CRISTIANO DINIZ DA SILVA

DETERMINAÇÃO DA CARGA FISIOLÓGICA IMPOSTA NO JOGADOR DE FUTEBOL INFANTIL E INDICADORES TÉCNICOS DE TREINO

Dissertação apresentada à Universidade Federal de Viçosa como parte das exigências do Programa de Pós-Graduação em Educação Física, para a obtenção do título de *Magister Scientiae.*

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APROVADA: 19 de março de 2009

Prof. Antônio José Natali
(Co-Orientador)

Prof. Jorge Roberto Perrout de Lima
(Co-Orientador)

Prof. Maurício Gattás Bara Filho

Prof. Emerson Silami Garcia

Prof. João Carlos Bouzas Marins
(Orientador)

Dedico
aos meus pais, Geraldo e Ana Maria,
a minha irmã, Ana Cristina,
aos meus amigos, professores e funcionários
do Departamento de Educação Física da UFV,
pela força, incentivo e auxílio porque sem vocês
nada disso teria sido possível.
Dedico também aos filhos que ainda terei.

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”Na ciência, a verdade pode ser definida como a hipótese de trabalho mais adequada para abrir o caminho para a próxima melhor hipótese.”

Konrard Lorenz

BIOGRAFIA

CRISTIANO DINIZ DA SILVA, filho de Geraldo Araújo da Silva e Ana Maria Diniz da Silva, nasceu no dia 14 de maio de 1980, na cidade de Viçosa, Minas Gerais.

Em abril de 1999, ingressou no Curso de Educação Física na Universidade Federal de Viçosa. Foi bolsista do Projeto "Bom de bola, bom de nota" da Prefeitura Municipal de Viçosa, MG, entre os períodos de maio de 2001 a dezembro de 2002, obtendo experiências de docência na área de atletismo e futebol. Graduou-se em março de 2003 em Licenciatura e Bacharelado.

No período de fevereiro a setembro de 2003, atuou como instrutor de Musculação na academia do colégio Anglo, em Viçosa, MG. De outubro de 2003 a janeiro de 2004, atuou como *personal trainer* na Clínica Espaço Vitae - Dietoterapia e Atividade Física, Viçosa, MG.

Em janeiro de 2004 ingressou no curso de Especialização em Futebol na Universidade Federal de Viçosa com conclusão em março de 2005. Em fevereiro de 2004 atuou como docente nas escolas estaduais "Effie Rolfs e José Lourenço de Freitas", ambas localizadas em Viçosa, MG. De maio de 2004 a março de 2007 atuou como professor da sala de musculação e avaliação morfofuncional do Clube Recanto das Águas, Viçosa, MG.

Em março de 2007, ingressou no Programa conveniado (UFV-UFJF) de Pós-graduação em Educação Física, em nível de Mestrado, na Universidade Federal de Viçosa, concluindo os requisitos para obtenção do título de "Magister Scientiae" com defesa de dissertação em março de 2009. Durante esse período atuou como secretário da Revista Brasileira de Futebol e professor convidado do Curso de Especialização em Futebol dessa instituição.

SUMÁRIO

RESUMO

SILVA, Cristiano Diniz, M.Sc., Universidade Federal de Viçosa, março de 2009. **Determinação da carga fisiológica imposta no jogador de futebol infantil e indicadores técnicos de treino**. Orientador: João Carlos Bouzas Marins. Co-orientadores: Antônio José Natali e Jorge Roberto Perrout de Lima.

O primeiro artigo visou estabelecer, através de uma revisão bibliográfica, a utilização da frequência cardíaca (FC) como parâmetro de mensuração de intensidade de exercício (IE) no futebol. Ficou evidenciado que a FC apresenta relação linear com o VO_2 mesmo nas ações intermitentes do futebol e sua relativização na forma de percentual da freqüência cardíaca máxima (FCM) ou da freqüência cardíaca de reserva (FCres) tem sido recomendados por serem simples e por permitirem comparações interindividuais, intraindividuais e de diferentes tipos de atividades. A IE média imposta em jogo, entre profissionais, está entre 70 e 80% do $V0_{2MAX}$ ou de 80 a 90% FCM. Essa tendência também é observada em jogadores mais jovens, recreativos e mais velhos. A zona de IE mais prevalente é de 70 a 90% da FCM, com aproximadamente 65% do tempo de jogo. Os jogadores de meio-campo são os que apresentam a maior média de IE, seguidos pelos atacantes e zagueiros. Há redução de IE no segundo tempo, demonstrando ser mais acentuada em jogadores recreativos e mais velhos. Treinamentos técnicos tradicionais com bola são menos intensos em comparação a treinos táticos, a minijogos ou coletivos, e mesmo estes últimos podem não corresponder às exigências de IE das partidas. Recomenda-se que estudos ampliem os tamanhos amostrais e o perfil de praticantes, assim como especifiquem melhor a IE para as diversas posições de jogo e nas diversas interações táticas. O segundo artigo objetivou determinar a IE durante jogos competitivos em jovens jogadores (Sub-15) Brasileiros de futebol, assim como comparar posições de jogo. A FC foi monitorada em vinte e um jogadores de futebol de duas equipes (Média ± DP; idade 14 ± 0.5 anos; peso 61.5 ± 6.5 kg; estatura 172 ± 7 cm) durante três partidas de futebol completas do Campeonato Mineiro Infantil (Sub-15). IE durante o primeiro (86.1 ± 3.4%FCM) foi maior significativamente que o segundo tempo (83.8 ± 4.1% FCM; $P<0.05$). IE nos 10 minutos depois do intervalo de jogo foi inferior que esses ao término da primeira metade e do que os 10 minutos do fim do segundo tempo ($P<0.05$). No segundo tempo os jogadores aumentaram o tempo de permanência em zonas de IE menor (<70%FCM [6.2 ± 9.5 vs. 3.5 ± 4.3%] e 71-85%FCM [43.3 ± 12 vs. 36.4 ± 13.4%]) e eles diminuíram nas maiores (91-95%FCM [20 ± 9.1 vs. 24.2 ± 10.3%] e >96%FCM [6.2 ± 5.6 vs. 9.8 ± 7.4%]) (P<0.05). Depois dos cinco minutos mais intensos da partida, houve redução (~5.5%) na IE nos cinco minutos subseqüentes (91.4 ± 3.6%FCM para 85.9 ± 4%FCM; P<0.05) que tendeu a ser menor que IE da metade de jogo considerada (86.4 ± 3.6%FCM) (P>0.05). Os laterais e meio-campistas demonstraram IE mais alta (88 ± 1.5%FCM e 86.9 ± 1.8%FCM, respectivamente) (P<0.05) como comparado aos zagueiros e atacantes (82 ± 4.5%FCM e 82.4 ± 1.8%FCM, respectivamente). Conclui-se que EI é de alta intensidade e diminui no segundo tempo de jogo. Os jogadores desenvolvem fadiga temporária durante a partida e EI é específico por posição de jogo e influenciando por tarefas táticas. O objetivo do terceiro artigo foi verificar a validade concorrente de dois testes de campo (Yo-Yo IR2 e Teste de Margaria) com o desempenho em alta intensidade de exercício durante jogos de competição em jovens jogadores (Sub-15), confiabilidade de suas medidas, e como critérios para obtenção da frequência cardíaca máxima (FCM) frente ao estímulo de jogo. Dezoito jogadores de uma mesma equipe em dois jogos oficiais do Campeonato Mineiro Infantil (Média ± DP; idade 14 ± 0,8 anos, estatura 172 ± 9 cm, peso 64,3 ± 8,5 kg) foram avaliados. Ficou demonstrado uma alta correlação entre o desempenho no Yo-Yo IR2 e no percentual de tempo de permanência acima de 85% da FCM individual (PTP>85%FCM) (rs=0,71; P<0,05). Não houve correlação estatisticamente significante entre o desempenho no Teste de Margaria (TM) e PTP>85%FCM (rs=0,44; P=0,06). O Yo-Yo IR2 se mostrou mais variável e menos reprodutível (CV= 11%; CCI [95% IC]= 0,38) do que TM (CV= 1%; CCI [95% IC]= 0,93). Porém, nenhuma extrapolação considerável aos limites de concordância ocorreu segundo Bland-Altman. O maior valor de FCM (P<0,001) ocorreu no jogo (202 ± 8 bpm). A FCM no Yo-Yo IR2 (194 ± 4 bpm) foi menor (P<0,006) do que TM (197 ± 6 bpm). Conclui-se que o Yo-Yo IR2 pode ser considerado mais válido para o critério de manutenção de alta intensidade de exercício em jogo que é uma importante medida de desempenho no futebol. Porém, há necessidade de padronização rigorosa entre os procedimentos de avaliação para estabilidade da medida. A FCM deve ser observada em diversas

situações, principalmente competitiva, para possibilitar que ocorra o maior valor individual. O quarto artigo objetivou avaliar o impacto da mudança no número de jogadores na IE, percepção subjetiva de esforço (IPE) e nas demandas técnicas (DTs) de três modelações de minijogos (MJs), assim como confiança da medida em jovens jogadores (Sub-15). Dezesseis jogadores de futebol masculinos (Média ± DP.; idade 13.5 ± 0.7 anos, estatura 164 ± 7 cm, peso 51.8 ± 8 kg) participou duas vezes em 3 vs. 3 (MJ3); 4 vs. 4 (MJ4) e 5 contra. 5 (MJ5) jogados em três *sets* de 4min separados com 3min de recuperação em campo de 30x30m. Filmagens foram feitas e as análises de DT foram executas usando um sistema de anotação manual. Não houve nenhum efeito principal simples na IE por "número de jogadores" no primeiro set (MJ3=87.9 ± 3%FCM; MJ4=86.7 ± 3%FCM; MJ5=85.8 ± 4%FCM). IE no segundo set foi maior ($P<0.05$) em MJ3 (90.5 ± 2%FCM) em relação a MJ4 (89.2 ± 2%FCM) e MJ5 (87.5 ± 4%FCM). IE no terceiro set para MJ5 (87.6 ± 3%FCM) foi menor ($P<0.05$) que no outro dois MJs (90.9 ± 2%FCM e 89.8 ± 2%FCM para MJ3 e MJ4, respectivamente). IE no primeiro set para todas as condições de MJs foi menor do que no segundo ($P<0.05$). IE no segundo set em todas as condições de MJs não diferiu do terceiro. O IPE no MJ3 (3.04 ± 0.71) foi maior no segundo *set* em relação ao segundo set no MJ4 (2.52 ± 0.60) e segundo *set* no MJ5 (2.39 ± 0.74). IPE não diferiu no primeiro e terceiro *set* entre os MJs como também entre os *sets* dentro de mesmo MJ. Nenhuma diferença significante foi observada em EB, passes, passes com sucesso, "esbarrões" e cabeceios entre todas as condições de MJs. Porém, foram observados mais passes longos, dribles e chute a gol jogando MJ3 ($P<0.05$). Essas diferentes condições de MJs não afetaram a variabilidade (CV) da IE (~8%). Um CV menor na maioria de DTs foi observado para MJ3. A maturação de jogador não correlacionou com IE ou número de EB em nenhum das condições de MJs. Conclui-se que o formato com menor número de jogadores pode prover valor maior de EI. Os MJs não alteram a maioria de DTs, porém formatos com número maior de jogadores podem prover estímulo técnico de um modo mais confiável. O IPE demonstrou não ser uma medida confiável de IE nos MJs nessa categoria.

ABSTRACT

SILVA, Cristiano Diniz, M.Sc., Universidade Federal de Viçosa, March of 2009. **Determination of the physiologic load imposed in youth soccer player and technical indicators of training.** Adviser: João Carlos Bouzas Marins. Co-Advisers: Antônio José Natali and Jorge Roberto Perrout de Lima.

The first article sought to establish, through a bibliographical revision, the use of the heart rate (HR) as measure parameter of exercise intensity (EI) in soccer. It was evidenced that HR presents linear VO_2 relation in the intermittent actions of the soccer and its relation in the form of percentage of the maximum heart rate (MHR) or percentage of HR reserve (HRres) has been recommended for be simple and for allow comparisons inter individual, intra individual and of different types of activities. The mean EI during professional matches is around 70 and 80% $V0_{2MAX}$ or 80 and 90% MHR. Such values are also observed in youth, master and recreational soccer players. The prevalent EI in a soccer match is around 70 and 90% of the MHR in approximately 65% of the match duration. Midfield players present the higher mean EI followed by the strikers and full-backs. Exercise intensity is reduced in the second half, especially in master and recreational players. Traditional technical training using balls are less intense compared with tactic training and small-sided games or simulated matches. We recommend that studies on EI with greater soccer player number and that distinguish the player position on the field are carried out. The second article aimed to determine the EI during competitive games in young Brazilian soccer players (U-15), as well as comparing players´ position. Heart rate was monitored in twenty-one soccer players (mean age 14 ± 0.5 years; body weight 61.5 ± 6.5 kg; height 172 ± 7 cm) during three complete soccer matches. EI during the first (86.1 ± 3.4%MHR) was larger than second half (83.8 ± 4.1%MHR; P<0.05). EI in 10 minute after the half-time was lower than those at the end of the first half and the end of the second half (P<0.05). In the second half the players increased the time spent in zones of smaller EI (<70%MHR [6.2 ± 9.5 vs. 3.5 ± 4.3 %] and 71-85%MHR [43.3 ± 12 vs. 36.4 ± 13.4%]) and they decreased in the larger (91-95%MHR [20 ± 9.1 vs. 24.2 ± 10.3%] and >96%MHR [6.2 ± 5.6 vs. 9.8 ± 7.4%]) (P<0.05). After the more intensive 5-minute interval of the match, there was a reduction (~5.5%) in the EI in the subsequent 5-minute (91.4 ± 3.6% to 85.9 ± 4%;

P<0.05) which tended to be smaller than EI of the considered half (86.4 ± 3.6) (*P*>0.05). The external defenders and midfielders demonstrated higher (*P*<0.05) EI (88 ± 1.5%MHR and 86.9 ± 1.8%MHR, respectively) as compared to central defenders and forwarders (82 ± 4.5%MHR and 82.4 ± 1.8%MHR, respectively). We conclude that the mean EI is of high intensity and decreases in the second half. The players develop temporary fatigue during the match and EI is specific for players´ position and influenced by tactical tasks. The objective of the third article was to verify the concurrent validity of two field tests (Yo-Yo IR2 and Test of Margaria) with the acting in high exercise intensity during competitive games in young players (U-15), reliability of their measures, and as criteria for obtaining of the maximum heart rate (MHR) front to the game stimulus. Eighteen players (mean ± DP; age 14 ± 0,8 years, height 172 ± 9 cm, weight 64,3 ± 8,5 kg) belonging to the same team were appraised in test-retest referred protocols and in the percentage of time spent above 85% of MHR (PTS>85%MHR) in two official games of the U-15 Championship. A high correlation was found among the performance in Yo-Yo IR2 and PTS>85%MHR (rs=0,71; p<0,05). There was not correlation among the performance in MT and PTS>85%MHR (rs=0,44; p=0,06). Yo-Yo IR2 shown more variable and less reproductively (CV= 11%; CCI [95% IC]=0,38) than MT (CV= 1%; CCI [95% IC]=0,93). However, any considerable extrapolation to the Bland-Altman agreement limits happened. The largest value of MHR (p<0,001) happened in the game (202 ± 8 beats.min^{-1}). MHR in Yo-Yo IR2 (194 ± 4 beats.min^{-1}) was smaller (p<0,006) than MT (197 ± 6 beats.min^{-1}). In conclusion, the Yo-Yo IR2 can be considered more valid for the criterion of maintenance of high exercise intensity in game that is an important acting measure in the soccer. However, there is need of rigorous standardization among the evaluation procedures for stability of the measure. MHR should be observed in several situations, mainly competitive, to make possible that happens the largest individual value. The fourth article aimed to evaluate the impact of the change in the number of players in EI, Rating of perceived exertion (RPE) and in the technical demands (TDs) of three small-sided games formats (SSGs), reliability of the measure in young players (U-15). Sixteen male soccer players (mean±S.D.; age 13.5 ± 0.7 years, height 164 ± 7 cm, weight 51.8 ± 8 kg) participated twice in 3 vs. 3 (SSG3); 4 vs. 4 (SSG4) and 5 vs. 5 (SSG5) performed in three 4 min bouts separated with 3 min recovery in pitch of 30x30m. Heart rate measurements were made and EI was expressed in relation to the maximal individual heart rate pick value (MHR) during the SSGs. Filming were made and TDs were analyzed using a hand notation system. There is no simple main effect “number of players” in EI at first set (SSG3=87.9 ± 3%MHR; SSG4=86.7 ± 3%MHR; SSG5=85.8 ± 4%MHR). EI in the second set was larger (P<0.05) in SSG3 (90.5 ± 2%MHR) in relation to SSG4 (89.2 ± 2%MHR) or SSG5 (87.5 ± 4%MHR). EI in third set for SSG5 (87.6 ± 3%MHR) were smaller (P<0.05) than in the other two SSGs (90.9 ± 2%MHR and 89.8 ± 2%MHR for SSG3 and SSG4, respectively). EI in first set for all SSGs conditions was smaller than second (P<0.05). EI in second set in all SSGs condition did not differ of the third. RPE in SSG3 (3.04 ± 0.71) was larger in second set in relation to second set in SSG4 (2.52 ± 0.60) and second set in SSG5 (2.39 ± 0.74). RPE did not differ in the first e third set among different SSG's as well as among the sets inside of same SSG. No significant differences were observed in IWB, pass, target pass, tackles and headers between all SSGs conditions. However, significantly more crosses, dribbles, and shot on goal were observed playing SSG3 (P<0.05). SSGs conditions do not affect variability measure for coefficient of variation (CV) for EI (~8%). The smallest CV in most of TDs was observed for SSG5. In summary, that smaller format can provide larger value of EI. SSGs conditions do not alter the majority of TDs, however formats with larger number of players can provide technical stimulus in a more reliable way. RPE demonstrated not to be a reliable measure of EI in SSG’s in that category.

INTRODUÇÃO GERAL

Para se aprimorar o desempenho de jovens jogadores de futebol é necessário diagnosticar qual intensidade de exercício esses atletas são submetidos em competição, criando conhecimento para que os treinamentos sejam planejados de forma específica para a demanda imposta nas partidas nesse público. Muitos métodos e meios de treinamentos utilizados atualmente no treinamento de jovens no futebol é, em sua grande maioria, baseado na tradição de treinamentos em adultos e nos conhecimentos empíricos da comissão técnica. Porém, jovens jogadores não são "adultos em miniaturas" e os treinadores devem estar atentos a isso, respeitando as características fisiológicas desses jogadores que estão em fase de maturação e crescimento físico[1,2].

Diferentes indicadores têm sido utilizados para determinar a intensidade de exercício no futebol como porcentagem do máximo consumo de oxigênio (%$VO_{2máx}$)[3,4], da velocidade de deslocamento[5,6], do limiar anaeróbico[5,7,8], percepção subjetiva de esforço[9], respostas termorregulatórias[10,11], assim como através do comportamento da frequência cardíaca (FC)[8,12-14]. Embora a intensidade de exercício mensurada através de medida direta do consumo de oxigênio (VO_2) seja considerada padrão ouro[15,16], esse método se vê aplicável somente em circuitos ou jogos simulados, pois sua utilização durante jogos oficiais é proibida e incompatível com situações competitivas[12,17].

Comparado com esses indicadores, a FC é fácil para monitorar, de baixo custo, não é invasivo e pode ser usado na maioria das situações com boa validade e confiabilidade[18-20], pois oferece alto grau de relacionamento com o VO_2, mesmo em atividades intermitentes, como o futebol, em jogadores profissionais[5,21], amadores[20,22] e jovens[19,23]. Atualmente a interpretação de dados de frequência cardíaca é facilitada pelo desenvolvimento da tecnologia de telemetria de rádio. Os denominados "sistema de time" possibilitam a gravação de dados para todos os membros da equipe ao mesmo tempo, sendo usada por muitos times profissionais europeus em diferentes contextos de treinamentos[17].

O futebol é uma forma exigente de exercício no qual os jogadores adultos em situação de competição estão expostos a uma taxa de intensidade de exercício em torno de 75-80% do $VO_{2máx}$[3,4,10] ou de 80-90% da freqüência cardíaca máxima individual[4,7,24,25]. No entanto, apesar dessa crescente necessidade de otimização do desenvolvimento de jovens jogadores pouca atenção tem sido prestada a esse público em termos científicos conforme consulta via *PUBMED* cruzando as palavras "*soccer players", "young" e "match play"*[1]. Dos trabalhos pesquisados relacionados ao tema, o padrão de intensidade de exercício em jovens jogadores dinamarqueses[14] e italianos[13] em partidas de competição segue o observado para adultos. Pesquisando também a base de dados da *SIBRADID*[2] com as palavras "*futebol", "adolescente" e "partida"* nota-se que não foram publicados estudos também no Brasil, nem sequer para as demais categorias. Estas consultas foram feitas no dia 21/02/2009.

