sobrecarga intensa ao organismo das jogadoras que pudesse ser observável através de alterações na razão T/C.

No presente estudo, os maiores valores nas concentrações de testosterona nos períodos T3 e T4 de treinamento estão de acordo com estudos anteriores que sugerem que o treinamento com predomínio aeróbio e de intensidade moderada, podem resultar em aumento dos níveis séricos de testosterona em homens (GRANDYS *et al.*, 2008). Esses autores relataram que um programa de treinamento aeróbico de 5 semanas (4 vezes/semana) aumenta os níveis plasmáticos de testosterona em homens jovens saudáveis. Em estudos com animais, o treinamento aeróbico (5 vezes/semana) aumentou significativamente os hormônios esteroides sexuais plasmáticos e musculares através do aumento das enzimas relacionadas à esteroidogênese (AIZAWA *et al.*, 2006). De fato, em mulheres quase 90% dos níveis circulantes de testosterona são derivados do metabolismo do seu percursor, a desidroepiandrosterona (DHEA), logo, as alterações nas concentrações de testosterona decorrentes do exercício, parecem ocorrer devido ao aumento da conversão metabólica de DHEA.

O fato do aumento das concentrações de T decorrente do treinamento estar associada ao aumento da capacidade aeróbia vai de encontro com o aumento do desempenho no teste de Yo-Yo IR1 (teste de campo para avaliação da capacidade aeróbia) observada nas atletas do presente estudo, nos últimos períodos de treinamento (dados não publicados). De acordo com esses achados, já foram observados que o aumento do VO_2máx após o treinamento em um grupo soldados, ocorre naqueles indivíduos com maior elevação da concentração plasmática de testosterona (REMES; KUOPPASALMI; ADLERCREUTZ, 1979). Esses achados podem ser explicados pelo fato de que a T tem influência em mecanismos como envolvidos no aumento da capacidade aeróbica, como a produção renal aumentada de eritropoietina, e o aumento do transporte de lactato através do sarcolemma muscular (monocarboxilato - MCT1 e MCT4) (ENOKI *et al.*, 2006).

Os resultados desse estudo contrastam com estudos anteriores que verificaram que atletas mulheres podem apresentar consequências negativas na produção de hormônios sexuais relacionadas ao exercício devido à carga de treinamento (WARREN; PERLROTH, 2001). Previamente, já foi relatado que o treinamento de alta intensidade em mulheres pode afetar o sistema reprodutivo feminino, podendo resultar em alterações como interrupção da ciclicidade menstrual, oligomenorréia, amenorréia hipoestrogênica ou supressão lútea. Essas alterações são comuns especialmente quando são acompanhadas de uma ingestão calórica inadequada (TORSTVEIT; SUNDGOT-BORGEN, 2005).

Nesse estudo, nós não observamos evidência de que o treinamento de futebol feminino pode levar a alterações no eixo HPG com consequente diminuição/alteração na produção dos hormônios estradiol e progesterona. No entanto, enfatizamos que a carga de treinamento aplicada ao grupo de atletas, não foi diferente daquela previamente observada em mulheres jovens atletas de futebol que treinam em alto nível (ALEXIOU; COUTTS, 2008). Uma vez que habitualmente essas as atletas participantes do estudo realizam programas de treinamento em seus clubes compostos por 6 a 7 sessões por semana, cada uma com duração de 45-55 minutos, os primeiros períodos de treinamento nesse estudo não podem ser considerados uma sobrecarga a qual não estariam adaptadas.