Apesar da maioria destes estudos serem oriundos da Europa, aspectos étnicos, culturais, geográficos ou de regras locais para jovens jogadores influenciam na seleção e desenvolvimento de talentos[26] podendo gerar diferentes estilos de jogar futebol entre os países e, conseqüentemente, diferente requerimento de demanda de esforço durante o jogo[15,27-29]. Além disso, a intensidade de exercício no jogo e desenvolvimento de fadiga no decorrer dele pode estar atrelada ao nível competitivo avaliado, pois a quantidade de atividades em alta intensidade de exercício na partida é correlacionada com o nível dela[5,10,30].

Além das informações de intensidade de exercício mantida em competição, outra questão importante como referência para desígnio de programas de condicionamento físicos é a avaliação da capacidade aeróbica, que é útil também para seleção de jogadores e para predizer e monitorar desempenho físico deles

[1] Site: http://www.pubmedcentral.nih.gov/
[2] Site: http://www.sibradid.eef.ufmg.br/pesquisa/Avancada.html

em competições[29]. No entanto, a validade de testes com característica retilínea e contínua de movimentação para o futebol pode ser questionada por não refletir a resposta fisiológica do jogo[16,31]. Nesse sentido o Yo-Yo IR2 tem sido recomendado como ótima medida de avaliação para o futebol[31,32] por tentar simular o desempenho do futebol através de corridas de idas e voltas intervaladas com pequenos intervalos de descanso.

O desempenho obtido no Yo-Yo IR2 tem demonstrado correlação significante com o tempo de fadiga em teste progressivo de corrida em esteira, com o VO_{2max} e forte correlação com a máxima distância de deslocamento coberta em cinco minutos durante jogo em jogadores adultos de elite[33]. Outra indicação de seu emprego é a possibilidade de ser observada a frequência cardíaca máxima (FCM) do avaliado durante sua realização, não diferindo dos valores observados nos procedimentos de teste de exaustão conduzidos em esteira[31,33].

Embora estudos prévios, como relatados anteriormente, tenham demonstrado as vantagens do Yo-Yo IR2 para o futebol há uma carência de estudos (nenhuma referências acusada em 21/02/2009 via *PUBMED* cruzando as palavras *"Yo-Yo test"*, *"soccer"* e *"young"*[3] *e* nenhuma em *SIBRADID*[4] com as palavras *"yo-yo test"*, *"futebol"* e *"adolescente"*) com jogadores jovens buscando detectar a validade concorrente[34] pelo desempenho em alta intensidade de exercício durante jogos oficiais. Da mesma forma, há carência na avaliação da confiabilidade e adequação dessa medida para observação da FCM ou mesmo comparação desses aspectos a outro procedimento de avaliação em campo. A informação da FCM é importante fator para relativização de intensidades de cargas na prescrição de treinamentos.

Minimizar os efeitos deletérios da fadiga no desempenho dos jogadores de futebol demanda prescrição de treinamentos mais específicos. Atualmente os chamados minijogos podem ser utilizados para aprimorar a resistência aeróbica de forma específica para o futebol com a vantagem de ser multifatorial[35-37]. A

[3] Site: http://www.pubmedcentral.nih.gov/
[4] Site: http://www.sibradid.eef.ufmg.br/pesquisa/Avancada.html

presença da bola impõe uma atividade específica e permite a melhoria concomitante de habilidades técnicas e táticas com alta motivação do jogador[38,39]. Dessa forma, a adoção dessa estratégia se torna uma alternativa interessante para jovens jogadores[39], desde que eles combinam as ações de jogo em forma mais realística desenvolvendo a musculatura específica, fazendo a transferência das adaptações de forma mais fácil para situações competitivas. No entanto, há carência de informação (sete referências acusadas em 21/02/2009 via *PUBMED* cruzando as palavras "*soccer", "youth" e "small-sided"*[5] *e* nenhuma em *SIBRADID*[6] com as palavras "*futebol, adolescente e treinamento"*) em relação à intensidade de exercício, demanda técnica e confiança de medida nessas modelações de treinamentos em jogadores da categoria Sub-15.

Portanto, os resultados obtidos neste trabalho poderão contribuir na construção do conhecimento sobre a intensidade de exercício em jovens jogadores de futebol (Sub-15), permitindo saber em que medida as exigências físicas acontecem em situação competitiva e em alguns formatos de minijogos e, da mesma forma, verificar os indicadores técnicos dos mesmos nessa categoria. A avaliação do teste de campo com maior validade e confiabilidade permitirá também conhecer qual protocolo simula uma carga física para alto desempenho no futebol e ainda se os estímulos dessas avaliações ou de jogo são melhores para obtenção da FCM. Isto permitirá aumentar a precisão na dosagem das cargas físicas no treinamento, adequações de treinamentos técnicos, assim como elaboração de estratégias para manutenção de desempenho dos jogadores durante jogo de acordo com a intensidade de exercício requerida no futebol brasileiro.

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[5] Site: http://www.pubmedcentral.nih.gov/
[6] Site: http://www.sibradid.eef.ufmg.br/pesquisa/Avancada.html

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OBJETIVOS

OBJETIVO GERAL

Determinar a carga fisiológica no jogador de futebol infantil em competição e treinamento, assim como o nível de influência sobre os indicadores técnicos.

OBJETIVOS ESPECÍFICOS

Esta dissertação foi estruturada com quatro sub-tópicos de objetivos específicos, onde cada um deu origem à confecção de um artigo, sendo distribuído da seguinte forma:

(i) estabelecer através de uma revisão bibliográfica a utilização da FC como parâmetro de mensuração de intensidade de exercício no futebol;

(ii) determinar a intensidade de exercício durante jogos competitivos em jovens jogadores (Sub-15) Brasileiros de futebol, assim como comparar posições de jogo;

(iii) verificar a validade concorrente de dois testes de campo (Yo-YoIR2 e Teste de Margaria) com o desempenho em alta intensidade de exercício durante jogos de competição em jovens jogadores (Sub-15), confiabilidade de suas medidas, e como critérios para obtenção da frequência cardíaca máxima (FCM) frente ao estímulo de jogo;

(iv) avaliar o impacto da mudança no número de jogadores na intensidade de exercício, IPE e nas demandas técnicas de três modelações de minijogos, assim como confiança da medida em jovens jogadores (Sub-15).

ARTIGO 1: EXERCISE INTENSITY DURING COMPETITIVE MATCH PLAY AND TRAINING MONITORED BY THE HEART RATE IN SOCCER PLAYERS

Type of Publication: REVIEW ARTICLE

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Brief running head: HEART RATE IN SOCCER GAMES AND TRAINING

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ABSTRACT

The identification of physiological loads imposed by a soccer match reveals important information which may help to improve the player training and recovery strategies. The technological advance in heart rate (HR) recording equipment resulted in a widely use of HR to monitor exercise intensity (EI) during several sport situations. The aims of this review are to analyze and compare the EI monitored by HR in professional, youth and recreational soccer players during matches and training sessions. The mean EI during professional matches is around 70 and 80% $V0_{2MAX}$ or 80 and 90% MHR. Such values are also observed in youth, master and recreational soccer players. The prevalent EI in a soccer match is around 70 and 90% of the MHR in approximately 65% of the match duration. Midfield players present the higher mean EI followed by the strikers and full-backs. Exercise intensity is reduced in the second half, especially in master and recreational players. Traditional technical training using balls are less intense compared with tactic training and small-sided games or simulated matches. We recommended more studies with a larger number of players in the sample and with distinction of players' position in the different game systems.
Key-words: Soccer. Heart rate. Exercise intensity. Sportive training.

1. INTRODUCTION

Soccer is the most popular sport in the world practiced by men, women, children, young persons and adults, with different levels of skill.[1] There are records that point to the existence of nearly 200 million soccer players in the entire world.[2] More than 12.000 Brazilian players play as professional registered in national clubs or abroad,[3] and the recreational apprentices' number reaches in the millions. Independent of the level and age group of the players, when a soccer game is disputed, there are basic characteristics of motor and metabolic solicitations which repeat themselves during the match. So, it has been observed that intermittent activities of high intensity, characterized by short duration sprints, jumps, headers and ball fights, are intercalated with moments of walking and standing.[4-8]

These characteristics of motor solicitation and the long duration of the game requires that players present differentiated physical conditioning, at the competitive level, when one considers the position occupied on the field.[4,9,10] This specificity of play position is due to the physiological load that each position is subjected to in competition and different types of trainings,[1,4,11,12] when marked outstanding characteristics in the types and intensities of position dislocations between professional players[8,13-17] and in the categories of younger ages.[6,18] There are also, between players of each position, small differences on account of the physical capacity and the tactical determinations necessary to the function of the adopted strategy of play.[8] In this way, identifying the exercise intensity (EI) and its variability during games becomes an important indicator for the planning of training and the adoption of the most efficient strategies of recovery.[19,20]

Several methods were used for evaluating the physiological load of high level professional soccer players in competitive situations. Measurement of the total distance covered during the game[4,5,8,17,21] with characterization of specific activities, like standing moments, side dislocations, backward movements, ball movements, spins, running and sprints;[5,8,14-16,22,23] lactate concentration;[4,5,21,22,24] core temperature;[4,25] muscular glycogen stock depletion;[4,26] and heart rate (HR)[4,6,7,9,22-25,27-30] in competitive games were amply investigated. Evaluations performed by direct measurements of oxygen uptake in simulated games[27,31] and in circuits reproducing game actions and small-sided games[32] also were performed on professional players.

Although the data obtained through direct measurements of oxygen uptake brings objective information as to the physiological load of a game, mainly in regard to energetic expenditure, this method is applicable only in circuits or simulated games. In spite of the technological evolution of equipment used in this evaluation, making them lighter and compact, their use during official games is prohibited and incompatible with competitive situations.[28,33] This method is even questioned in simulations. Besides bothering the players, it is believed that its interference provokes a fall in the yield and deprives the players´ movements of characteristics during soccer practice,[1,28,33,34] making its ecological validity decrease. Considering also that the high financial cost of this equipment makes its acquisition impractical for most teams.

With the impossibility of determining the volume of oxygen uptake (VO_2) during more realistic situations of soccer games, the measurement of other physiological parameters for the evaluation of the physiological load in soccer games and training have become an alternative. However, several limitations and critical points can be identified in some of the utilized methodologies. For example, the modern techniques of filming and computational analysis of the games in order to determine the speed and characterization of the types of dislocations made by the players also brings a financially elevated cost. Besides, the diverse commercial systems available need an evaluation of scientific sensibility and validity;[33,35] used separately, without other physiological variables, it does not supply reliable estimates of energetic expenses, since they omit information in non-dislocation situations, such as jumps, headers, contact and spins.[15,34]

On the other hand, the measurements of blood lactate concentration come against methodological aspects, such as the number of times and moments in which blood collection are made. Owing to the competitive characteristics of soccer, it is not possible to do evaluations during games, and the values of blood lactate observed hardly reflects the last physical demands prior to the collection,[5,19,34,36] possibly still not having a good correlation with the muscular lactate.[36] This type of evaluation still brings ethical implications, because it is invasive; as well as to measure core temperature there are difficulties in recruiting volunteers and approval from ethics committees in human research in many countries, mainly with younger players.[33]

Due to the limitations of the methods previously presented, the HR shows a variable of easy application for indirect determination of the aerobic energy production resulting from the effort spent in soccer.[19,20,28,30,34,37] It is an accessible method and widely used in the last years for evaluating the physiological individual load resulting from several sporting demands.[38,39] The great methodological advantage of most of the equipment available in the market is centered on the possibility of measurement and memorization of records of the HR with good validity and reliability.[38,40] Physiologically, the HR offers a high degree of relationship with physiological variables such as VO_2, even in intermittent activities, like soccer, amongst professional players,[22,32] amateurs[37,41] and younger players.[42,43] Current systems of radio telemetry allow monitoring of short intervals of time in all the players simultaneously, making the planning and control of the training easy.[20,33]

Considering the advantages presented by monitoring the HR – such as the correlation with other variables, ease of data collection, security for those evaluated and applicability in daily training - several studies carried out recently, mainly in Europe, have analyzed the physiological load through this parameter in several situations that involve the practice of soccer. Examples of this are the studies that evaluated several situations of professionals' training;[19,30,32,44-53] games[25,37,54,55] and amateurs' training[37,55,56] and young players in adapted games of traditional soccer,[7,42,43] competitive,[6,7,9,29,57-61] friendly[62] and training.[51,60,63-66]

Having in mind the growing use of HR as a parameter of physiological load,[38,39] this review had as objectives to analyze and to compare the EI in male professional, youth and recreational soccer players in game and training situations. Our intention was how this variable could help in determining the physiological load of soccer in different competitive levels and how specific effort demands of the positions of the players on the field occur. We also aimed at contributing to the planning and development of more effective training models.

2. HISTORICAL ASPECTS OF THE USE OF HEART RATE

In spite of the use of HR having grown in the last years, it is possible to note that, since the end of 60’s, the search to know and quantify the physiological load during soccer game situations[67] and training[68] through the measurement of this variable has been made. The behavior of HR before the stimuli of the sporting activities was measured directly, by continuous recording of electrocardiograms (ECG), and transmitted by radiotelemetry.[39] Some limitations from poorly functioning equipment, owing to the actions of soccer, such as “bumps“, jumps and sweat, interrupted the connection of the electrodes to the bodies of the players.[28] In the beginning of the 80’s, the wireless frequencimeters appeared using electronic transfers of data from a belt put on the chest.[40] That made mensurations possible in near real play situations, without the drawback of the equipment used in the ECG. An example using this innovation was the study of Van Gool et al.[69] in a friendly match of university Belgian players.

New technologies brought more efficient, light, compact systems, with greater memory capacity, making it easier and improving the scientific validity of these measurements,[28,38-40] even in competitive environments. Evaluations in official division one professional games in Denmark[24] and of semiprofessionals in

Scotland[28] were carried out. Nevertheless, there were still some limitations in this era, such as the interference of electromagnetic waves of the equipment between players,[28] which made amplification difficult for the collective interaction of the EI of the positions of the players on the field in this type of evaluation.

In the beginning of the 90's the first heart rate monitors integrated with microcomputers appeared, with the codification of signal transmissions and with specific data analysis software.[40] Currently, there are systems that make the simultaneous monitoring of all players possible, with the storage of data in the belt itself for subsequent transfers to the microcomputer. These innovations have made the systematic attendance of the EI in several sporting situations and the application of the knowledge acquired in the prescription of the trainings easy.

The HR, after its recording, can be analyzed in several forms to estimate the EI. Some studies reported the intensity of play through the HR only as an average of observed values,[4,27,28,62,69] like percentage distribution of the HR in absolute values[7] or even with the grouping in a single strip of more frequent values.[70] Those approaches take to the substantial loss of information for not making possible comparisons interindividuais that if they turn valuable in the determination of EI and for orientation of more specific activities in agreement with the game positions. There is great response variability in function of physical conditionings and histories of different training and in function of the decrease in the values of beats.min^{-1} as the age augments and the activity of the autonomous nervous system changes.[71]

Amongst the alternatives considered valid are the analysis expressed as percentage of the obtained maximum heart rate (MHR)[39] or the HR of metabolic transition.[22] To identify the temporal distribution of permanence of the HR in zones of prearranged intensities, some studies analyzed this effort as a function of the MHR in official games[9,24,59] and in friendly games;[50,54,72] in function of the corresponding HR to the anaerobic threshold of 4 mmol.L^{-1} of blood lactate in friendly games,[72] group training[51] and competitive games;[59] and corresponding to the concentrations of 2 and 4 $mmol.L^{-1}$ of blood lactate in diverse training situations.[30,50] Another strategy is to make calculations of the percentage of HR reserve (%HRres) proposed by Karvonen et al.[73] by the formula [%HRres=(mean exercise HR – resting HR)/(MHR – resting HR)*100]. By taking into consideration biorhythm variations, such procedure allows to compare inter individual responses of HR and in different types of soccer trainings.

In the following sections, the EI of the soccer from several competitive levels will be outlined in accordance with different strategies of analysis of the HR. Comparisons between first and second half of the game, between positions on the field, as well as the responses of the HR in specific soccer training and the intervenient factors in the behavior of the HR will also be outlined.

3. ANALYSIS OF THE ABSOLUTE VALUES OF HEART RATE

The most common HR observed in youth and adult players is between 165-175 bpm, independent of the game situation, competitive (Table I) or friendly game (Table II). In regards to the age, some peculiarities are observed in the younger or in the oldest players. In the study of Capranica et al.[7], where six 11 year old soccer players were evaluated, during official games with regular field dimensions (100 x 65 m), at 84% of the time, the HR was above 170 bpm. When we consider older amateur players (62.8 ± 5.9 years old), in 70 minute games, the HR was between 120 and 140 bpm.[54]

Table I. Male soccer players' heart rate in competitive game expressed as average in absolute values (bpm) and in percent of individual maximal heart rate (%MHR).

Source	Level	n	HR(bpm)	%MHR	Number of games (min)
Rohde & Espersen (1988)[24]	1st division/Denmark	6	~170	~84	Four (90)
Klimt et al. (1992)[70]	U-11/12/Germany	15	160-180		Two in competitive*
Bangsbo (1994)[22]	Profissional/Denmark	6	167		One (90)
Florida-James & Reilly (1995)[74]	University/UK	12	161		One (90)
Rico-Sanz et al. (1996)[75]	National junior/Porto Rico	8		~83	One (90)
Helgerud (2001)[9]	Junior elite/Norwegian	8	171	~84	Two (90)
Capranica et al. (2001)[7]	11 years old/Italy	6	~180		One in dimension (100x65m)# (90)
Thacher et al. (2004)[58]	U-20 profissional/UK	6	~166	~83	One in formation 4x4x2 (90)
Strøyer et al. (2004)[6]	12 anos/Denmark	10	160	~87	One in formation 4x4x2 (90)
Strøyer et al. (2004)[6]	Elite beginning the puberty/Denmark	9	174	~87	One in formation 4x4x2 (90)
Strøyer et al. (2004)[6]	Elite in the end of the puberty/Denmark	7	174	~87	One in formation 4x4x2 (90)
Billows et al. (2005)[61]	Academy/UK	20		~86	Series of matches (70)§
Coelho (2005)[59]	U-17/Brasil	26		~85	Fourteen (90)
Coelho (2005)[59]	Junior/Brazil	18		~85	Fifteen (90)
Mortimer et al. (2006)[29]	U-17/Brazil	13	168	~84	Fourteen (90)
Mortimer et al. (2006)[29]	Junior/Brazil	12	169	~84	Eight (90)
Impellizzeri et al. (2006)[45]	Junior of professional teams/Italy	29		~83	Two of pre-training# (90)
Rodrigues et al. (2007)[60]	U-17 of high level/Brazil	8	166	~84	Six (90)

* Level of the competition no-moderated.
#Against teams of the same level (similar position in classification in the league).
§ Exact number not presented.

Table II. Male soccer players' heart rate in friendly game expressed as average in absolute values (bpm) and in percent of individual maximal heart rate (%MHR).

Source	Level	n	HR(bpm)	%MHR	Number of friendly games (min)
Seliger (1968)[68]	No informed/Czechoslovakia	16	165	80	Simuled (10)
Van Gool et al. (1983)[69]	University/Belgium	5	166		One (90)
Van Gool et al. (1988)[76]	University/Belgium	7	167	~85	One (90)
Ali & Farraly (1991)[28]	Semiprofissional/UK	9	~171		One (90)
Ali & Farraly (1991)[28]	University/UK	9	~167		One (90)
Ali & Farraly (1991)[28]	Recreational/UK	9	~168		One (90)
Ogushi et al. (1993)[27]	Profissional/Japan	2	161	82	One (90)
Fernandes (2002)[72]	First division/Brazil	19	166	86	Two (90)
Mohr (2004)[77]	Four division/Denmark	9	160	85§	One (90)*
		16	162	86§	One (90)#
Bachev et al. (2005)[62]	Junior national/Bulgaria	16	165		One (90)
Tessitore et al. (2005)[54]	Amateurs ~ 62 years old/Italy	12		~85	One (70)
Eniseler (2005)[30]	First division/Turkey	10	157		One (20)
Krustrup (2006)[36]	Four division/Denmark	31	156		Three (90)
Edwards et al. (2006)[25]	University/UK	8	156	80	One (90)
Edwards et al. (2006)[25]	First division/UK	7	161	84	One (90)
Krustrup et al. (2007)[55]	Recreationais adults/no informed	12	157	84	Two (90)
Condensa (2007)[50]	First division/Brazil	22	171	~86	One (45)

§ Individual maximal heart rate defined as the peak heart rate reached during the match.
* With experimental interruption to determine muscle temperature.
#Against teams of the same level (similar position in classification in the league).

The analysis of HR during a soccer game, considering only the absolute values (bpm), must be done in a discerning form, since the age of the players, together with the individual responses, can cause mistaken interpretations. So, it is necessary to consider, in the study of the HR as parameter of EI, the percentage of the MHR obtained in preestablished values, HR corresponding to the individual metabolic thresholds and/or as %HRres. That will allow larger comparisons and extrapolation of the results found by the scientific community and technical commission of the teams.

4. EXERCISE INTENSITY THROUGH THE HR-VO_2 RELATION

Having in mind the linear VO_2 relation obtained in laboratory treadmill tests, it was observed that the average intensity of force from high level male professional players, in a game, fell between 70 and 80% of the $V0_{2MAX}$.[4,5,24,27] The same tendency was found by Strøyer et al.[6] for 12 to 14 year old Danish players, with the application of linear individual regression equations between HR-VO_2 built from the sub maximum and maximum treadmill tests. In terms of energy expenditure, that means a production of energy of 1,360 kcal for a player with a physical weight of 75 kg and $V0_{2MAX}$ of 60 ml.(kg.min)$^{-1}$ during a competitive game.[34]

This intensity appears to be elevated, keeping in mind that the time of permanence of the players in the stopped and walking condition is high in professional soccer[5,8,17] and in the high level young players,[6] corresponding to approximately 15 and 40 % of the actions of play, respectively. However, the intermittency of the physical demands of the game makes the players to execute actions that raise the EI to maximum values, near those of the MHR.[4,22] The small interval of recovery between one action and another also helps in the elevation of the average EI values.

During a soccer game 1.200 to 1.600 actions take place involving changes of rhythm, direction and execution of the characteristic skills of the game.[5,17] On average, there is an exchange of movements each 4-5s.[5,17] Most of the actions are of low and moderate intensities, which confers to the soccer its aerobic characteristics. Of the total energy spent, 90% comes from aerobic sources.[34] Meanwhile, the 150-250 (approximately 15%) actions executed in high intensities[8] are sufficient to cause the accumulation of blood lactate from 3 to 8 $mmol.L^{-1}$ by the end of official game periods from several levels and categories,[4,5,7,8,21,36,74]. It has to be considered that these values may be subestimated because of already having spread to the entire body and suffered the process of removal at the moment of collection.[24,34]

Restrictions have been made in the use of HR-VO_2 linear regressions. According to some studies,[27,32,34] since this calibration generally is done in continuous treadmill tests, there may be a loss of linearity between these variables in game situations. Considering that the demands in soccer have intermittent characteristics, with some actions at high intensity, there may be an overestimation of oxygen uptake in the game. Lima[78] emphasizes that the relation of HR x EI can be described by a sigmoid equation where the tendency of the HR to plateau at the highest intensities is obvious. However, it is believed that, even taking into account limitation, this strategy could be adopted, if the actions that raise the HR values to where there is no linearity with the VO_2, such as *sprints*, last only a minute.[5,8] Even with overestimation, the estimate of EI obtained with this strategy can be considered acceptable.[22]

Another restriction is the adaptation of the tests used for constructing the regression equation of HR-VO_2. However, some studies did not demonstrate significant differences in the HR-VO_2 relation obtained either by intermittent testing on the treadmill with specific speeds of soccer dislocations or by test in *steady-state* for the same speed averages in university players.[41] There were also no differences between field tests (circuits) simulating game actions and intermittent and continuous tests until exhaustion on the treadmill in amateurs[37] and in professionals soccer players.[32,79]

5. EXERCISE INTENSITY THROUGH THE HR AND METABOLIC THRESHOLDS RELATION

Some studies analyzed the EI by the HR in the game taking the anaerobic threshold obtained in a continuous standardized laboratory test in professional players[27,50,72,76] and in a field test in youth players[59] as a reference. For example, Fernandes,[72] while evaluating professional first division Brazilian players at two friendly games, noticed metabolic balance, seeing that in 56.7 ± 21.9 % of the game time the HR stayed below such anaerobic threshold and in the remaining time was maintained either at the transition point (3.5 ± 1.4%) or above it (39.7 ± 21.4%). Apart from this, Condessa,[50] also evaluating friendly games of high level Brazilian professionals, observed more anaerobic characteristics, with the permanence of approximately 61% of the time at the values of blood lactate concentration higher than 4 $mmol.L^{-1}$.

Physiological load with more anaerobic characteristics was also found by Coelho[59] while evaluating high level junior and juvenile players in the State of Minas Gerais in Brazil at competitive games. Using linear interpolation in field tests to determine the percentage of corresponding HR to 4 $mmol.L^{-1}$ of blood lactate, this author noticed that, in more than half of the game, the players remained in EI zones above 85% of the MHR, a corresponding percentage to the anaerobic threshold (~86%MHR). Recently, Eniseler,[30] also using field protocol to obtain the HR corresponding to 2 and 4 $mmol.L^{-1}$ of blood lactate, verified that in 49.6 ± 21.1% of the time the HR was above the reference level of 4 $mmol.L^{-1}$ during a simulated game of 20 minutes in elite Turkish players.

The results obtained in the previous studies that used the anaerobic threshold as a reference points to the complexity of the physiological stimuli of soccer. The metabolic fields above the anaerobic threshold demand intense aerobic power expressed by the VO_{2MAX} percentage such as the elevated level of recovery and removal of the produced lactate. That demonstrates that trainers can structure HR zones that correspond to 2 to 4 $mmol.L^{-1}$ of blood lactate, individualizing the intensities of work in simulated games in this manner, as well as for the rest of the tactical-technical work for the players. Stimuli that raise the blood lactate above the fixed value of 4 $mmol.L^{-1}$ should also be part of routine training, as soon as the players are suitable to perform the actions with an elevated accumulation of this metabolite during several moments of the game.

6. EXERCISE INTENSITY THROUGH THE MAXIMUM HEART RATE PERCENTAGE

Taking as a parameter the percentage of the individual MHR, it was verified that the average intensity maintained, most of the time, was between 80 and 90 % for professional players in official games[5,22,24] and in friendly games,[25,27,50,72] or when the considered MHR was a peak during a friendly game.[77] Since this strategy favors the interindividual comparison, it is possible to check that the same zone of EI is observed in professional players of inferior divisions in friendly games;[28,36,37,77] in high level youth of the U-12,[7,70] U-13,[6] U-15,[6,61] U-17[29,59-61] and Junior category[9,29,45,58,59,75] in competitive games; in friendly university games;[28,74,76] and in adult players[28,55] and older players in recreational games[54] (Tables I and II).

In spite of similarities in EI between several categories and competitive levels, in adolescents the anaerobic pathways of supply of energy are not well developed and it may lead to doubts when the results are expressed as time of permanence below and above 85%MHR which a limit accepted as a mark of aerobic and anaerobic supply of energy, respectively, for adults.[61] Billows et al.[61] observed in adolescent players that HR held above below 85%MHR in 37% of the game and the remaining of that limit of metabolic transition (relationship of 1:3) being different from what is observed for adult players (relationship of 2:1). However, even with those safeguards it is expected that the high level professional players use a greater percentage of time in actions of higher speed of dislocation.[18] This can be explained because the professionals have better physical conditioning and a greater level of specialization in game position, as well as for the style of differentiated and more vigorous play, which raises the absolute motor and physiological demands during the game.[1,4,6,8] On the other hand, the smallest duration of the soccer game of the youth and older adult players, as well as smaller technical and tactical abilities of them can cause an increase of intensity and be a determinant making the cardiac response similar, in percentage terms of the MHR, to those observed in high yield professional players.

With the possibility of distinguishing the EI better through studies that adopted strategies of grouping the HR values observed in fields or limits, it was noted that, in approximately 65% of the total play time, the HR remained between 70 and 90% of the MHR for junior and professional players in games with normal time duration. Helgerud et al.,[9] calculated the time spent in different intensities as zones of <70%, 70-85%, 85-90%, 90-95% and >95% of the MHR. They studied elite junior players of Norway, contending an official game on artificial grass, on a neutral field, before the experimental period. It was thought that, around 37 % of the time, the HR remained at the intensity of 85-90% and a similar time around 70-85% of the MHR.

The permanence around the EI of 85-90% of the MHR verified in Helgerud's et al.[9] study was above the Coelho's[59] observations for high level players of the same category in Brazil. It was verified that the greatest time of permanence took place around the intensity of 70-85%. Finding the time spent in different intensity zones in four games for six players of the Denmark first division, Rhode and Espersen[24] thought that, in 63% of the time, the HR remained in the zone from 73 to 92% of the MHR. In the study of Fernandes[72] with first division Brazilian players, in two friendly games, it was found that in 2/3 of the game time the HR was above 77% of the MHR.

When they observed the EI of the older players, for predetermined limits, Tessitore et al.[54] thought that, in approximately 50% of the time, the activities were above 85% of the MHR. As seen previously, this EI corresponds to the middle intensities checked in other studies for other age groups and competitive levels.

However, when the distribution of HR of these players was observed, a tendency was noticed in the dispersal by a greater number of fields and higher standard-deviation regarding the most homogeneous distribution found in young players, for example, in those evaluated by Capranica et al.[7] In this way, Tessitore et al.[54] noticed that there was a greater percentage participation of time spent in intensity below 70% of the MHR, mainly in the second half of the game, different from other age groups. That may have taken place due to the low capacity of recovery after high intensity stimuli, culminating in a high rate percentage (~69%) of participation of walking during the game, in comparison to the approximate values of 40% in studies of youth[6] and professional adult[5,8,17] categories.

7. EXERCISE INTENSITY IN THE FIRST AND SECOND HALF OF THE GAME

The fall of EI, measured by HR, in its different forms of analysis, is observed in the second half of a game in practically all the studies carried out with professional players,[22,24,25,27,77] juniors,[9,29,58,59] U-17,[29,59,61] university,[25,28,76] recreational players[28] and younger players,[6,7,61] independent of the importance of the game. When the EI was considered as a function of time of permanence in exercise intensity zones of MHR percentages, Helgerud et al.[9] found redistribution of the zones most solicited in the second half. They observed a reduction of the time of permanence in the 85-90% intensity field and an increase in the smaller intensity field such as 75-80% and less than 70% before the specific experimental protocol period of aerobic training. The same tendency of reduction and redistribution was found in the study by Coelho,[59] in which a drastic change of the time of permanence in the intensity of 70-85% of the MHR of the first half (34.5 ± 2.4%) to the second half of the game (43.9 ± 1.1%) took place.

During the second half of the game, the professional players moved distances 5 to 10% less than in the first half of the game,[5,8,16,17,21] especially in the average (11.1-19.0 km/h^{-1})[14] and high intensity (18.0-30.0 km/h^{-1})[8] activities. In other physiological parameters, such as blood lactate concentration, distance covered and number of times of the high speed actions, reductions were also noticed at the end of the game in different age groups and competitive levels.[4-6,8,16,17,21,22,36,58]

In spite of this reduction also occurring at the end of the game with players at inferior levels, better physical capacity may be crucial in this reduction. It has been shown that the percentage of time spent in more intense activities, like high intensity races and *sprints*, there is a tendency to suffer fewer reductions in the second half in players with greater physical capacity, in comparison to their peers with lesser physical conditioning.[6,8] This demonstrates the players' better adaptation of a higher level to physical capacity evaluation and for physiologic demands of soccer. These have higher rates in some indicators, such as maximum aerobic power and muscular force.[1,10] This can reflect in a lesser reduction of the most intense activities in the second half, which are crucial to high performance.

However, the reduction of the average value of HR in the second half of play cannot be connected with the reduction of physical performance, verified through the reduction of the distance run and number of *sprints*, as previously quoted. A possible reason for this is that the HR of a player during a game rarely reaches values less than 65% of the MHR, even in younger (18-36 years old)[28,55] or older (62.8 ± 5.9 years old)[54] amateurs, suggesting that the flow of sufficient blood to the muscles of the legs is continuously maintained.[19] So, during the constant and brusque changes of intensity during the play it seems that the consumption of oxygen is limited by local factors, such as the oxidative capacity of the active muscles.[19,80]

Some physiological local mechanisms are suggestive of a lesser physical yield of the player at the end of the second half of the game. During the game, a progressive degradation of the muscular glycogen (40 to 90%) in some muscular fibers takes place, mainly in that of the IIb type.[36,80] There is also a reduction in the levels of creatine phosphate; reduction in the muscular pH; an increase of muscular monophosphate ionosine; [36] an accumulation of the levels of potassium;[22,36] and a temporary fall in the muscular temperature of the quadríceps[77] and body[25,77] in the game interval, which continued for more or less 20 minutes of the second half. In spite of these suggestive factors, the reasons which caused fatigue in the soccer players are not clear[80] and are not always associated with a reduction in the performance of *sprints*,[36] an important activity for the soccer.

The imposition of physiologic load of the soccer and the hydration difficulty during competitive situations provoke a loss from 1-4L of sweat.[36] As a consequence of loss sweat it happens reductions of 1.5-4% in the weight[22,25,36,77] and reduction of 7-12% in the blood plasma.[25] These aspects hinder the thermogenesis' regulation and that would take the players theoretically to present an increase of the HR in the second half of play for cardiovascular compensation. However that does not happen and the non-elevation of the HR in the second half probably takes place in function of the lesser physical demands of the main actions of the game when they were practiced at that moment. The temporary fall of the number of times and of the quality of the actions of running at high speed of the players during the game were verified, mainly in the five minutes that follow the most intense periods[8] and at the end of the second half.[8,17,22,36,77]

It is also suggested that the yield reduction in the second half of the game does not just take place as a function of physiological mechanisms, but due to other factors of tactical and psychological order. For example, according to Ali and Farrally,[28] depending on the partial results, based on the necessity of determining results and on the importance of the game, the players will make a different effort, tending to make less of an effort when the results are favorable and the spread on the scoreboard is comfortable. The same tendency of less effort can happen when no hope already exists in winning the game, because of an adverse scoreboard with a considerable difference in goals.

Keeping in mind that the evidences points to the second half of the game presenting less intensity compared the first, two practical order recommendations can be made. The first refers to the return of injured athletes after the recovery period; it is recommended that they are introduced during the second half of the game, when the rhythm tends to be less intense. The second refers to the necessity that the team is well prepared physically and that nutritional strategies are established to minimize the fall of muscular glycogen reserves at the end of the games, increasing the chance of better performances.

Few studies continuously measured HR during the intervals of the games. One verified that, in that moment, it remained around 70% of the MHR in players of the fourth division in Denmark;[77] 73 % in professionals and English university students;[25] 58% in high level Brazilian youth;[59] and less than 50% of the MHR in a first division midfielder in Sweden.[4] Perhaps this could be an interesting measure of accepted control, being that Mohr et al.,[77] in spite of not having reported the environmental conditions, demonstrated that the decline of the physical and muscular temperature during the interval was associated to the reduction of the capacity of *sprints* (~2.4%) at the beginning of the second half. Nevertheless, this capacity was maintained when low intensity activities (~70% of the peak HR reached during the game) were carried out to preserve the temperature of the quadricep muscles. So, maintenance strategies of the physical temperature can be adopted in the intervals of the games (e.g.: calisthenics and activities involving ball control).

8. EXERCISE INTENSITY PER PLAY POSITION

Some studies analyzed the EI for positional roles. In professional players,[22,24,76] junior and juvenile,[59] university students[69] and in young players of the U-13[6] and U-15[6] categories, the HR varied in accordance with the position of play, being greater in the midfielders and fewer in the defenders. Ali and Farrally,[28] evaluating semiprofessional English players at friendly games, observed a greater HR (176 ± 9 bpm) for midfielders, in comparison to the 173 ± 12 bpm when forwards were observed and 166 ± 15 bpm for defenders.

The biggest cardiovascular overload of the midfielders can be explained by the tactical functions practiced by these athletes in the modern tactical systems. These players take on a function as forwards (setup and follow through of plays) as well as defense (marking adversaries), which causes spacious and constant movement on the field of play,[5,8,14-17,58] also becoming a noted standard in younger players.[6,18] The midfielders, generally, also have the best rates of cardiorespiratory conditioning, which can give them greater possibilities of active participation during games.[1,6,10,12]

An interesting strategy for future studies is the adoption of the relative intensity of the HR for the time of permanence in groups of EI for the play position. Coelho[59] made use of that observing, in Brazilian junior and juvenile players that the midfielders remained more time in the 85-90% and 90-95% intensities of the MHR than the other positions. This author also observed that the external defenders remained more time in the 95-100% MHR, intensity considered the maximum, but in contrast this position was also the one that remained more time in the smallest EI at 70% of the MHR, together with the forwards.

This strategy would make the differentiation of physical loads between the positions possible, since a middle value cannot reflect the HR group in which a determined position remains for more time. For example, in studies using the methods of characterization for distance and type of movement made, it was observed in the forwards[14,15,17] and fullbacks[8,14] had a greater number of anaerobic actions (ex.: *sprints*) than the other positions. The defenders ran backwards more[15,17] and the midfielders remained more time in actively *jogging* and in races at high intensity.[8,14,17] Owing to these differences of movement, style of play and tactical obligations, the time of permanence in the EI group will better represent the physiological load to which each position is really subjected. The interaction of several positions in a determined tactical system, as well as the confrontation with different tactical systems, can bring important information to set goals and strategic projections for the physical preparation, for a game and its recovery.

Another question to consider is the style of play between the countries or connections. Few studies have undertaken this up to now,[17,81] but show strong evidence that the style can be an important factor in the differentiation of physiological game load. In a recent review, Silva and co-works[82] pointed out that the Brazilian players present certain differentiation of physical transport and conditioning for game positions, with a distinction in the external defenders players because they present the greatest VO_{2MAX} values which contrasts with what is found in studies made with European players.

9. USE OF HEART RATE IN SPECIFIC SOCCER TRAINING

Keeping in mind the training prescription attending to the specificities of all the game positions, the values of HR and groupings of intensities observed can be used to prepare target-zones to be maintained during several training models.[39] The technical traditional trainings with the ball are less intense in comparison to the tactical training, small-sided games or group training, and even the group training do not correspond to intensity of the games.[30,51,60,83] There is a tendency where the games with reduced fields played in the 2 vs. 2, 3 vs. 3, 4 vs. 4 or 5 vs. 5 player forms in dimensions of approximately $150m^2$ per player and with 2 to 4 blocks of stimulus duration from three to eight minutes with 2 to 4 minutes of recovery represent the demands of soccer better,[32,45-49,52,56,63,64,66] being as efficient for the development of the VO_{2MAX} as the interval running training[45,47] (Table III).

Table III. Male soccer players' heart rate in different training situations expressed as average in absolute values (bpm), in percent of individual maximal heart rate (%MHR) and percentage of heart rate reserve (%HRres).