Além disso, o volume de treinamento realizado pelas atletas do presente estudo, pode ser considerado significativamente inferior ao praticado em modalidades como triátlon e ginástica artística, esportes em que geralmente são identificados distúrbios nos hormônios do ciclo menstrual (TORSTVEIT; SUNDGOT-BORGEN, 2005). O treinamento de atletas mulheres principalmente em modalidades individuais, que muitas vezes acompanham o insuficiente fornecimento de energia e/ou déficit energético (TORSTVEIT; SUNDGOT-BORGEN, 2005), pode ser a principal razão para o nível de alterações nas concentrações de hormônios sexuais femininos, comprometendo o ciclo reprodutivo feminino e, em alguns casos, podendo alcançar níveis diagnosticados como tríade da mulher atletas (TORSTVEIT; SUNDGOT-BORGEN, 2005). Parece provável que quantidades diminuídas de substratos energéticos disponíveis para oxidação durante períodos de suprimento de energia insuficiente sejam o sinal metabólico responsável pelo declínio da função reprodutiva devido à secreção do neuropeptídio Y e sua ação inibitória na secreção do gonadorelina (GnRH) em nível hipotalâmico (CHROUSOS; TORPY; GOLD, 1998). Além disso inibição em nível hipotalâmico da produção de hipotalâmica GnRH pelo hormônio liberador de corticotrofina (CRH) também são evidenciados (CHROUSOS; TORPY; GOLD, 1998).

No presente estudo, uma vez que não foram observadas variações na razão T/C ao longo do treinamento, assim como nas concentrações dos hormônios sexuais femininos, mesmo com variação da carga total semanal, é possível inferir que as cargas de treinamento e os períodos de recuperação prescritos às atletas foram adequados para permitir um balanço entre estresse e recuperação, permitindo ainda um aumento no desempenho físico (dados não publicados). Entretanto, essas conclusões devem ser analisadas com cautela, uma vez que nesse estudo não foram precisamente controlados aspectos como a fase do ciclo menstrual, o estado nutricional das atletas e houve ausência do monitoramento da carga externa de treinamento, fatores que podem influenciar os resultados e devem ser melhor controlados em estudos futuros.

De acordo com nosso conhecimento esse foi um dos primeiros estudos que investigou o efeito do treinamento pré-competitivo no ciclo hormonal de atletas de futebol feminino. Os resultados observados neste estudo podem ser úteis para as atletas do sexo feminino e seus treinadores ao planejar programas de treinamento de futebol. No entanto, para maximizar os efeitos do treinamento, são importantes ainda mais estudos com intuito de desenvolver uma melhor compreensão de como o treinamento e alterações com maiores magnitudes na carga de treino possam afetar o sistema endócrino de atletas de futebol sexo feminino.

Conclusão

Os resultados do presente estudo mostram que as cargas de treinamento nos diferentes períodos prévios à competição não alteraram os ciclos hormonais de atletas de futebol feminino.

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3 CONSIDERAÇÕES FINAIS

Nessa pesquisa foram realizados quatro estudos diferentes, avaliando mais de 200 atletas de futebol feminino de nível internacional, proporcionando a possibilidade de maior compreensão sobre as características físicas e fisiológicas dessas atletas em treinamento e competição.

No estudo 1, foi realizada a caracterização e comparação do desempenho em testes físicos dessas atletas (Objetivo Específico 1), além da comparação do desempenho de atletas selecionadas e não selecionadas para competições internacionais (Objetivo Específico 2, estudo 1). Os resultados mostraram que existe uma evolução do desempenho físico ao longo das categorias, sendo que os desempenhos no Yo-Yo IR1e no SJ são capazes de diferenciar todas as categorias, com maiores valores observados nas categorias mais velhas. Embora as melhorias observadas no desempenho em testes físicos ao longo das categorias permitem inferências sobre a prescrição do treinamento apropriado à idade (LLOYD *et al.*, 2015) o presente estudo não investigou a influência da maturação sexual nessas variáveis. Dessa forma, sugere-se que outros estudos sejam feitos considerando essa perspectiva.

Nesse estudo, o desempenho no Yo-Yo IR1 apresentou uma diferença de quase 45% na categoria sênior quando comparado às categorias mais jovens. Sabe-se que a seleção de atletas é um processo complexo e, portanto, exige que diferentes aspectos sejam investigados, porém esse trabalho traz um indicativo de que a performance no Yo-Yo IR1 pode ser um bom indicador de desempenho em atletas de alto nível, uma vez que parecem auxiliar na discriminação entre atletas selecionadas e não selecionadas para fazer parte da seleção brasileira em competições internacionais. Portanto, parece importante que esse teste seja incluído em procedimentos de avaliação e detecção de atletas no futebol feminino.