Source	Level	n	HR(bpm)	%MHR	%HRres	Training situations (min)
Seliger (1968)[67]	No informed/Czechoslovakia	15	160			Simuled game (10 min)
Hoff et al. (2002)[32]	First division/Norwegian	6	184	~91		5x5 with goalkeeper (50x40m)
Flanagan & Merrick (2002)[83]	Junior elite/Australia	13	135-155	~59		Kick direct to the goal (15 min)
			155-178	~78		Physical of zigue-zague (10 min)
			155-178	~78		6x7 (2/3 of the field; 20 min)
Esposito et al. (2004)[37]	Six division/Italy	7	156			Modified circuit of Ekblom (1998)
Rampinini et al. (2005)[65]	No informed/Italy	15		~88		4x4 (4x4 min)
				~78		4x2 (2x4 min)
				~85		10x10 (10 min)
Sassi et al. (2005)[47]	Profissional elite/Champions League	9	~178	~91		4x4
			~170	~91		8x8 (pressure marcation)
			~160	~82		8x8
			~167	~85		4x1000m
			~140	~72		Technician-tactical
Eniseler (2005)[30]	First division/Turkey	10	135			Simuled game (20 min)
			126			Tactical (20 min)
			118			Technical (20 min)
Tessitore et al. (2006)[44]	Regional level/Italy	9	>160			6x6 (30×40 m)*
			>160			6x6 (50×40 m)*
Little & Williams (2006)[48]	Division I/England	23	173	~90		2x2; 3x3; 4x4;5x5;
				~87		6x6; 8x8
				~90		5x5 e 6x6 (pressure half switch)*
Castagna et al. (2007)[42]	Collegiate U-17/Italy	15	166	83		Indoor game 30x15m (30 min)
Rampinini et al. (2007)[56]	Adult amateurs/Italy	20		80-90		3x3; 4x4; 5x5; 6x6*
Fontes et al. (2007)[51]	First division/Brazil	10		~71		Technical
				~78		Tactical
				~77		Modified game
				~79		Simuled game
Willians & Owen (2007)[46]	Premier League/England	9	163			2x2; 3x3; 4x4; 5x5*
Little & Williams (2007)[49]	Division I/England	38		~89		2x2; 5x5; 8x8;
				~91		3x3;
				~90		4x4;
				~87		6x6
Rodrigues et al. (2007)[60]	U-17 of high level/Brazil	8	150	~75		Simuled game
			157	~79		8x8 (1/4 of the field; 25 min)
Condensa (2007)[50]	First division/Brazil	22	124	~62		Technical (~12 min)
			~137	~69		Tactical (16 min)
			116	~58		Warm up "to play dumb" 8x8m; 7 players (~13 min)
Kelly & Drust (2008)[52]	Second division/England	8	~173	~90		4x4*
Mallo & Navarro (2008)[64]	Elite U-19/No informed	10	~173	~91		3x3 ball in possession
				~91		3x3+two out players
				~88		3x3 with GK
Dellal et al. (2008)[53]	First division/France	10			77	1x1
					80	2x2
					77	4x4+GK
					80	8x8+GK
					71	8x8
					75	10x10+GK*
Hill-Hass et al. (2009)[66]	Domestic League/Austrália	16		89		2x2
				85		4x4
				83		6x6

*Several combinations of time and field dimensions.
GK= goalkeepers

An interesting aspect in the adoption of small-sided game strategies is that the motivational factor, through incentives and commands given by the trainer, can strongly influence the intensity of this type of training.[56] Another type of manipulation that can increase the EI in this type of training is the quick ball replacement and emphasis in marking for pressure.[56] Dellal et al.[53] observed that the goalkeepers' presence increased in ~11 the tax of %HRres in comparison to the same model without the presence of them in small-sided games in French professional players. In this way, the adoption of small-sided games becomes an interesting alternative, mainly for younger players,[20] since they combine the technical actions in more realistic game situations and develop the specific musculature of the game actions, making the transfer to competitive situations easier.

Furthermore, in spite the small-sided games being excellent strategy training, keeping in mind the beginning of specificity and motivational aspect, it is necessary to point out that that training type cannot reach the objective proposed for the work load, what also hinders the reproducibility of incentives wanted by the higher intersubject variability.[53,65] Castagna et al.[43] affirmed that it is necessary to have an idea of the EI of a determined small-sided game in order to daily use it by the fact that the intensity of the stimulus is related to the technical quality of the players. Another question is the type of involved marking, which can alter the EI of the small-sided games.[47,48] Even this way, the traditional training of continuous or interval running must not be discarded completely, on the account of having a smaller number of intervenient variables providing greater control over the EI and of allowing a larger reproducibility of the proposed stimulus.[53] High loads of training (e.g. 90-95%MHR) are maintained more easily with activities of continuous or interval running.

10. LIMITING FACTORS OF THE HEART RATE USE

Although the use of the HR is practical, its responses may be influenced during the games and training by several aspects besides the physical force of the player. Among these, environmental conditions can be cited, such as temperature, humidity, altitude and air resistance; psychological aspects, such as anxiety and stress; and the use medications.[38] It is suitable to also note that the conditions of the field, such as a wet state, and tall or short grass, can also interfere in the EI of the players. These factors may lead to the overestimation or underestimation of the VO_2, since they alter the behavior of the HR without affecting the consumption of oxygen in the same proportion.[24,32,33,37,80]

For better characterization of the game environment, it is necessary that the studies specify the environmental conditions of the game location and the place where the tests are carried out to relate physiological load. So that the environmental influence in the HR-VO_2 relation remains small, it is suggested the reproduction of temperature and relative air humidity of the game environment during the laboratory tests. This strategy was recently adopted in the study of Esposito et al.,[37] who observed a very strong correlation (0.991; $p<0.001$) between HR-VO_2 obtained in the laboratory and in the field from amateur players executing characteristic activities of soccer in circuit training, measured in both situations with a portable gas analysis system.

It is suggested that the EI, in function of the MHR, is done from the greatest value of HR observed in several situations, such as laboratory and field tests or in real game and training situations, keeping in mind that there can be varied motivations for the players effort amongst these conditions.[10,32,77] There is a strong tendency of observing the largest value of HR in competitive soccer situations;[84] which is answer specific of the activity in question. Also, it is advised to use the equation "220-age", keeping in mind that it may lead to estimative mistakes in players, compromising rise of EI in games, training or prescribed activities based on the MHR percentage.[84]

Some alternatives for evaluation of the MHR are suggested: the simultaneous attainment in maximum aerobic potential tests on the treadmill, as adopted by Wisløff et al.,[10]; or even during field protocols for indirect aerobic evaluation of players, such as the *Yo-Yo intermittent recovery test,* which has been ratified as high specificity for soccer.[85,86] Exclusive tests for getting the MHR, such as the 1000m maximum running[60] or 3x600m with intensity increases[51] have been used in players, being interesting options.

When the objective was to estimate the energetic expense of the players through the HR, some considerations should be observed. First of all, though this estimate is valid, it is necessary to obtain the individual relation between HR and VO_2.[38] It is still considered that, in this case, the energetic estimate should be done only on the aerobic metabolism, without clearly indicating the energy originating from the anaerobic metabolism.[19,34] To appreciate the anaerobic participation in the supply of energy, it is necessary to consider the total duration of the high intensity exercises, the number of involvements and their intensity with the ball during a game.[22] Studies have demonstrated that the total duration of the activities involving more intense actions during a play is approximately seven minutes, which includes approximately 57 high speed runs and 19 *sprints* with an average duration of two seconds.[5] Regarding the participation with the ball, it has been observed that the players execute around 111 actions with the ball[15] and that 1.5 to 3% of the total movement is carried out directing the ball.[14,18] Another important factor concerns the hormonal behavior, which can change the distribution of participation of the energetic sources without directly reflecting the HR. Hormonal changes, like the reduction in the insulin plasma rates and increases in the concentrations of catecolamines during the game, can increase the concentration and use of free fatty acids[22,36,80] progressively.

As observed, practical enriching situations for improvement of the ways of training can be elaborated based on the behavior of HR. Thus, it is suggested that an increase and methodological deepening of research with this variable, such as the increase in sample size, better characterization of game positions, interaction between tactical systems, valid training models and their responses in longitudinal studies. Furthermore, the climactic differences and the style of play of the South American countries in relation to Europe,[17] where the majority of the studies were performed, can bring different implications in the distribution of

HR intensity groups in training and games between the countries of these continents. These aspects of geographical location and cultural influence in the game style should be better studied in order to obtain information about specific physiological load in soccer players.

Currently, low cost and safer equipment exists which can amplify these research situations, including studies on the efficiency of simulated games, determined models of small-sided games and technical training in more diverse categories and age groups in feminine soccer that have not been studied as it should be. As suggested by Carling et al.,[35] the application of the evaluation systems of synchronized HR with the use of multicamera systems to bring the profiles of individual work can promote advancement in the understanding of the specific and global physiological loads of soccer players.

11. CONCLUSION

In conclusion, some points that appear to be well documented in the literature are highlighted: (i) the HR can be utilized to monitor the physiological load in soccer players with good scientific validity, being indicated its normalization as percentage of MHR or HRres; (ii) in competitive conditions between professionals, the average game intensity is about 70-80%VO_{2max} or 80-90%MHR, being similar to the rest of the competitive levels, including recreational players; (iii) when intensity zones are considered, approximately 65% of the game time is spent in an intensity of 70-90% and rarely below 65%MHR;(iv) the midfielders have a greater EI, followed by forwards and defense; (v) in the second half of the game, the EI is smaller and this reduction can be correlated with the level of specialization of athletic conditioning of the player; and (vi) the small-sided games are effective strategies of trainings, however the ideal stimulus should be defined starting from previous evaluation of the model and the team. In that way, the control of EI through HR in training should be a permanent action inasmuch as HR is a tool of easy using.

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ARTIGO 2: EXERCISE INTENSITY AND FATIGUE DEVELOPMENT DURING COMPETITIVE MATCHES IN YOUNG BRAZILIAN SOCCER PLAYERS

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Brief running head: EXERCISE INTENSITY AND FATIGUE IN BRAZILIAN YOUNG SOCCER PLAYERS

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Abstract

The aim of this study was to evaluate the exercise intensity (EI) with special reference to the development of fatigue during competitive games in Brazilian young soccer players. Heart rate was monitored in twenty-one soccer players (mean age 14 ± 0.5 years; body weight 61.5 ± 6.5 kg; height 172 ± 7 cm) during three complete soccer matches. EI was expressed in relation to the maximal individual heart rate (MHR, maximum pick value) during the matches. Fatigue was expressed as fall of the EI between halves or phases of the half. Temporary fatigue as reduction in 5-minute interval subsequent to the 5-minute interval more intense. EI during the first (86.1 ± 3.4%MHR) was larger than second half (83.8 ± 4.1%MHR; $P<0.05$). EI in 10 minute after the half-time was lower than those at the end of the first half and the end of the second half ($P<0.05$). In the second half the players increased the time spent in zones of smaller EI (<70%MHR [6.2 ± 9.5 vs. 3.5 ± 4.3 %] and 71-85%MHR [43.3 ± 12 vs. 36.4 ± 13.4%]) and they decreased in the larger (91-95%MHR [20 ± 9.1 vs. 24.2 ± 10.3%] and >96%MHR [6.2 ± 5.6 vs. 9.8 ± 7.4%]) ($P<0.05$). After the more intensive 5-minute interval of the match, there was a reduction (~5.5%) in the EI in the subsequent 5-minute (91.4 ± 3.6% to 85.9 ± 4%; $P<0.05$) which tended to be smaller than EI of the considered half (86.4 ± 3.6) ($P>0.05$). The external defenders and midfielders demonstrated higher ($P<0.05$) EI (88 ± 1.5%MHR and 86.9 ± 1.8%MHR, respectively) as compared to central defenders and forwarders (82 ± 4.5%MHR and 82.4 ± 1.8%MHR, respectively). We conclude that the mean EI is of high intensity and decreases in the second half. The players develop temporary fatigue during the match and EI is specific for players´ position and influenced by tactical tasks.

Keywords: heart rate, soccer, exercise intensity, competition demands, fatigue, positional roles**.**

INTRODUCTION

Competitive matches bring out more interest and dedication from the players what submits them into a physiological effort, leading to fatigue (6,26,31), and a lower performance, also compromising, individually, the technique and tactical performances, what, in the end, also compromises the whole team as one (34). So, the exercise intensity (EI) and player's performance information throughout the periods of the match, obtained in competition, are important indicators for more specialized training and for the development of better recuperation strategies, with the objective of reducing the development of fatigue (6,13,33).

Different indicators have been used to determine EI such as percentages of maximum oxygen uptake, speed and lactate threshold, perceived exertion and thermoregulatory responses. However, compared to these indicators, the heart rate is easy to monitor, it is relatively cheap, is not invasive and could be used in nearly every situation with good validity and reliability (1,12,21). Besides, the heart rate keeps high the relationship with oxygen consumption even in intermittent exercise, like soccer, in professional players (5,24) as much as in non-professional (18,21) and young players (11,12). So, the heart rate can be used to classify the exercise intensity and to be a way of comparing fatigue identifications in soccer players.

In general, the EI observed in male, adult, players in a competitive match is between 165-175 beats.min^{-1}, what represents 80-90% of maximal heart rate (5,22,36). In order to this high rate of work and the long duration of a professional soccer match a reduction of the performance is expected in second half (5,22,36) due to the reduction of muscle glycogen storage (26), thermoregulation limitation and metabolic impact in the central nervous system and muscle fibers (6,34). Another aspect recently observed is that the players may show signs of fatigue in the beginning of the second half of the match caused by the reduction of the quadriceps muscles temperature during the half-time (30) and temporally during the match as a consequence of the high solicitation of intense working moments, which compromises the succeeding actions by dependence of anaerobic metabolism (31).

Despite the importance of the selection and development of the young players, lack of attention, for our knowledge, has been given to scientific evaluation in competition of the EI (10,38) e and the standards movement in Europe (10,13,38) and Brazil (15). The EI of young Danish (38) e Italian (10) players in competitive matches follows a pattern found for adults. However, the reduction in the level of performance has not been clearly shown in the second half of the match. Factors like lack of technical accuracy, short duration of the match and little specialization may have blocked such reduction. Castagna et al. (13) observed the permanence in small areas of the field during the match in young Italian players and that may be added to the factors shown before as an explanation of the constant physical effort throughout the game, found in the evaluated players.

Although the majority of the studies come from Europe, ethnic, cultural and geographic aspects influence in the selection and in the talent development (23), what may cause different styles of playing between different countries, and, consequently, different requirement of EI shown throughout the match (9,35,37,39). Besides, the EI of game and fatigue development may be linked to the competitive level evaluated, because the amount of activities with a high intensity at the start is related to its level (5,20,29) and the quantity of movements in a high or very high intensity executed in the first half of the match might influence on the second half and end up reducing the performance substantially (32).

Therefore, the aim of this study was to evaluate the exercise intensity with special reference to the development of fatigue during competitive matches of young Brazilian soccer players. In addition, the exercise intensity of every position in the field was also investigated. This information may contribute to build up the knowledge to orientate and improve training programs, as well as strategies for the maintenance of the player's performance during the match, according to the exercise intensity required in the Brazilian soccer.

METHODS

Subjects

Twenty-two young male soccer players belonging to two teams that participated in regular competitions recognized by the Federação Mineira de Futebol (Member of the Confederação Brasileira de Futebol – CBF) accepted to take part in the study as volunteers after parental consent. Ethical approval was obtained at local university's ethical procedures following the recommendations of the Code of Ethics of the World Medical Association (Declaration of Helsinki 1975).

During the experimental period, the two teams were participating in the main U-15 category competition in the state. The players were engaged in a training program, one session/day, 1.5 hour/session, 5 days/week and had one competition match at the weekends. They had no supplemental training (e.g., resistance training) either in season or off season. All volunteers had 4 ± 1 year experience in systematic soccer training and competition.

Due to injuries, a midfielder was excluded from the study. The players' mean age, height, and body weight were 14 ± 0.5 years, 172 ± 7 cm, 63.1 ± 6.5 kg, respectively. The number of players per position in the field was as following: External defenders (N=5); Central defenders (N=5); Midfield (N=6) and Forwards (N=5). The two teams employed the 4-4-2 system (four defenders, four midfielders, and two forwards) during the matches.

Experimental procedures

The analyzed matches were valid for the state U-15 championship. For this category the matches last 70 minute divided into two 35 minute halves and are played on pitches with official dimensions. Permission was obtained from the

Referee's Committee to monitor the players' HR during the matches. Individual HR was monitored using a telemetry being recorded at each 5s (Polar Team System®, Polar Electro Oy, Kempele, Finland). The values of EI were expressed in relation to the maximal individual heart rate (MHR) obtained as maximum pick value during the matches. This strategy have been recommended recently as valid (3,30).

In order to assure similar levels within the test matches, the opposing teams were chosen from those with similar classification in the tables´ competition as the experimental teams. All matches were played between 1h30min and 3h00min pm (Wet Bulb Globe Temperature=24.3 ± 3.3°C [TGM 100, Homis®, Brazil), on natural grass pitches.

To be included in the study the players had to participate in three complete matches occupying the same position in the field. These matches occurred in between six weeks. A standard nutritional guideline was maintained by the coaching staff and the players could ingest water *ad libitum* during the matches. To test the intra-individual variation of HR (beats.min^{-1}) amongst the different matches, the coefficient of variation (CV=SD/mean*100) was used as a reliability measure (4). The coefficient of variation (mean ± SD) found in the first half (2.4 ± 1.7%) and second half (2.7 ± 2.3%) are in agreement with the values reported by Strøyer et al. (38).

Exercise intensity was assessed by taking the % MHR of the first 10 minute of the match, the following 15 minute and the last 10 minute (beginning, middle and end) in each half of the matches. We also determined the percentage of time spent in each one of the five intensity zones (<70%MHR, 71-85%MHR, 86-90%MHR, 91-95%MHR and >96%MHR) (22) in each half of the matches.

To evaluate temporary fatigue during the matches, we first used the moving average to identify the 5-minute period with highest EI for each player in each match. Then we considered the following 5-minute interval to that period and in relation to the respective EI of the half. Such procedure has been used to assess temporary fatigue through peak distance covered by high intensity running in female players (29) and professional male adult players (26,31).

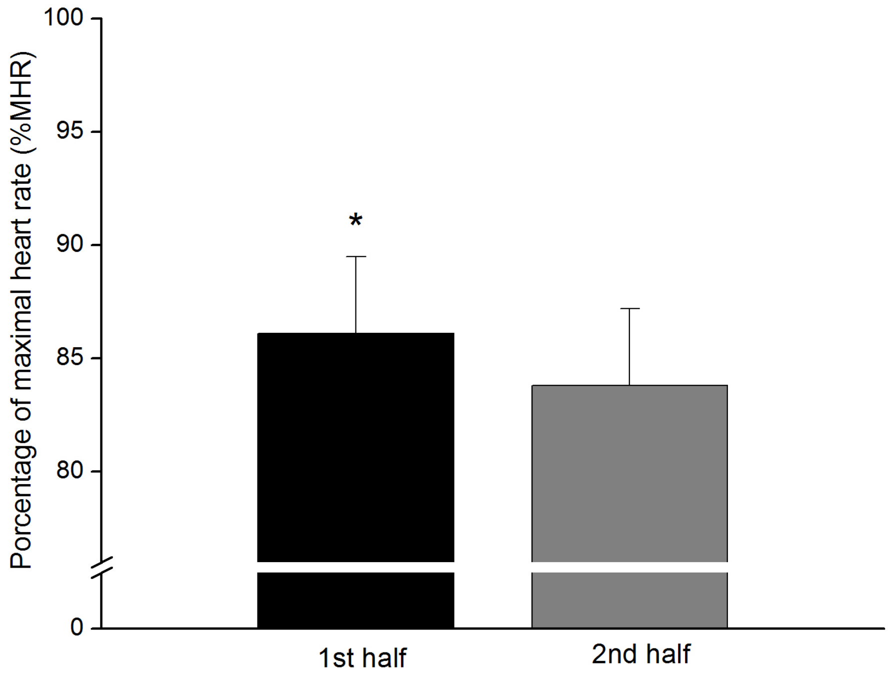
Statistical analysis

Data are expressed as means ± SD. Wilcoxon Signed Ranks Test was used for comparisons among first and second half. The four positional groups were compared using a series of Kruskal Wallis H tests. When a significant positional effect was found, Mann-Whitney U tests were used to compare each pair of positions. Temporary fatigue was tested by Friedman test with post hoc of Wilcoxon Signed Ranks Test for each pair of comparison. All statistical analyses were carried out using the *Statistical Package for the Social Sciences* (*SPSS® 15 for Windows*, Chicago, IL, USA). The significance level was set at $P<0.05$.

RESULTS

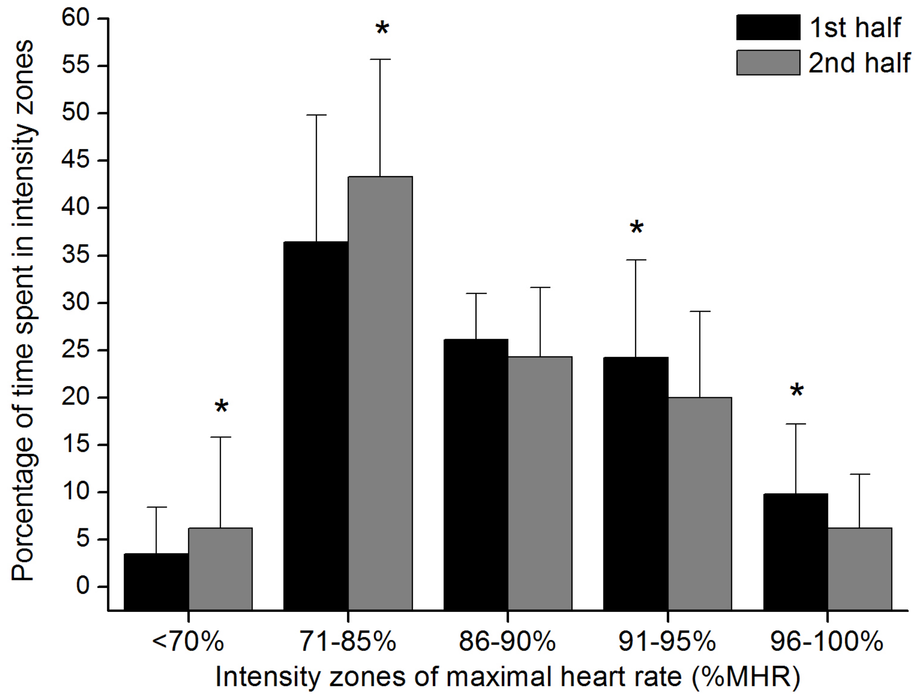
The EI in the first half (86.1 ± 3.4% MHR) was larger ($P<0.05$) than in second half (83.8 ± 4.1% MHR) (Figure 1). The reduction of EI along the match is better discriminated when the time spent in different intensity zones of MHR is observed (Figure 2). The players stayed a larger ($P<0.05$) percentage of the time in lower intensity zones (<70%MHR and 71-85% MHR) than in higher intensity zones (91-95%MHR and >96%MHR) in the second half as compared with the first half of the match (Fig 2).