Além disso, uma vez que o bom desempenho aeróbico permite a recuperação entre os esforços de alta intensidade, o maior desempenho no Yo-YoIR1 da categoria sênior parece ser uma das justificativas para os maiores valores de distância total, distância em alta intensidade, distância em sprints, número de acelerações e desacelerações observados durante partidas oficiais na categoria sênior quando comparado às categorias inferiores (Objetivo específico 3, estudo 2).

Nesse estudo, a categoria U-20, composta de atletas que já treinam ou mesmo atuam em clubes profissionais, apresentou menores valores de distância total, distância em sprints, número de acelerações e desacelerações quando comparada à categoria adulta. Considerando que essas atletas possuem chances de atuar como a próxima geração de jogadoras profissionais, compondo times participantes dos campeonatos profissionais nacionais e da própria seleção nacional, é interessante que estratégias de desenvolvimento da capacidade aeróbica sejam utilizadas nessa categoria.

Diferenças observadas entre as posições das atletas em partidas oficiais podem auxiliar no processo de direcionamento do treinamento para atender as demandas específicas e individuais de jogo (REILLY, 2005). Partindo desse pressuposto, avaliamos as atletas de diferentes categorias de acordo com suas posições em campo, e observamos que as laterais das categorias Sub-20 não apresentaram diferenças no desempenho físico em distância em alta intensidade, sprint e número de acelerações em relação às atletas sênior. Isso pode ser um indicativo que para algumas posições específicas as atletas de categoria de base já estariam com desempenho físico próximo à categoria profissional.

No entanto, é importante ressaltar que foram observadas queda no desempenho físico de atletas da categoria Sub-20, principalmente no segundo tempo e ao final dos jogos oficiais (Objetivo específico 4, estudo 3). Dado que essas também apresentaram menor desempenho em testes físicos e de distância percorrida em jogos quando comparadas às atletas sênior, deve-se ter cautela quanto à decisão de inserção de uma atleta de uma categoria mais jovem em detrimento de uma mais velha durante uma partida. Estudos investigando o desempenho ao longo do jogo incluindo diferentes categorias que competem em torneios oficiais organizados pela FIFA podem auxiliar na compreensão desses fatores.

A queda no desempenho observada principalmente no segundo tempo e aos 15 minutos finais de jogo, está de acordo com a hipótese de que as jogadoras de futebol feminino experimentam sinais de fadiga durante os jogos. Assim, parece que estratégias para atenuar essa redução no desempenho podem ser interessantes como, por exemplo, substituições no intervalo ou ao decorrer da partida (MOHR; KRUSTRUP; BANGSBO, 2003a). Vale ressaltar que a queda no desempenho ocorreu mesmo quando as partidas apresentavam resultados de empate e, portanto, não seria esperada uma redução da intensidade de jogo decorrente do placar, como já demonstrado anteriormente, principalmente ao final do jogo (BRADLEY; NOAKES, 2013).

No presente estudo, não observamos variações nas concentrações hormonais das atletas submetidas aos períodos de treinamento com a seleção brasileira, incluindo as concentrações dos hormônios sexuais femininos, mesmo com variação da carga total semanal (Objetivo específico 5, estudo 4). Com isso, é possível inferir que as cargas de treinamento e os períodos de recuperação prescritos foram adequados para permitir um balanço entre indicadores do nível da adaptação e remodelação induzidas pelo esforço do treinamento, o que evitou também uma redução na razão T/C.