Figure 1. Exercise intensity expressed as percentage of maximal heart rate (%MHR) in the first and second half of the soccer matches.



*Data are mean ± SD. * Significantly different vs. second half (P<0.05). Number of players, 21.*

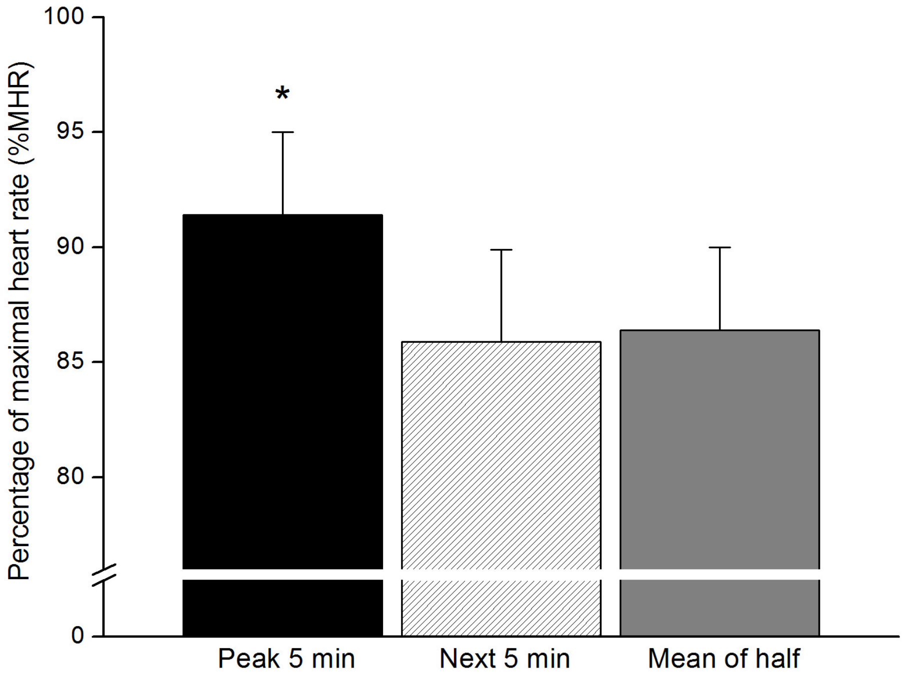
Figure 2. Time spent expressed as percentage in different intensity zones of maximal heart rate in the first and second half of the matches.



*Data are mean ± SD. * Significantly different among the halves (P<0.05). Number of players, 21.*

Concerning temporary fatigue, sixty of the 63 evaluations (~95%) of the 5-minute period with highest EI were observed in the first half. There was a EI reduction in the following 5-minute interval to the 5-minute period with highest EI (91.4 ± 3.6% vs. 85.9 ± 4%MHR; $P<0.05$) (Figure 3). The EI maintained at the following 5-minute interval to the 5-minute with highest EI tended to be lower than the mean EI of the considered half (86.4 ± 3.6%MHR), however there was no statistical difference ($P>0.05$) (Fig. 3).

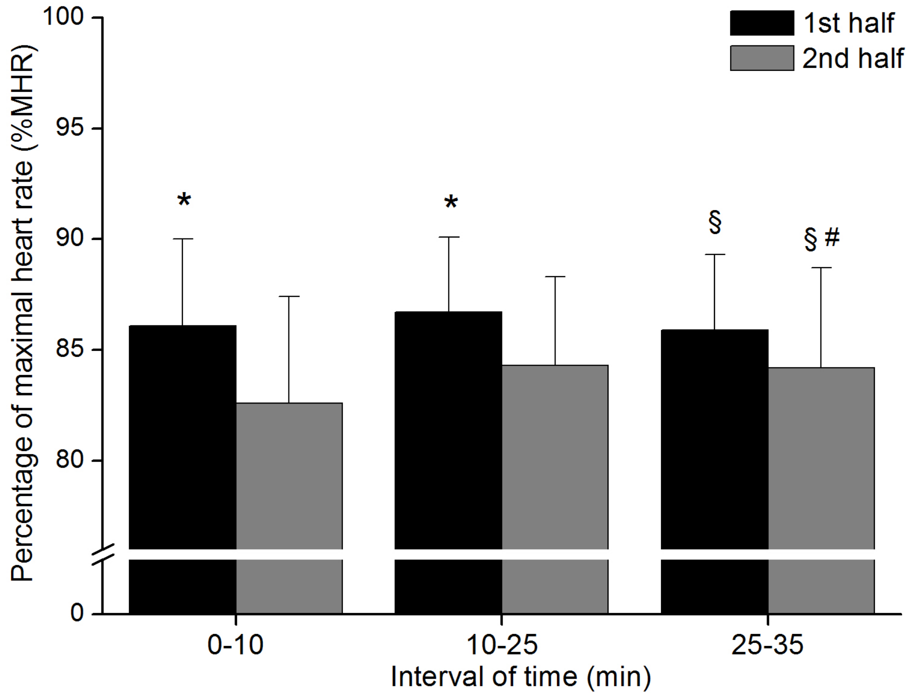
Figure 3. Peak value of exercise intensity during a 5-minute interval in a match compared with the exercise intensity in following 5-minute interval (after the peak interval), as well as average exercise intensity in the respective half.



*Data are mean ± SD. * Significantly different vs. other values (P<0.05). Number of* evaluations*, 63. Exercise intensity expressed as percentage of maximal heart rate (%MHR).*

Figure 4 displays EI observed in two halves of the matches, as well as its behavior amongst different intervals of time in the first and second half. Exercise intensity in the last 10 minute of the match showed lower EI (84.2 ± 4.5%MHR) than the first 10 minute (86.1 ± 3.9%MHR) (P<0.05). EI in 10 minute after half-time (82.6 ± 4.8%MHR) was lower than 10 minute at the end of the first half (85.9 ± 3.4%MHR) and 10 minute at the end of the second half (84.2 ± 4.5%MHR) (P<0.05). No difference was found among EI in 10 minute at the end (25-35 minute) of the two halves (86.7 ± 3.4% *vs.* 84.3 ± 4%MHR) (P>0.05).

Figure 4. Exercise intensity expressed as percentage of maximal heart rate (%MHR) for different intervals of time in the first and second half of the soccer matches.



*Data are mean ± SD. * Significantly different to same interval of time among the halves (P<0.05), # different from the first 10 minutes of the same half (P<0.05), §different from the first 10 minutes of the other half (P<0.05). Number of players, 21.*

There were differences in EI among the players´ positions in the field (*P*<0.05) (Table 1). The external defenders (ED) and midfielders (MD) showed larger (*P*<0.05) EI (88 ± 1.5%MHR and 86.9 ± 1.8%MHR, respectively) compared to central defenders (CD) and forwarders (FW) (82 ± 4.5%MHR and 82.4 ± 1.8%MHR, respectively). No difference of EI was found among ED and MD (*P*=0.27). In addition, the reflection of the EI among the players´ positions is observed in the time of spent in different intensity zones (Tab. 1). The positions ED and MD had larger percentage of time spent in the zone of 91-95%MHR and lower in the zone of 70-85%MHR as compared with CD and FW (*P*<0.05). The FW had a larger percentage of time spent in the intensity zone <70%MHR, compared to ED and MD (*P*< 0.05), but was not different from CD (*P*>0.05) (Tab. 1).

Table 1. Exercise intensity in percent of individual maximal heart rate (%MHR) and time spent (%) in different intensity zones for players' position during match play in young Brazilian soccer players.

Exercise intensity	Players´Position				Main Effect	Mann Whitney U post hoc Test
	ED (N=5)	CD (N=5)	MD (N=6)	FW (N=5)		
%MHR	88 ± 1.5	82 ± 4.5	86.9 ± 1.8	82.4 ± 1.8	P = 0.004	(ED=MD)>(CD=FW)*
<70%MHR (% of time spent)	0.6 ± 0.7	9.8 ± 12.5	1.4 ± 1.3	8.1 ± 3.3	P = 0.022	CD=FW>(ED=MD)*
71-85%MHR (% of time spent)	30.5 ± 8.5	48.2 ± 6.8	34 ± 10.5	47.8 ± 8.1	P = 0.013	(CD=FW)>(ED=MD)*
86-90%MHR (% of time spent)	29 ± 4.3	21.6 ± 6.4	26.4 ± 3.4	23.4 ± 2.5	P = 0.117	
91-95%MHR (% of time spent)	29 ± 5.3	15.4 ± 7	27.1 ± 7.4	15.9 ± 6.8	P = 0.009	(ED=MD)>(CD=FW)*
>96%MHR (% of time spent)	10.77 ± 5.2	4.9 ± 2.5	11 ± 6.8	4.7 ± 4.4	P = 0.072	

*Data are mean ± SD. ED=External defenders; CD=Central defenders; MD=Midfield; FW=Forwards. * Significantly different (P<0.05).*

DISCUSSION

The aim of this study was to evaluate the EI with especial reference to the development of fatigue during competitive matches of young Brazilian soccer players using, as a parameter, the heart rate. The EI in players on the analyzed matches (~85 %MHR, Fig. 1) is next to those observed for players from different categories (10,22,25,30,36,38). This demonstrates that, even in younger player's categories, a competitive soccer match can be considered as a high intensity physical activity (20,39), having rare moments of EI lower than 70%MHR (Fig. 2).

Such high EI may cause fatigue in most players that compromises their performance during the match (31,34).

A demonstration of fatigue is the lower EI on the second half of the match (~2,3%MHR; P<0.05) (Fig. 1) which confirms what was also analyzed in referees (40) and adult soccer players (2,5,19,30,36). Such reduction on the EI is more specifically noticed on the redistribution of the permanence time on each intensity zone for each half of the match, which is a more precise factor to guide the training prescriptions. The rise of time spent on less intense zones (<70% e 71-85%MHR)and reduction in time spent on higher intensity zones (91-95% e 96-100%FCM; P<0.05) (Fig. 2) are as observed by Helgerud et al. (22) for Norwegian elite junior, and by Rhode and Espersen (36) for Danish professional players.

There are only a few studies (10,38) using the heart rate as a parameter of EI as a comparison between young soccer players. In the work of Strøyer et al. (38) where players with age and game rules similar to this research were evaluated, there was a reduction in the heart rate values (178 vs. 173 beats.min^{-1}), however no differences (P>0,05) in the relative work load were found (%VO_2). In another study with slightly younger players (11 years old), also during official eleven-a-side match, Capranica et al. (10) did not find statistical differences between the two halves of the game, not only on the heart rate behavior (exceeded 170 beats.min^{-1} for 88% of the first half and 80% of the second half) but also on the movement pattern. The main reason pointed out by those researchers (10) as an explanation of the constant effort during the match found was the lack of accuracy technique and little specialization of the participants. A shorter duration of their matches (30 minute each half) may have caused their performance during the second half not to reduce so much.

The EI reduction observed on the second half of the mach (Fig. 1 and 2) may be a demonstration of the high competitive difficulty faced and that may represent, consequently, a larger stress physical from the players from the last parts of the match. The competitive level on the Brazilian soccer is high due the great number of people playing and their great desire to play. I addition, the evaluated matches were between teams with basically the same competitive level, and this fact is important to a lower EI on the second half of the match for professional top-level soccer players (32). This factor could be one of the reasons that the results of performances on the second half were different from this study and the ones mentioned before (10,38).

Researchers have been giving a lot of attention for temporary fatigue in male (7,26,31) and female (29) professional adult players during the matches, as a try to explain better the physical work in soccer and to improve training and recovery strategies for more specific forms. Some studies (26,29,31) show a fall in the number of high speed runs on the 5-minute that come before the 5-minute period with highest peak distance covered by high-intensity running show that they might be provoked by temporary fatigue throughout the match.

The reduction of EI followed by the 5-minute period with highest EI (Fig. 3) may be caused by the intermittent characteristic of competitive soccer, in which may occur a lack of balance among the stimulations in high intensity and necessary time for recovery, as said by Mohr et al. (30). Besides, Bangsbo and Mohr (7) demonstrate that the recovery time duration depends on the time of the match, for elite players. According to these researchers (7), the recovery was 17% shorter in the first half of the match and grew to 89% in the last 15 minute of the game. In this study, the majority of the observations (~95%) from the players' 5-minute period with highest EI were observed in the first half of the match and confirms the level of temporary fatigue found in Italian professional players for high intensity running (7).

The coaches should be alert to temporary and accumulative EI matters, as the fatigue might incur in technical mistakes (28) that imply on the fall of the team's performance. This way, player substitutions throughout the match and wiser tactical determinations may lower the early fatigue in the players. Those with a better physical condition may lower the EI reduction during and at the end of the matches. Some studies (31,38) have shown that the percentage of time spent on more intense activities, such as high intensity races, tend to have lower reductions on the second half of the match in players with higher physical capacity compared to the others. Training models like small-sided games have been proving to be effective for the specific resistance development (16,27). In addition, in younger players, that kind of training is an interesting alternative, because it counts on the work with a ball in more realistic situations of the match, which is a strong attraction and motivation (33).

However, training for more elevated intensities (e.g.: 90-100%MHR), that reduce substantially on the second half of the match (Fig. 2), in ball activities may be hard to organize in categories with less technique and physical capacity. For that, Helgerud et al. (22) showed that four times 4-minute at 90-95%MHR, with a 3-minute jog in between, twice per week for 8 weeks were efficient to improve the junior player's performance, having lower heart rate levels and staying on the more intense game zone for a longer period after training. Therefore, this way, the generic and strategic training strategies for the player's specific resistance training can be combined to improving their performance. Although, young athletes are not "adults in miniature" and the coaches must be aware of that, because some lack information of specific training, respecting physiological characteristics of players that are still growing up, and the importance of that to avoid or delay the fatigue during the match.

The half-time interval during the match is a crucial moment for adjustments in the strategy and on the team, also being a moment for the coaches to pay attention to the players' performance level, to not let it reduce on the second half. Reduction on the sprint capacity during match (30) and muscle strength after protocol simulating game intensity (18) in adult players after the half-time has been demonstrated. This study showed a lower performance from the players as well, mainly in the first 10 minutes of the second half of the match, with the EI being lower then the last 10 minutes of the first half or even in the 10 last minute of the second half (*P*<0.05) (Fig. 4). One of the factors pointed out by Mohr et al. (30) explain that such fact is the reduction of the body temperature during half-time. Strategies to keep that temperature (e.g.: activities involving ball control and calisthenics) (30) and re-hydration (14,34), as well as tired players substitution might be important always to try to lower the players' EI once get back to the match and during the second half.

The real physiologic reason of fatigue in soccer players during the match has not been clearly defined yet (34) and could also be related to psychological aspects, like the score, that could be a motivation or not (2). We believe that the explanation according to the lower EI on the second half of the match caused by the last aspect mentioned in this study, is very unlikely, because there was an attempt to control the competitive balance between the teams and in only two evaluated matches (eleven evaluations), the difference was over two goals. The same EI between the matches can be seen with the low CV observed (~2.5%). No additional physiological evaluations of fatigue were done, as a limitation from the ethics committee for invasive measures. Nevertheless, reductions on the phosphate creating, on the muscular pit, on the rise of muscular ionosine monophosphate (26) and on the accumulation of the potassium levels (5,26) are suggested as a cause of fatigue in adult players. Future studies may verify some bioquimics aspects such as performance reduction influences on/in young players during competitive matches.

Soccer at any competitive level is mostly dependent of the tactical-technique interaction and that reflects in EI for players' position EI. The midfielders EI was not different from the external defenders (*P*>0.05), being, both of them larger than the ones observed on the central defenders and forwards (*P*<0.05) (Tab. 1). Ali and Farraly (2) observed in a friendly match of adult English players 176 ± 9 beats.min^{-1} for midfielders, 173 ± 12 beats.min^{-1} for forwards e 166 ± 15 beats.min^{-1} in defenders. A larger EI in midfielders/forwards (~179 beats.min^{-}

^{1}) *versus* defenders (~169 beats.min^{-1}) was also found by Strøyer et al. (38) Danish players ageing approximately 14 years, in competitive matches.

Methodological differences when dividing players' position and differenced tactical tasks make difficult to compare better the researches done. However, Brazilian coaches must be aware to the fact that the external defenders playing by the 4-4-2 contemporary system may have high EI during the matches. In Brazil, the external defenders players have, as a function, not only the defense (man marking) but also the attack (helps transposing to the attack field with ball possession/to provide crosses), what causes a constant participation, mainly by the side of the field. That is demonstrated by a large time spent on the 91-95%MHR (P<0.05; Tab.1). Traditionally, on the European soccer, the function of such position in the same game system is characterized by a bigger importance of the defensive action, advancing only a little from the side to the middle of the field, what is normally done by a midfielder player, more openly positioned. Another characteristic that differs the Brazilian soccer from the European is the use of a less direct game, what may influence on different prosecution per position in the match (37).

In professional Brazilian players, Barros et al. (8) demonstrated, in matches from the Brazilian First Division Championship, a recent study that the external defenders e midfielders have larger rates of distance totally covered. From the other side, the midfielder more larger distance covered prevailed in studies done at the same time with high level European players (17,32). Another study (15) done in young Brazilian players (U-20) also indicated more larger distance covered of the external defenders. Rienzi et al. (35) indicated movements profiles and game style differences between European and South Americans. There is a necessity to verify in future researches if these tendencies are due to the different methods used for the physiologic work evaluation or if they really exist because of the cultural, ethnic, or geographic differences combined to different styles of playing soccer between countries. Only a few researchers have given attention to this so far (9,35) and might be an important factor to be considered in training prescriptions and mainly in talent identification and development of soccer players.

In conclusion, the results observed suggest that there is a similarity between the EI of young players evaluated with the standard shown by professional players, being a high intensity activity. Likewise, there was a reduction on the EI after the half-time and on the second half of the match, and after the intense periods in the match. The EI was specific by players' position, with higher significant rates in midfielders and external defenders when compared to defenders and forwards.

PRACTICAL APPLICATIONS

Information about the exercise intensity, of young players is essential to plan detailed training sessions. Performance reductions after the half-time, on the second half and even temporarily during the match seem to happen to young players as well as with adults, in high-level competitions. Therefore, young soccer players practices should improve the match's specific resistance, meaning that the high intensity intermittent aerobic training, like speed resistance, must be a priority to minimize the exercise intensity reductions observed. Nutritional interventions at certain moments during the match may also be done, as well as more rational substitutions. That seems even more important in higher competition standards, where the work routine and the competitive demands are larger. It was observed that the exercise intensity in players is specialized by players' position and influenced by tactical systems, tasks and the game style used in the Brazilian soccer nowadays.

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ARTIGO 3: YO-YO IR2 TEST E TESTE DE MARGARIA: VALIDADE, CONFIABILIDADE E OBTENÇÃO DA FREQÜÊNCIA CARDÍACA MÁXIMA EM JOGADORES JOVENS DE FUTEBOL

TIPO DE PUBLICAÇÃO

Artigo original

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RESUMO
Os objetivos do presente estudo foram: i) avaliar a validade concorrente do Yo-Yo Intermittente Recovery Test Level 2 (Yo-Yo IR2) e do Teste de Margaria (TM) com o desempenho em alta intensidade de exercício durante jogos oficiais em jogadores de futebol; ii) verificar a confiabilidade (teste-reteste) dos dois testes; iii) comparar os valores da frequência cardíaca máxima (FCM) obtida nesses protocolos e em jogo. Dezoito jogadores (Média ± DP; idade 14 ± 0,8 anos, estatura 172 ± 9 cm, peso 64,3 ± 8,5 kg) pertencentes à mesma equipe foram avaliados em teste-reteste nos referidos protocolos e no percentual de tempo de permanência acima de 85% da FCM individual (PTP>85%FCM) em dois jogos oficiais do Campeonato Mineiro Infantil. Uma alta correlação foi encontrada entre o desempenho no Yo-Yo IR2 e PTP>85%FCM (rs=0,71; p<0,05). Não houve correlação estatisticamente significante entre o desempenho no TM e PTP>85%FCM (rs=0,44; p=0,06). O Yo-Yo IR2 se mostrou mais variável e menos reprodutível (CV= 11%; CCI [95% IC]= 0,38) do que TM (CV= 1%; CCI [95% IC]= 0,93). Porém, nenhuma extrapolação considerável aos limites de concordância ocorreu segundo Bland-Altman. O maior valor de FCM (p<0,001) ocorreu no jogo (202 ± 8 bpm). A FCM no Yo-Yo IR2 (194 ± 4 bpm) foi menor (p<0,006) do que TM (197 ± 6 bpm). Conclui-se que o Yo-Yo IR2 pode ser considerado mais válido para o critério de manutenção de alta intensidade de exercício em jogo que é uma importante medida de desempenho no futebol. Porém, há necessidade de padronização rigorosa entre os procedimentos de avaliação para estabilidade da medida. A FCM deve ser observada em diversas situações, principalmente competitiva, para possibilitar que ocorra o maior valor individual.

Palavras-chave: Futebol. Intensidade de exercício. Desempenho. Frequência cardíaca. Teste de campo.

ABSTRACT
The aims of the present study were: i) to evaluate the concurrent validity of Yo-Yo Intermittente Recovery Test Level 2 (Yo-Yo IR2) and of the Margaria Test (MT) with performance in high exercise intensity during official games in soccer players; ii) to

verify the reliability (test-retest) of the two tests; iii) to compare the values of the maximal individual heart rate (MHR) obtained in those protocols and in game. Eighteen players (mean ± DP; age 14 ± 0,8 years, height 172 ± 9 cm, weight 64,3 ± 8,5 kg) belonging to the same team were appraised in test-retest referred protocols and in the percentage of time spent above 85% of MHR (PTS>85%MHR) in two official games of the U-15 Championship. A high correlation was found among the performance in Yo-Yo IR2 and PTS>85%MHR (rs=0,71; p<0,05). There was not correlation among the performance in MT and PTS>85%MHR (rs=0,44; p=0,06). Yo-Yo IR2 shown more variable and less reproductively (CV= 11%; CCI [95% IC]=0,38) than MT (CV= 1%; CCI [95% IC]=0,93). However, any considerable extrapolation to the Bland-Altman agreement limits happened. The largest value of MHR (p<0,001) happened in the game (202 ± 8 beats.min^{-1}). MHR in Yo-Yo IR2 (194 ± 4 beats.min^{-1}) was smaller (p<0,006) than MT (197 ± 6 beats.min^{-1}). In conclusion, the Yo-Yo IR2 can be considered more valid for the criterion of maintenance of high exercise intensity in game that is an important acting measure in the soccer. However, there is need of rigorous standardization among the evaluation procedures for stability of the measure. MHR should be observed in several situations, mainly competitive, to make possible that happens the largest individual value.

Keywords: Soccer. Exercise intensity. Performance. Heart rate. Field test.

RESUMEN

Los objetivos de este trabajo fueron: i) evaluar la validez del test "Yo-Yo Intermittente Recovery Level 2 (Yo-Yo IR2)" además del test de Margaria (TM) frente al desempeño en alta intensidad de ejercicio durante partidos oficiales en jugadores de fútbol; ii) averiguar la confiabilidad (test-retest) de los dos tests; iii) comparar los valores de frecuencia cardíaca máxima (FCM) obtenida en estos protocolos frente al partido. Dieciocho jugadores (Media ± DP; edad 14 ± 0,8 años, talla 172 ± 9 cm, peso 64,3 ± 8,5 kg) del mismo equipo fueron evaluados en test-retest en los referidos protocolos además del porcentaje de tiempo de permanencia por encima del 85% de la FCM individual (PTP>85%FCM) en dos partidos oficiales del Campeonato Mineiro Infantil. Una alta correlación fue encontrada junto al desempeño del Yo-Yo IR2 y PTP>85%FCM (rs=0,71; p<0,05). No hubo correlación estadísticamente significativo entre el desempeño en el TM y PTP>85%FCM (rs=0,44; p=0,06). El Yo-Yo IR2 demostró ser más variable y menos reproductible (CV= 11%; CCI [95% IC]= 0,38) frente al TM (CV= 1%; CCI [95% IC]= 0,93). Sin embargo, ninguna extrapolación ante los límites de concordancia sucedió según Bland-Altman. Lo mayor valor de FCM (p<0,001) se registró durante el partido (202 ± 8 bpm). La FCM en el Yo-Yo IR2 (194 ± 4 lpm) fue menor (p<0,006) frente TM (197 ± 6 lpm). Se concluye que el test Yo-Yo IR2 puede ser considerado más válido para el criterio de manutención de alta intensidad de ejercicio en partido que es una importante medida de desempeño en el fútbol. Todavía, es necesaria un padrón rigoroso entre los procedimientos de evaluación para estabilidad de la medida. La FCM debe ser observada en diversas situaciones, principalmente en competición, para posibilitar que ocurra un mayor valor individual.

Palabras clave: Fútbol. Intensidad de ejercicio. Desempeño. Frecuencia cardíaca. Test de campo.

INTRODUÇÃO

A avaliação da capacidade aeróbica de atletas é útil para seleção, no desígnio de programas de condicionamento físicos e para predizer e monitorar desempenho físico em competições(1). Na literatura, existem muitos métodos descritos para avaliação da capacidade aeróbica dos jogadores de futebol(1). Em laboratório, a medida direta do consumo máximo de oxigênio (VO_{2max}) em teste de exaustão em esteira(2,3) é considerada padrão ouro, pois permite avaliações simultâneas de outros parâmetros importantes como limiar de transição metabólica, economia de corrida e trabalho cardíaco. Esse procedimento, apesar de controvérsias(4,5), é considerado válido para o futebol, uma vez que tem sido encontrada correlação significante do VO_{2max} com a classificação final da equipe em competição[6] e com algumas variáveis de desempenho em jogo tais como: distância percorrida[6-9]; número de sprints realizados[6-8]; tempo de atividades em alta intensidade[7,9,10]; e número de envolvimentos com a bola pelo jogador[7]. No entanto, uma importante limitação dessa avaliação, especialmente para esportes coletivos, é que os procedimentos consomem muito tempo, requerem pessoal treinado e equipamentos caros[11,12].

Entre os testes de campo, o Teste de Margaria[13] (TM) tem se destacado na avaliação de jogadores de futebol por permitir ajustes na distância de deslocamento utilizada, que deve ser percorrida no menor tempo possível e com velocidade constante para estimativa do VO_{2max}. Assim, em somente um procedimento, é possível estimar o desempenho pelas equações do Teste de 2.400m de Copper[14] ou a do Teste de Weltman[15]. Outra vantagem desse procedimento é a fácil adequação de local e a necessidade de poucos equipamentos. Porém, a validade desses testes para o futebol pode ser questionada por não refletir a resposta fisiológica do jogo[3,16], visto que possuem característica retilínea e contínua de movimentação e, portanto, não simulam a carga competitiva, onde na qual os jogadores são exigidos em inúmeras trocas repentinas de movimentos e direções[10,17-19].

O *Yo-Yo Intermittente Recovery Test Level 2* (Yo-Yo IR2) foi proposto como um teste de campo de fácil aplicação e baixo custo[4,16,20]. Fundamentado em corridas de ida e volta (20 m) com incremento de velocidade de deslocamento controlado por sinal sonoro, seu principal atributo de mensuração é a intermitência de ações, caracterizadas com paralisação de 10 segundos de recuperação entre os estímulos para novo deslocamento. Os deslocamentos são conduzidos até a exaustão do jogador, caracterizado pelo não acompanhamento dos sinais sonoros nas respectivas marcações. Devido a essa característica, o Yo-Yo IR2 tem sido recomendado como ótima medida de avaliação para o futebol[5,16]. O desempenho obtido no Yo-Yo IR2 tem demonstrado correlação significante com o tempo de fadiga em teste progressivo de corrida em esteira, com o VO_{2max} e forte correlação com a máxima distância de deslocamento coberta em cinco minutos durante jogo em jogadores adultos de elite[20]. Outra indicação de seu emprego é a possibilidade de ser observada a frequência cardíaca máxima (FCM) do avaliado durante sua realização, não diferindo dos valores observados nos procedimentos de teste de exaustão conduzidos em esteira[16,20]. A informação dessa variável é importante fator para relativização de intensidades de cargas na prescrição de treinamentos.

Embora estudos prévios, como relatados anteriormente, tenham demonstrado as vantagens do Yo-Yo IR2 para o futebol, pelo nosso saber, há uma carência de estudos com jogadores jovens buscando detectar a validade concorrente[21], confiabilidade e adequação dessa medida para observação da FCM ou mesmo comparação desses aspectos a outro procedimento de avaliação em campo. Outra questão é a comparação de protocolos de campo contínuos com intermitentes, pois ambos os estímulos podem ser utilizados para facilitar as adaptações fisiológicas e melhorar desempenho de jogadores de futebol[7,9].

A validade concorrente e a confiabilidade são importantes fatores a serem considerados pelas comissões técnicas na hora da seleção de um protocolo. Primeiramente pela validade concorrente, que uma alta validade concorrente providencia boa simulação fisiológica e pode servir como medida diagnóstica para um critério de desempenho no jogo[21]. Da mesma forma, é através da confiabilidade que se pode comparar se resultados semelhantes são obtidos sob as mesmas circunstâncias de aplicação em teste-reteste, demonstrando que a variação do protocolo é pequena e tem menores fontes de erro de medida[5], o que é critério importante para reavaliações ao longo da temporada. Do ponto de vista prático é ainda interessante que os estímulos desses testes de campo sejam ainda adequados para obtenção da FCM por resultar em ganho de tempo para a comissão técnica pela não necessidade de aplicação de teste específico para essa variável, que é atualmente muita utilizada para relativização da carga de esforço em prescrição e controle de treinamento.

Dessa forma, os objetivos deste estudo foram: i) avaliar a validade concorrente do Yo-Yo IR2 e do Teste de Margaria pelo desempenho em alta intensidade de exercício durante jogos oficiais em jogadores Sub-15 de futebol; ii) verificar a confiabilidade (teste-reteste) dos dois testes; iii) comparar os valores da FCM observada nesses protocolos e em jogo.

MÉTODOS

Participantes

Vinte e cinco jogadores masculinos pertencentes a uma equipe que participa de competições regulares reconhecidas pela Federação Mineira de Futebol aceitaram participar do estudo como voluntários. Os jogadores que não participaram das partidas completas por motivo de não escalação (por lesão; N=1) ou de substituição ao longo do jogo (N=6), foram excluídos do estudo. Os participantes (N=18) tinham idade de 14 ± 0.8 anos, estatura de 172 ± 9 cm e peso corporal de 64.3 ± 8.5 kg (média ± desvio padrão). A representação por posição de jogo foi da seguinte forma: laterais (N=3); zagueiros (N=4); meio-campistas (N=7) e atacantes (N=4). A equipe jogava numa formação regular de 4-4-2, usando quatro defensores, quatro meio-campistas e dois atacantes.

Durante os procedimentos experimentais, os participantes estavam participando da principal competição da categoria Sub-15 do estado de Minas Gerais. Eles eram submetidos a uma sessão de treino por dia (treinos físicos-técnicos e táticos), com duração aproximada de 90 minutos, cinco vezes por semana e participavam de uma partida oficial por semana (70 min.) aos sábados ou domingos. Todos os voluntários tinham experiência de 4 ± 1 ano de treinamentos sistemáticos e competições do futebol.

O termo de consentimento livre e esclarecido sobre o estudo foi assinado pelos pais ou responsáveis para participação no estudo, após aprovação pelo Comitê de Ética em Pesquisas com Seres Humanos da Universidade Federal de Viçosa, seguindo as recomendações da Resolução 196/196 do Conselho Nacional de Saúde – MS.

Procedimentos experimentais

Inicialmente os participantes foram familiarizados com os protocolos do Yo-Yo IR2 e do de Margaria, assim como com o uso dos monitores de frequência cardíaca (Polar Team System®, Polar Electro Oy, Kempele, Finland) durante sessões de treinamentos. A frequência cardíaca foi monitorada em intervalo de 5 segundos. Foram seguidos os procedimentos de Krustrup et al.[20] para realização do Yo-Yo IR2, onde no qual os jogadores utilizam a mesma vestimenta do jogo de futebol e o teste é realizado em grama natural. Para emissão dos sinais sonoros foi utilizado o CD que acompanha o *kit Yo-Yo tests* (www.teknosport.com, Ancona, Itália). Os procedimentos do Margaria[13] foram seguidos adotando-se a distância de 2.400m, demarcada em uma pista de 300m, de forma circular num campo de futebol de terra batida, paralelo ao campo com grama natural utilizado para os treinamentos. Essa distância foi assim adotada por considerá-la usual em protocolos de pista com características similares. Do ponto de vista fisiológico, essa distância exige um tempo maior que cinco ou seis minutos que é o tempo necessário para manter um alto nível de ritmo estável (*steady-state*) de captação de oxigênio[13]. A predição do VO_{2max} é dada pela equação (distância adotada+30[tempo]/5[tempo]+5)[13].

Para verificar a confiabilidade (estabilidade da medida)[21] os dois protocolos de testes foram executados duas vezes (teste-reteste), com intervalo de uma semana interprocedimento e 48 horas intraprocedimento (Terças-feiras para Yo-Yo IR2 e Quintas-feiras para Margaria). Os testes foram executados durante o período da tarde, entre 14h00min e 16h00min (mesmo horário dos jogos), no começo de cada sessão de treinamento, após 20 minutos de aquecimento e alongamentos típicos do futebol. A temperatura ambiente durante a realização dos testes foi monitorada (TGM 100, Homis®, Brasil) e não foi estatisticamente diferente entre os procedimentos (IBUTG = 24.3 ± 0.2°C *vs*. 24.1 ± 0.4°C; p=0,655, *Wilcoxon Signed Ranks Test*). Os sujeitos foram distribuídos de forma randomizada para a realização dos testes e cada jogador foi encorajado verbalmente a realizar esforço máximo.

Como critério de desempenho em jogo foi utilizado o percentual de tempo de permanência acima de 85% da freqüência cardíaca máxima individual (PTP>85%FCM) obtida em dois jogos completos, para cada jogador, válidos pelo Campeonato Mineiro Infantil. Essa estratégia foi assim definida porque a capacidade de realização de grande quantidade de atividades em altas intensidades pelos jogadores durante o jogo é desejado por treinadores e tem sido indicada como a melhor medida de desempenho para o futebol atualmente(8,10,18,22,23). Atividades em alta intensidade têm comportamento constante entre partidas(10,17,19,24) e é por onde os jogos frequentemente são ganhos ou perdidos, porque as tentativas prósperas a marcar gols são executas em alta intensidade(25). A temperatura ambiente durante a realização dos jogos foi também monitorada e não foi estatisticamente diferente entre os dias (IBUTG= 24.4 ± 1.8°C *vs*. 23.6 ± 2°C; p=0,585, *Wilcoxon Signed Ranks Test*).

A intensidade de exercício observada durante as partidas foi de 85 ± 3,7%FCM. Esse valor corrobora o que é relatado em outros estudos para jogadores de diferentes categorias(7,26-28), demonstrando que as partidas foram disputadas de forma típica. O PTP>85%FCM observado foi de 20,5 ± 5,1%. Essa medida mostrou boa confiabilidade (teste-reteste) através do Coeficiente de Variação (CV) observado (8,6 ± 5,4%) e do Coeficiente de Correlação Intraclasse (CCI=0,92). Alguns estudos recentes(17,22,24) têm encontrado CV variando de 3 a 9,2% utilizando método de *video-recording* ou *computerised, semi-automatic video match analysis image recognition system* para a classificação em corridas de alta-intensidade dos jogadores profissionais em jogos oficiais. Assim, a estratégia PTP>85%FCM pode ser considerada um critério consistente para avaliação do desempenho em alta intensidade de exercício nos jogadores avaliados.

A frequência cardíaca durante os jogos foi monitorada com permissão dos árbitros da Federação Mineira de Futebol. As partidas avaliadas antecederam e sucederam as aplicações dos testes Yo-Yo IR2 e Margaria em no máximo duas semanas. A FCM individual foi definida como a de maior valor de pico obtida durante os jogos, Yo-Yo IR2 ou Margaria. Como os jogadores residem em regime de concentração, uma diretriz nutricional padrão foi mantida pela comissão técnica e os jogadores podiam ingerir água *ad libitum* durante os testes e as partidas.

Análise estatística

Os dados são apresentados como média ± desvio-padrão. Para verificar a validade concorrente, foi aplicado o teste de Spearman (rs) para correlação entre o desempenho nos testes e no PTP>85%FCM nos jogos, sendo considerado a média entre o par de medidas em cada procedimento. A interpretação da correlação observada seguiu a orientação de Morrow et al.[29] com valores <0,20; 0,20-0,39; 0,40-0,59; 0,60-0,79; 0,80-1, classificadas como muito baixa, baixa, moderada, alta e muito alta, respectivamente. O limite de concordância entre os pares de medidas obtidas em teste-reteste foi observado de acordo com o método sugerido por Bland e Altman[30]. O Coeficiente de Variação (CV) foi usado também como uma medida de confiabilidade[31]. O CV foi estabelecido para cada sujeito a partir da divisão do desvio padrão de cada par de medidas pelos seus valores médios (CV = [(DP/média)*100]. A seguir, o CV médio foi calculado a partir da média dos CV individuais. Além disso, para confiabilidade dos pares de valores obtidos em teste-reteste, foi utilizado o Coeficiente de Correlação Intraclasse (CCI)[31]. A utilização dessas três abordagens segue as recomendações de Atkinson e Nevill[31], pois existem vantagens e desvantagens para cada caso. Para a comparação entre as FCM obtidas durante o Yo-Yo IR2, TM e jogo foi utilizado Wilcoxon Signed Ranks Test. A análise estatística foi realizada nos pacotes Statistical Package for the Social Sciences (*SPSS® 15 for Windows*, Chicago, IL, EUA) e MedCalc Software, Mariakerke, Belgium (MedCalc 9.2.1.0). Em todos os casos o nível de significação estatística foi fixado a p<0.05.

RESULTADOS

Uma alta correlação positiva (p<0,05) foi encontrada entre o desempenho no Yo-Yo IR2 e a PTP>85%FCM durante o jogo (rs=0,71; p=0,001) (Figura 1). Entretanto, não houve correlação (p>0,05) entre o desempenho no TM e a PTP>85%FCM durante os jogos (rs=0,44; p=0,064) (Figura 2).

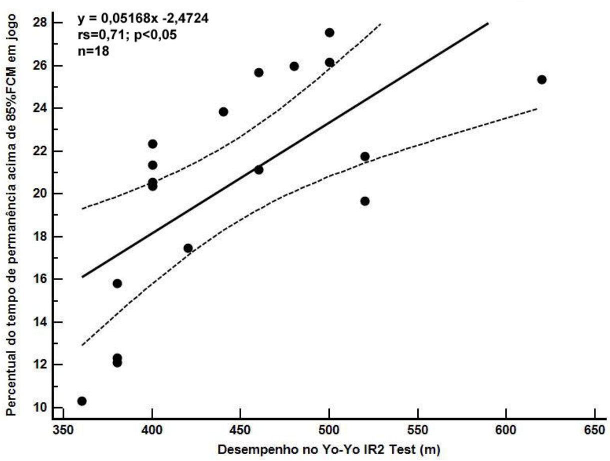

Figura 1 – Dispersão e reta de regressão linear simples correspondentes ao desempenho no Yo-Yo Intermittente Recovery Test Level 2 (Yo-Yo IR2) e o percentual de tempo de permanência acima de 85% da FCM individual (PTP>85%FCM) durante jogo (N=18; rs=0,71; p=0,001). Linha tracejada denota o IC95%.

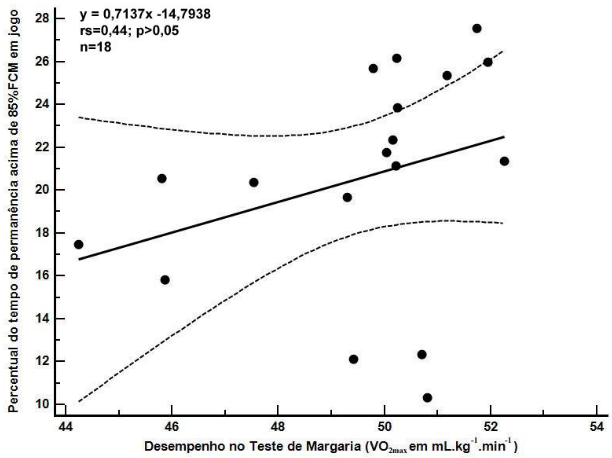

Figura 2 – Dispersão e reta de regressão linear simples correspondentes ao desempenho no Teste de Margaria e o percentual de tempo de permanência acima de 85% da FCM individual (PTP>85%FCM) durante jogo (N=18; rs=0,44; p=0,064). Nota: Linha tracejada denota o IC95%.