Em parte, esses resultados são diferentes daqueles observados anteriormente na literatura (FREITAS *et al.*, 2014) que verificaram alterações nas concentrações de cortisol salivar em jogadores de futebol concomitantemente à variação na da carga de treinamento. No entanto, cabe ressaltar que no presente estudo a carga de treinamento não possuía o objetivo de gerar uma sobrecarga física elevada às atletas e a variação da carga interna dos treinamentos foi de baixa magnitude, o que pode ter contribuído para a ausência de modificações nos ciclos hormonais. Mesmo assim, o período de treinamento pré-competitivo aumentou as concentrações de testosterona salivar com a proximidade da competição e um aumento na razão T/C no período noturno (momento de recuperação) fator que demonstra a adaptabilidade das atletas ao treinamento e a adequação das cargas para adaptações positivas.

Em conjunto, os resultados desse estudo apresentam parâmetros de avaliações físicas para atletas de futebol feminino em diferentes categorias e demonstram que os resultados no teste de Yo-Yo IR1 parecem ser importantes na detecção de atletas selecionadas para a disputa de competições internacionais de futebol feminino. Além disso, o aumento progressivo no desempenho físico de jogo de acordo com a categoria avaliada, sugere que o treinamento deve seguir uma carga progressiva de acordo com a categoria, porém carga de treinamento pré-competitivo não altera os ciclos hormonais de atletas de futebol feminino.

De um modo geral, esses resultados trazem informações relevantes para o futebol feminino, principalmente do Brasil, no que diz respeito ao desempenho físico de atletas de alto nível. Para ser possível um melhor desenvolvimento da modalidade, parece ser interessante que os profissionais das equipes de futebol feminino se atentem ao desenvolvimento de capacidades físicas específicas da modalidade em atletas desde as categorias de base.

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ANEXOS

Anexo I – Parecer de aprovação do COEP / UFMG

UNIVERSIDADE FEDERAL DE MINAS GERAIS

PARECER CONSUBSTANCIADO DO CEP

DADOS DO PROJETO DE PESQUISA

Título da Pesquisa: Avaliação das possíveis alterações dos ritmos biológicos de mulheres atletas de futebol submetidas a condições de treinamento físico e competição.

Pesquisador: Cândido Celso Coimbra

Área Temática: Genética Humana:
(Trata-se de pesquisa envolvendo Genética Humana que não necessita de análise ética por parte da CONEP;);

Versão: 1

CAAE: 30514414.5.0000.5149

Instituição Proponente: UNIVERSIDADE FEDERAL DE MINAS GERAIS

Patrocinador Principal: CNPQ

DADOS DO PARECER

Número do Parecer: 648.430

Data da Relatoria: 14/05/2014

UNIVERSIDADE FEDERAL DE MINAS GERAIS

Continuação do Parecer: 648.430

Necessita Apreciação da CONEP:
Não

Considerações Finais a critério do CEP:
Aprovado conforme parecer.

BELO HORIZONTE, 15 de Maio de 2014

Assinado por:
Maria Teresa Marques Amaral
(Coordenador)

Anexo II – Carta de aceite artigo: Movement patterns of an U-20 National female soccer team during competitive matches

International Journal of Sports Medicine - Decision on Manuscript ID IJSM-11-2016-5983-tt.R2

01-May-2017

It is a pleasure to accept your manuscript entitled "Movement patterns of an U-20 National female soccer team during competitive matches" in its current form for publication in the International Journal of Sports Medicine.

The galley proofs will be sent to you within a few weeks. After receipt of your printing approval, your article will be published online ahead of print (eFirst) at www.thieme-connect.com. Please note that the date of the online publication is the definite publication date of your article.

Thank you for your fine contribution. On behalf of the Editors of the International Journal of Sports Medicine, we look forward to your continued contributions to the Journal.

Sincerely,

Prof. Jose Duarte

Editor, International Journal of Sports Medicine

jarduarte@fade.up.pt

Anexo III – Carta de correções artigo: Activity profiles in U17, U20 and senior women's Brazilian National soccer teams during international competitions: Are there meaningful differences

JSCR-08-8647, entitled "Activity profiles in U17, U20 and senior women's Brazilian National soccer teams during international competitions: Are there meaningful differences?"

Expert reviewers carefully evaluated your manuscript. The comments are included below. The reviewers wanted to give you a chance to revise and address the experimental concerns. Thus, you and your research team need to really revise your paper with this in mind.