O desempenho no Yo-Yo IR2 e no TM, Coeficiente de Variação (CV), assim como o Coeficiente de Correlação Intraclasse (CCI) para todos os procedimentos são apresentados na Tabela 1. Pode-se observar que os CCI e CV são maiores e menores, respectivamente, para o TM em comparação ao Yo-Yo IR2.

Tabela 1. Desempenho no *Yo-Yo Intermittente Recovery Test Level* 2 (Yo-Yo IR2), no Teste de Margaria (TM), Coeficiente de Variação (CV) e Coeficiente de Correlação Intraclasse (CCI) com intervalo de confiança de 95%.

	Desempenho*	CV*	CCI (95% IC)
Yo-Yo IR2	445,5± 67,8m	11%	0,38 (-0,38-0,80)
TM	49,5 ± 2,2 $mL.kg^{-1}.min^{-1}$	1%	0,93 (0,82-0,97)

*Dados expressos como *média ± desvio padrão*. Número de jogadores, 18.

Os gráficos de Bland-Altman demonstrando o grau de concordância entre os pares de medidas obtidos em teste-reteste são apresentados na Figura 3 para o Yo-Yo IR2 e na Figura 4 para o TM. Um jogador esteve fora dos limites de concordância no TM (fig. 4). Apesar de baixo CCI e alto CV para o Yo-Yo IR2, a plotagem de Bland-Altman (fig. 3) revelou que as diferenças médias entre teste-reteste estiveram dentro dos limites de concordância, assim como para o TM (fig. 4). Nenhum dos protocolos apresentou erro heterocedástico.

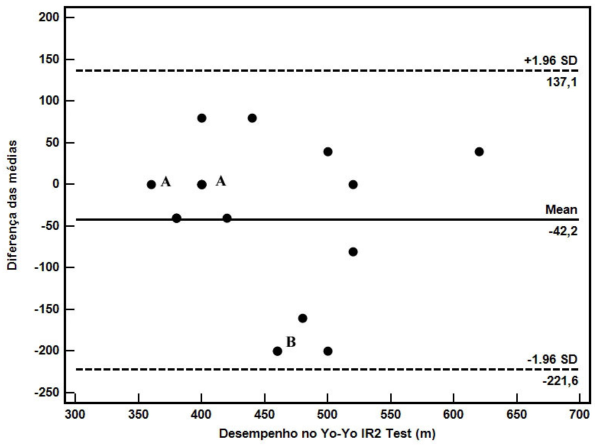

Figura 3 – Plotagem do viés (média das diferenças) e limites de concordância (± 1,96 IC95%) entre os desempenhos obtidos no teste de Yo-Yo Intermittente Recovery Test Level 2 (Yo-Yo IR2), de acordo com os procedimentos de Bland-Altman (N=18). Nota: "A" representa sobreposição de três jogadores e "B" dois jogadores.

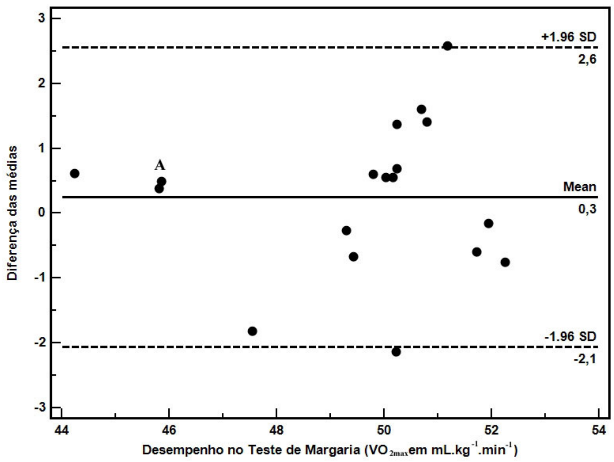

Figura 4 – Plotagem do viés (média das diferenças) e limites de concordância (± 1,96 IC95%) entre os desempenhos obtidos no Teste de Margaria, de acordo com os procedimentos de Bland-Altman (N=18). Nota: "A" representa sobreposição de dois jogadores.

Houve diferença entre as FCM obtidas nas diferentes situações (Figura 5). O maior valor de FCM ($p<0,001$) foi observado na situação de jogo (202 ± 8 bpm. A FCM obtida no Yo-Yo IR2 (194 ± 4 bpm foi menor ($p<0,006$) que aquela durante o TM (197 ± 6 bpm).

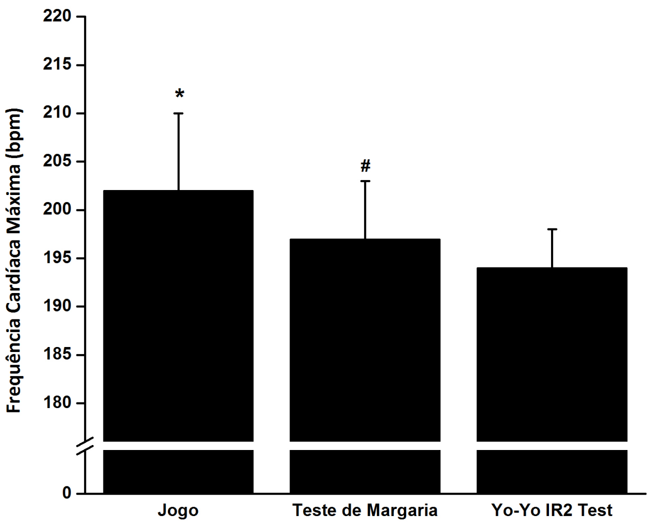

Figura 5 – Frequência cardíaca máxima observada durante jogo, Teste de Margaria e Yo-Yo Intermittente Recovery Test Level 2 (Yo-Yo IR2) (N=18). * $p<0,05$ em relação às demais situações. # $p<0,05$ em relação ao Yo-Yo IR2 Test.

DISCUSSÃO

Um dos objetivos deste estudo foi avaliar a validade concorrente de dois protocolos de campo através da correlação do desempenho dos jogadores nesses procedimentos com desempenho em alta intensidade de exercício em jogo durante jogos oficiais em jogadores Sub-15 de futebol. Uma alta correlação entre o desempenho no Yo-Yo IR2 e o percentual de tempo de permanência acima de 85% da frequência cardíaca máxima individual (PTP>85%FCM) durante o jogo ($rs=0,71$; $p<0,05$) foi encontrada (fig. 1), demonstrando que esse procedimento pode ser considerado mais válido do que TM ($rs=0,44$; $p=0,06$; fig. 2).

Em virtude da execução na forma de estímulos intermitente, o desempenho no Yo-Yo IR2 parece ser facilitado por adaptações morfo-fisiológicas específicas que os jogadores adquirem nos jogos e treinamentos do futebol. As combinações da velocidade de deslocamento e de seu incremento a cada estágio fazem com que a habilidade de suportar estímulos em que ambos os sistemas aeróbicos e anaeróbicos são estimulados fortemente seja avaliada nesse protocolo[16,20]. Assim, o desempenho no Yo-Yo IR2 pôde refletir melhor o condicionamento dos jogadores para atividades específicas do futebol e ter correlação significativa com a manutenção de alta intensidade de exercício durante as partidas, que é uma medida de desempenho importante para o futebol[8,10,18,22,23] em virtude da valorização que o componente físico tem ganhado nos últimos anos.

Alguns estudos têm encontrado correlação significativa entre desempenho no Yo-Yo IR1 Test (outro nível de exigência de intensidade de exercício físico mais brando)[16] e desempenho em atividades de altas intensidades em competição em jogadores adultos no futebol de elite masculino[32], feminino[10], em árbitros em competições de alto nível no futebol[33] e no desempenho em corridas de curta duração após partida experimental de basquetebol com jogadores juniores[11]. Uma alta correlação ($r=0,74$, $p<0,05$), parecida a encontrada no presente estudo (fig. 1), foi observada por Krustrup et al.[20] entre o desempenho no Yo-Yo IR2 e a máxima distância de deslocamento percorrida em cinco minutos durante os jogos em jogadores adultos de elite da região da Escandinávia. Ainda foi observado nesse estudo[20] que essa correlação entre o Yo-Yo IR2 foi maior do que a obtida para o VO_{2max} nesse mesmo critério de atividade de alta intensidade durante o jogo.

Desde categorias mais jovens, a dinâmica de treinamentos do futebol atual leva os jogadores a trabalharem os aspectos aeróbico e anaeróbico combinados nas formulações dos treinamentos. Corridas de longas distâncias ou oportunidades típicas para condicionamento aeróbico são raras, ainda mais no período competitivo, momento em que foram feitas as avaliações do presente estudo. Mohr et al.[24] observaram que o período competitivo foi a fase que jogadores profissionais apresentam as maiores taxas de deslocamentos em alta intensidade, refletindo a fase de treinos que tem os procedimentos mais intensos, intermitentes e próximos da realidade de jogo. Esses aspectos podem tornar os protocolos que utilizam procedimentos contínuos, como o TM, pouco específicos e válidos para avaliação de jogadores de futebol, principalmente nesse momento.

Outro objetivo do estudo foi avaliar a confiabilidade (teste-reteste) dos dois testes. A análise dos gráficos de Bland-Altman para o desempenho nos dois protocolos apontou que eles não apresentaram erro heterocedástico nem sistemático absoluto, ou seja, a diferença entre teste-reteste não guardaram relação significativa com a magnitude da medida nem apresentaram tendências a serem sistematicamente positivas ou negativas. No entanto, a análise teste-reteste do TM revelou que em dois jogadores as diferenças entre esses pares de medidas foram altas, próximas aos limites de aceitação (fig. 4). Do outro lado, o CV para o Yo-Yo IR2 foi maior que o do TM (11% vs. 1%; tab. 1), sendo, portanto, uma medida com maior grau de variabilidade teste-reteste, reforçado ainda pelo baixo valor CCI (0,38). A variabilidade encontrada no presente estudo para o Yo-Yo IR2 está próxima da que foi reportada (CV= 9,6 %) no próprio estudo de Krustrup et al.[20] para validação desse protocolo.

Essa maior variabilidade reporta a necessidade de adoção de padronização rigorosa entre os procedimentos de avaliação para o Yo-Yo IR2, uma vez que as interpretações de possíveis mudanças, associadas ao treinamento ou a intervenções nutricionais, por exemplo, podem estar comprometidas pela baixa estabilidade da medida e isso pode comprometer a validade de um teste[21]. Estratégias de motivação e condições do gramado também podem ser fontes que levarão a baixa confiabilidade desse protocolo. Vale lembrar que os avaliadores foram os mesmos e que houve tentativa de minimizar esses fatores. Mesmo assim, Bangsbo et al.[16] consideram que os protocolos Yo-Yo IR têm uma alta confiabilidade em que os componentes psicológicos envolvidos podem alterar os resultados dentro do teste-reteste por se tratar de um teste exaustivo como outro qualquer dessa característica.

A baixa estabilidade da medida pode ser uma importante limitação nos testes de campo, em comparação aos procedimentos realizados em condições controladas de laboratório[5]. No entanto, uma considerável limitação dos procedimentos em laboratório é sua validade ecológica, porque se os treinos e competições ocorrem no campo, então os procedimentos de avaliação devem ser realizados nesse mesmo ambiente[12,21]. Contudo, a importância dos procedimentos de avaliação de VO_{2max} em esteira em condições laboratoriais é destacada, principalmente médica-desportiva através da avaliação cardiológica simultânea, tornando indispensável sua realização de pelo menos duas vezes, uma no começo e outra no meio da temporada, com os testes de campo podendo ser utilizados nos outros momentos como forma de controle para a comissão técnica[4].

O principal objetivo dos procedimentos de avaliação no futebol é a simulação das demandas fisiológicas do jogo. Do ponto de vista prático, é interessante que eles sejam simples para a rotina do dia-a-dia do futebol. Assim, apesar de ter sido observada maior variabilidade teste-reteste no Yo-Yo IR2 no presente estudo, do ponto de vista prático esse protocolo apresenta a vantagem do tempo de avaliação despendida ser mais rápido (geralmente de 5 a 10 min.)[16]. No presente estudo, o tempo despendido foi de aproximadamente 6 min. para esse protocolo e de 10 min. para o TM. Isso pode significar ganho de tempo ao avaliar muitos atletas, sendo importante também por permitir um número maior de avaliações ao longo da temporada. Além disto, o Yo-Yo IR2 pode ser realizado junto às seções de treinamento, no próprio campo de jogo, com as vestimentas específicas do jogador de futebol, aproximando-se das condições competitivas. Essas vantagens de aplicação podem ser interessantes para os clubes de menor poder aquisitivo, nas categorias de base, nos quais as avaliações indiretas realizadas em campo são muito utilizadas[1].

O ultimo objetivo desse estudo foi avaliar qual estímulo (Yo-Yo IR2, TM ou jogo) proporciona o maior valor de pico de FCM. O maior valor de FCM foi encontrado durante os jogos (202 ± 8 bpm; $p<0,05$) em relação ao Yo-Yo IR2 (194 ± 4 bpm) e TM (197 ± 6 bpm) (fig. 5). Isso está em conformidade com os resultados encontrados por Antonacci et al.[34] para jogadores brasileiros de futebol de alto nível das categorias juvenil, júnior e profissional. Eles observaram que o maior valor de FCM foi observado em jogos oficiais, em comparação ao teste de esforço máximo (1.000m de corrida continua) e pela equação de predição 220-idade. Segundo Santos et al.[35], há uma forte tendência da FCM ser observada em testes de campos do que em testes em laboratório. Segundo esses autores[35], as diferenças entre os valores de FCM obtidos nesses dois ambientes podem ser parcialmente explicadas pelo fato de que como a temperatura e umidade do ar são geralmente maiores no ambiente de campo, isso levaria a uma maior carga de estresse fisiológico. Além disso, o aspecto psicológico e maior motivação para alto desempenho em situação de competição parecem ser os principais motivos que levam a FCM ser observada em situações competitivas, como acontece também em outras modalidades de característica intermitente como no rúgbi[36], futebol americano[37] e futebol gaélico[38].

No presente estudo, a FCM durante o Yo-Yo IR2 foi menor que durante o jogo e TM ($p<0,05$) (fig. 5), o que poderia subestimar essa variável e, conseqüentemente, as prescrições de atividades com intensidade controlada pela FC. No entanto, alguns estudos recomendam que o Yo-Yo IR2 pode ser um bom indicador de FCM, pois não observaram diferenças ($p>0,05$) em relação a testes de VO_{2max} em esteira[16,20] em jogadores adultos. Aspectos como duração das avaliações no Yo-Yo IR2 (~5 min), fadiga de membros inferiores e motivação podem ter dificultado a observação de maiores valores de FCM nos sujeitos do presente estudo. No TM, a FCM também foi subestimada, em relação à observada em jogo (fig.3). A falta de marcadores de fadiga durante os testes como, por exemplo, lactato sanguíneo, pH muscular ou K^+ plasmático pode ser considerada uma limitação do presente estudo. Estes parâmetros ajudariam a caracterizar melhor os testes e monitorar o esforço máximo despedido, ou não, pelos jogadores no ato das avaliações e diferenciar entre limitação fisiológica e/ou motivacional para tal procedimento. Há, porém, que destacar que como são medidas invasivas, isso tem limitação do comitê de ética por se tratar de voluntários jovens.

Em quatro jogadores dos 18 avaliados (~22%) no presente estudo, a FCM individual foi observada no Yo-Yo IR2 ou no TM e não necessariamente na situação de jogo. Vale ressaltar que as posições de jogo têm demanda diferenciada de esforço(2,18,19,24) e isso pode refletir em maior facilidade, ou não, da posição apresentar maior valor de FCM na partida. Cabe destacar a carência de estudos que direcionaram atenção para a relação das posições ocupadas no jogo e FCM. Assim, apesar da literatura apontar que os maiores valores de FCM ocorrem em situação de competição(34,36-38), recomenda-se que essa variável seja avaliada em outras situações de esforço em jogadores de futebol. Desta forma, há possibilidade dos jogadores expressarem o maior valor individual, melhorando a acuidade das prescrições e controle de treinamento pela FCM. Afonso et al.(39) ainda alertam sobre a influência circadiana na resposta da FCM. Eles observaram decréscimo na FCM na fase escura do ciclo claro/escuro em seu estudo usando o protocolo de Bruce em esteira, o que reportaria a necessidade de considerar as variações circadianas individuais, para observar e prescrever atividades tomando como parâmetro essa variável, principalmente em horários mais tardios.

Algumas das limitações do presente estudo foram os controles da carga de trabalho previamente aos procedimentos de avaliação e da variabilidade cotidiana da FC. O controle dessas situações é dificilmente realizado em situações com equipes em período competitivo, pois isto impõe muita organização e perturba o horário regular e rotina de treinamento da equipe. Mesmo sabendo da variabilidade da FC, muitos outros estudos foram administrados em jogador de futebol usando essa variável para controlar a intensidade de exercício. Estudos futuros devem ser realizados com a intenção de analisar a correlação entre outros protocolos de campo e/ou medida direta de consumo de oxigênio com outros fatores indicadores de alto desempenho durante o jogo a fim de evidenciar os procedimentos de avaliação mais válidos e com maior confiabilidade para jovens jogadores de futebol, onde há uma grande limitação de conhecimentos publicados.

CONCLUSÕES

Os resultados encontrados neste estudo demonstram que o Yo-Yo IR2 apresenta-se como mais recomendável do que o Teste de Margaria, obtendo alta correlação entre o desempenho nesse protocolo e o desempenho em alta intensidade de exercício durante os jogos em jogadores jovens. No entanto, esse protocolo apresentou a maior variabilidade, reportando a necessidade de adoção de padronização rigorosa entre os procedimentos de avaliação para não comprometer sua confiabilidade. O maior valor de FCM foi encontrado nos jogos em comparação aos dois testes de campo, demonstrando que a situação competitiva pode ser o melhor referencial para obtenção dessa variável.

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ARTIGO 4: THE EFFECT OF NUMBER OF PLAYERS ON EXERCISE INTENSITY AND TECHNICAL DEMANDS, AND RELIABILITY OF THE MEASURE IN SMALL-SIDED GAMES IN YOUNG BRAZILIAN SOCCER PLAYERS.

Running head: Small-sided games in young soccer players

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ABSTRACT & KEYWORDS

The aim of this study was to examine: (I) the impact of changes in number of players on exercise intensity (EI), Rating of perceived exertion (RPE) and technical demands (TDs) when the pitch area per player was kept constant; and (II) reliability of the measure. Sixteen male soccer players (mean±S.D.; age 13.5 ± 0.7 years, height 164 ± 7 cm, weight 51.8 ± 8 kg) participated twice in 3 vs. 3 (SSG3); 4 vs. 4 (SSG4) and 5 vs. 5 (SSG5) performed in three 4 min bouts separated with 3 min recovery in pitch of 30x30m. Heart rate measurements were made and EI was expressed in relation to the maximal individual heart rate pick value (MHR) during the SSGs. Filming were made and TDS were analyzed using a hand notation system. There is no simple main effect "number of players" in EI at first (Rever Inglês) set (SSG3=87.9 ± 3%MHR; SSG4=86.7 ± 3%MHR; SSG5=85.8 ± 4%MHR). EI in the second set was larger ($P<0.05$) in SSG3 (90.5 ± 2%MHR) in relation to SSG4 (89.2 ± 2%MHR) or SSG5 (87.5 ± 4%MHR). EI in third set for SSG5 (87.6 ± 3%MHR) were smaller ($P<0.05$) than in the other two SSGs (90.9 ± 2%MHR and 89.8 ± 2%MHR for SSG3 and SSG4, respectively). EI in first set for all SSGs conditions was smaller than second ($P<0.05$). EI in second set in all SSGs condition did not differ of the third. RPE in SSG3 (3.04 ± 0.71) was larger in second set in relation to second set in SSG4 (2.52 ± 0.60) and second set in SSG5 (2.39 ± 0.74). RPE did not differ in the first e third set among different SSG's as well as among the sets inside of same SSG. No significant differences were observed in IWB, pass, target pass, tackles and headers between all SSGs conditions. However, significantly more crosses,

dribbles, and shot on goal were observed playing SSG3 ($P<0.05$). SSGs conditions do not affect variability measure for coefficient of variation (CV) for EI (~8%). The smallest CV in most of TDS was observed for SSG5. These results demonstrate that smaller format can provide larger value of EI. SSGs conditions do not alter the majority of TDS, however formats with larger number of players can provide technical stimulus in a more reliable way. RPE demonstrated not to be a reliable measure of EI in SSG’s in that category.
Keywords: Soccer; Exercise intensity; Technical actions; Heart rate; Rating of perceived exertion.

Introduction

Small-sided games (SSGs) can be used for soccer-specific aerobic endurance training with the advantages of multifactorial training.[1,2] The presence of the ball, which imposes a specific activity and allows the concomitant improvement of technical and tactical skills with high player motivation.[3,4] In that way, the adoption of SSGs becomes an interesting alternative for younger players,[4] since they combine the game actions in more realistic form and develop the specific musculature, making the transfer to competitive situations easier.

Researchers have examined several factors that can to influence the intensity of SSGs as the dimensions of the pitch,[5] the number of players on each side,[6-9] coach encouragement,[9] continuous and intermittent,[10] and goalkeepers' participation.[3,11] Collectively, these findings suggest that SSGs offer a safe, effective, and specific method of conditioning for soccer players. Heart rate responses around 90–95% of maximal heart rate (MHR) were observed in professional players[5,7,8,11,12] to appear to be suitable for developing VO_{2max}[12,13] when used as a physical conditioning tool.

Although many of these studies described the influence of altering these factors on acute physiological and perceptual responses in adult amateur or professional players, no studies have examined the influence of increasing the number of players on physiological as well as the technical response of SSGs in young players. Besides, to reach the physical and technical benefits, the SSGs should have high reliability to produce the same responses and that not very clear to what this training modality have this potential. It still fits to verify RPE is a valid measure for EI in that category as confirmed in adults[14,15], since it is a cheap and practical method for the training day by day and to design periodization strategies.

Therefore, the aim of this study was to examine: (I) the impact of changes in number of players on EI, Rating of perceived exertion (RPE) and TDs of SSGs when the pitch area per player was kept constant; (II) reliability of the measure.

Methods

Participants

Sixteen male U-15 outfield soccer players (body mass 51.8 ± 8 kg, height 164 ± 7 cm, and age 13.5 ± 0.7 years) from the same team that participate in regular competitions recognized by the Federação Mineira de Futebol (member of the Confederação Brasileira de Futebol – CBF) were involved in the study. At that time of the experimental procedures they trained a session a day (90 min) three times a week and played competitive matches at least once a week (70 min). All the volunteers had experience of 3 ± 1 year of systematic trainings and competitions of the soccer. None of them had heart compromising and being considered seemingly healthy.

Consent forms were completed for each participant by a parent or guardian because the players were under the legal age of consent. Ethical approval was granted by local university's ethical procedures following the recommendations of the Code of Ethics of the World Medical Association (Declaration of Helsinki 1975) and recommendations of the Resolution 196/196 of National Council of Health, Brazil.

Procedure

Before the beginning of the study, the players were familiarized with all of the procedures during sessions of trainings. We examined three- (SSG3), four- (SSG4), and five- (SSG5) a-side games, without goalkeepers, using small goals (1.20x0.80m), free touches, and with the ball always being replaced promptly when out of play. Scores were considered valid only when all team-mates were in the opponent's half of the pitch. The SSGs were played in 30x30m, which are similar to the sizes used in previous studies,[5,7-9,11] performed outdoors, on a natural turf surface after a 20-min warm-up which consisted of low-intensity running, striding, and stretching at the beginning of a training session. Each small-sided game was performed as interval training consisting of three bouts of 4 min duration with 3 min of active recovery between bouts. This was done twice a week (Monday and Thursday) throughout the season. The order in which the small-sided game were performed during the course of the competitive season was randomized. Each small-sided game was separated by approximately 2 weeks. Experiment's temperature was monitored (TGM 100, Homis®, Brazil) and it was not different inter (IBUTG= 19.3 ± 1.2°C vs. 18.9 ± 1.2°C vs. 18.8 ± 0.9, *P*=0,55) and intra procedures (IBUTG= 19.7 ± 1.5°C vs. 18.9 ± 1.2°C vs. 19.3 ± 1.3, *P*=0,45) respectively for SSG3, SSG4 and SSG5 analyzed for Kruskal-Wallis one-way analysis of variance by ranks.

The trainer's experience was used to allocate players into balanced small-sided game teams with same teams against the same opponents in each confrontation. To encourage the maintenance of a high work-rate, verbal support was given to all participants during each 4-min exercise bout by the team's fitness coach. In all SSGs, players were allowed hydration *ad libitum*.

Physiological, perceived effort and technical evaluations

Individual HR was monitored with a system of telemetry of short distance and registered to each 5s (Polar Team System®, Polar Electro Oy, Kempele, Finland). The values of effort intensity were expressed in relation to the maximal individual heart rate (%MHR) obtained as maximum pick value during the SSGs.

Rating of perceived exertion (RPE, Borg's CR-10 scale)[14] was also used as a measure of intensity for the small-sided game. Each player's RPE was collected at the end of each set of small-sided game to ensure the perceived effort. Video recordings of all small-side games was obtained using a camcorder (SC-D381/XAZ, Samsung Electronics America, Inc., Ridgefield Park, NJ, USA) to evaluate the TDs. The video recordings were subsequently analyzed by one experienced observer to determine the amount technical action for each player performed during each small-sided game. TDs were segregated into eight discrete categories (involvements with the ball; crosses; headers, tackles, shot on goal, dribble, pass, and target pass) based on match activities frequently performed in game play.

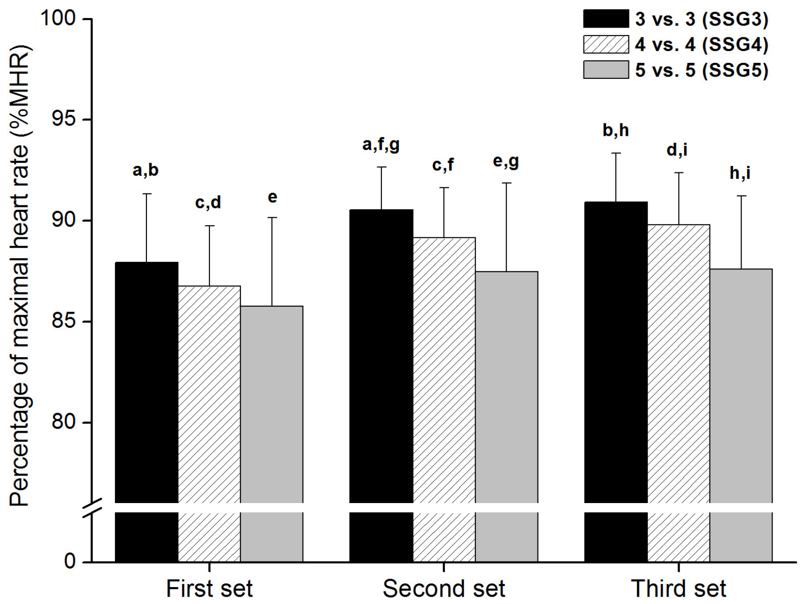
Statistical analysis

Descriptive statistics are represented as mean ± SD. All data sets of EI were assessed for the assumption of normality using the Shapiro-Wilks test for normality of distribution statistic. Mauchly's test of sphericity was performed on all data to assess for the assumption of sphericity. A two-way analysis of variance (ANOVA) with repeated measures (within subject) was employed to evaluate the differences in EI between each number of players condition for the exercise periods. Post hoc analysis using the Bonferroni adjustment for multiple comparisons was applied to make pair-wise comparisons among the different levels of the within subjects factor (number of players and exercise bout). Effect sizes (η^2) were also calculated and values of 0.01, 0.06, and >0.15 were considered small, medium, and large respectively.[16] Technical demands and RPE were tested by Friedman test with post hoc of Wilcoxon Signed Ranks Test for each pair of comparison of small-sided format. The standard deviation expressed as a coefficient of variation of the different SSGs completed by the players was used as a measure of inter-participant variability.[17] All statistical analyses were carried out using the *Statistical Package for the Social Sciences* (*SPSS® 15 for Windows*, Chicago, IL, USA). The significance level was set at *P*<0.05.

Results

Data relating to the EI (%MHR) responses to each number of players condition in small-sided game are shown in Figure 1. There was main effect for factor “changes in number of players” in EI [$F(2, 30)=9.49$, $P<0.05$] with large effect size ($\eta 2=0.39$). Post-hoc analyses using the Bonferroni adjustment for multiple comparisons revealed that mean EI in the second set was larger ($P< 0.05$) in SSG3 (90.5 ± 2%MHR) in relation to SSG4 (89.2 ± 2%MHR) or SSG5 (87.5 ± 4%MHR) condition. EI in third set for SSG5 (87.6 ± 3%MHR) were smaller ($P<0.05$) than in the other two small-sided condition (90.9 ± 2%MHR and 89.8 ± 2%MHR for SSG3 and SSG4, respectively). There is no simple main effect “number of players” at first set (SSG3=87.9 ± 3%MHR; SSG4=86.7 ± 3%MHR; SSG5=85.8 ± 4%MHR, $P>0.05$). The interaction effect [$F(4, 60)=0.97$] did not reach statistical significance ($P=0.43$).

Figure 1. Exercise intensity in small-sided games expressed as percentage of maximal heart rate (%MHR) during each exercise period for 3 vs. 3 (SSG3), 4 vs. 4 (SSG4) and 5 vs. 5 (SSG5) condition.



Data are mean ± SD. Same letters are different amongst themselves (P<0.05). Number of players, 16.

There was a statistically significant main effect for factor "set" in EI [F(2, 30)=49.68, P<0.05] with large effect size (η^2=0.77). Post-hoc comparisons (Fig. 1) indicated that EI in the first set was smaller (P<0.05) than in the second and third set with the players playing in SSG3. The first set for SSG4 were smaller (P<0.05) than the second and third set. In the SSG5 the player's EI in the second set was larger than the first set. The first set in SSG5 did not differ (P>0.05) of the third set. In all conditions of number of players, EI in the second set did not differ of the third set in the SSGs (P>0.05).

The Rating of perceived exertion (RPE) was different in the second set (*P*<0.05) with SSG3 being larger than SSG4 and SSG5 (Table 1). SSG4 and SSG5 not differing for RPE in the second set. The first and third set of the all number of players conditions offered same answer (*P*>0.05). Inside of the same number of players the observed RPE for first, second and third set were not different amongst themselves with *P*=0.81 for SSG3, *P*=0.34 for SSG4 and *P*=0.15 for SSG5.

Table 1. Rating of perceived exertion (RPE) for player in each small-sided condition for number of players.

RPE	3 vs. 3 (SSG3)	4 vs. 4 (SSG4)	5 vs. 5 (SSG5)
First set	2.72 ± 0.73	2,53 ± 0.45	2.28 ± 0.90
Second set	3.04 ± 0.71*	2.52 ± 0.60	2.39 ± 0.74
Third set	3.22 ± 1.02	2.80 ± 0.62	2.56 ± 0.60

*Data are mean ± SD. * Significantly different (P<0.05) for other two conditions of number of players in the same set. Number of players, 16.*

Table 2 highlights the frequency of TDs for player in each small-sided condition. Significantly more crosses, dribbles, and shot on goal were observed playing in the SSG1 (*P*<0.05). No significant differences were observed in the number of involvements with the ball, pass, target pass (%), tackles and headers between all SSGs (*P*<0.05).

Table 2. Frequency of technical action for player in each small-sided condition for number of players.

Technical action	3 vs. 3 (SSG3)	4 vs. 4 (SSG4)	5 vs. 5 (SSG5)
Involvements with the ball	31 ± 6	32 ± 4	31 ± 4
Pass	19 ± 4	20 ± 4	22 ± 4
Target pass (%)	73.4 ± 9	75 ± 11	76 ± 9
Crosses	3 ± 1*	1 ± 1	1 ± 1
Dribble	4 ± 2*	2 ± 1	2 ± 1
Shot on goal	3 ± 1*	2 ± 1	2 ± 1
Tackles	2 ± 1	2 ± 1	2 ± 2
Headers	1 ± 1	1 ± 1	1 ± 1

*Data are mean ± SD. * Significantly different (P<0.05). Number of players, 16.*

Inter-participant variability expressed as coefficients of variation is reported in Table 3. Changes in number of players do not appear to affect variability for EI. The smallest coefficients of variation for involvements with the ball, pass, target pass (%), crosses, dribble and shot on goal were observed for SSG5 format. Smaller variability for tackles and headers were observed playing SSG3.

Table 3. Variability expresses as coefficient of variation of the exercise intensity and of technical demands each small-sided condition of number of players.

Variability criterion	3 vs. 3 (SSG3)	4 vs. 4 (SSG4)	5 vs. 5 (SSG5)
Exercise intensity (%MHR)	8%	7%	7%
Involvements with the ball	21%	23%	18%
Pass	34%	33%	19%
Target pass (%)	41%	38%	20%
Crosses	82%	73%	43%
Dribble	63%	67%	60%
Shot on goal	68%	64%	61%
Tackles	21%	27%	32%
Headers	9%	18%	12%

Discussion

The EI values (%MRH) for all conditions of number of players attained in this study are similar to those previously reported for small-format (2 vs. 2 and 3 vs. 3) intermittent games training in adult players.[7,8,11] It is clear that this type of training, irrespective of the number of players, presents a significant stress to the cardiovascular system. However, there was main effect for factor "change of number of players" in EI (*P*<0.05) with SSG5 presented the lowest values in second e third set (Fig. 1).

Those results follow the tendency presented for Rampinini et al.[9] where EI of SSGs increases while the number of players decreases (three-, four-, five- and six-a-side games). They[9] also showed that this is also dependent on the playing area, with the game intensity decreasing when the available game area is decreased. This way, SSGs with smaller numbers of players (i.e. 3 vs. 3 and 4 vs. 4) for same area provide physiological responses suitable for soccer endurance training based on current recommendations in the literature,[12,13] if the guidelines advocated for adult players are relevant to this specific population. On the other side, these results suggest that SSG5 small-sided game argued in the molds of our study may be useful for pre-season aerobic base training or for lower-intensity specific training in soccer players.

No difference was noticed in RPE for the other set comparisons or number of players in spite of difference to be observed for EI measured for %MHR among some comparisons of sets and format of SSG. The answer for RPE was extremely low in relation to %MHR (Fig. 1). That can suggest that RPE was not sensitive when noticing the differences of physiologic load in SSG's in young players. On the other side the answer of that variable might have been influenced by the friends' answers out of the experimental procedures. This way, the players seem not to answer the subjective perception of effort appropriately due to age that can produce a smaller estimate of the real effort. Impellizzeri et al.[15] observed recently that RPE can be recommended for 17 year-old players finding individual correlations between various HR-based training load and session-RPE. Like this, IPE demonstrated not to be a reliable measure of EI in SSG's in U-15 category.

An important lack for that training type for high soccer performance observed by Gabbett and Mulvey[18] is that repeated sprint bouts were uncommon in SSGs in elite women soccer players. These findings demonstrate that SSGs simulate the overall movement patterns of women's soccer competition but offer an insufficient training stimulus to simulate the high intensity, repeated-sprint demands of international competition.[18] These findings suggest that SSGs should be supplemented with specific training that simulates the high-intensity and repeated-sprint. Trainers can reach that with different types of intermittent exercise both with and without the ball.

The factor "set" was main effect to increase the EI ($P<0.05$; $\eta^2=0.77$). However, in all condition of number of players, EI in the second set was larger than the first and equal to the third ($P>0.05$; Fig. 1). These findings have important practical implications. Firstly, they indicate that some additional repetitions assured that the EI demanded is maintained during the demanded time so that improvements in fitness are reached. Secondly, they suggest that a tight control of the initial periods of such training is important to facilitate the rapid attainment of the desired intensity. This way, the duration of SSGs around 20 minute (within the limits of conditions in the current investigation) seems to be ideals so much of the physiologic and practical point of view. Longer sessions can harm other important works for the improvement of performance of the team and fatigue may directly affect upon the work-rate of individual players and hence their involvement in the games.

The similarity in the frequency of the majority of TDs in each condition of number of players in SSGs in the current investigation suggests that the players' inclusion (i.e. 3 vs. 3 up to 5 vs. 5) is not a major determinant of the frequency number of TDs performed when the pitch area per player was kept constant (Tab. 2). This is supported by the data of Kelly and Drust[5] that did not find differences for passing, receiving, turning, dribbling, interceptions or heading among 5 vs. 5 condition argued in pitch dimensions (30×20m; 40×30m, and 50×40m) for same rules. This was not, however, the case in present study for all TDs as crosses, dribble and shots on goal was significantly larger playing in SSG3 (P<0.05; Tab. 2). Those actions that involve directly the ball can be one possible explanation for the greater EI observed for this small-sided condition. Those actions can turn that more dynamic format taking the players to larger energy expenditure.

Previous research has shown that running with the ball results in a greater energy expenditure than running without the ball.[19] That can increase EI and this increased energy requirement may partly explain the increased EI in the smaller game formats, mainly for the second and third set where the athletes will already be more committed by fatigue (Fig 1). This would suggest that coaches in their organization of practice should only carefully consider the 3 vs. 3 condition if the drill is required to combine a high physical training stimulus with technical work on crosses, dribbles or shooting is important.

Homogeneity of the training stimulus of these drills is important to verify whether the physiological strain and TDs is consistent within and between soccer players when is wanted the reproducibility of stimulus. Changes of number of players do not appear to affect variability (CV) for EI (~8%) being larger to the found by Rampinini et al.[9] (~4%) and smaller than observed for Dellal et al.[3] (~12%). That can be considered satisfactory for a training format that has countless variables, however small-sided argued in regime continue has been presenting smaller variability than interval regime in young players of Australian domestic league.[1] In the same way, homogeneous during the different SSGs revealed to be larger than during the shorts-duration intermittent running in elite soccer players belonging to a French first league senior.[3]

In general, SSGs can be used as an effective type of endurance training at all levels of the game.[1,6-8,11] The results of the present study reinforce that idea and SSGs can be an effective form of training for that category (U-15). However, players with poor ball skills may at first have problems maintaining a high EI.[20] Even this way, the traditional training of continuous or interval running must not be discarded completely, on the account of having a smaller number of intervenient variables providing greater control over the EI and of allowing a larger reproducibility of the proposed stimulus.[3] High loads of training (e.g. 90-95%MHR) are maintained more easily with activities of continuous or interval running.

Although the reproducibility of the TDs of SSGs in this study could be interpreted as poor, our findings revealed that at least playing the SSG5 was less variable in most of the appraised technical actions (Tab. 3). In spite of we control the dispute with players of balanced technique and maintenance of the same groups in the confrontations in the different days of experiment, during sided games, coaches cannot accurately control the activity of their players because the moves of soccer players were different depending on their experience, their position during the competition game, the movements of the opponents, and/or their motivation.[21] Reproducibility of stimulus for technical trainings can be a problem in SSGs and traditional trainings for the basic development of the technique should not be inconsiderate. SSGs can be used to approximate of the game reality and when to improve of the technique is wanted.

Some of the limitations of the present study are to standardize the loads of training prior to the experimental procedures because the subjects were in competitive period and we did not want to disturb the team. Randomization must have avoided any order effect of any exercise in any other. Researches considering different indicators of EI and different formats or rules in SSGs can be accomplished in the attempt to confirm this format as form of effective training for soccer players. For example, Dellal et al.[3] demonstrated recently that during the 8 vs. 8, the presence of goalkeepers induced an ~11% increase in %HRres and reduced homogeneity when compared to this format without goalkeepers (CV=15.6% versus 8.8%). Trainers can make that attempt and future researches can be made in the sense of identifying the goalkeeper's inclusion in the SSGs formats of that study does not do to lose the reliable and frequency of the actions for technical work.

Conclusion

Our results support the idea that small-sided games allow reliable and satisfactory answers of exercise intensity to be effective in enhancing player endurance. Exercise intensity increases while the number of players decreases. The changes of number of players for constant pitch dimension did not alter the frequency of most of the technical demands. There is a great variability intra-subject for the technical demands and the trainers should be careful to that for difficulty of repeating the technical stimulus in subsequent trainings. Small-sided format with larger number of players (i.e. 5 vs. 5) provided technical demands measure with smaller variability, however with smaller exercise intensity. The players seem not to answer the subjective perception of effort appropriately due to age that can produce a smaller estimate of the real effort.

Practical implications

• Within the limits of our training protocols, there are impacts of changes in number of players on exercise intensity in small-sided games, increasing while the number of players decreases.

• There were not differences for most of the technical demands for changes in number of players, however the 3 vs. 3 presented more crosses, dribbles and shot in goal that it seems to increase the exercise intensity in that condition.

• Careful organization and maintenance of practice should be an important consideration for coaches as both the physical and technical stimulus can to have high variability.

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DISCLOSURES

The authors declare does not have any conflict of interest.

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CONCLUSÕES GERAIS

Como conclusões do primeiro artigo estabelecem-se que: i) a FC pode ser utilizada na monitoração da carga fisiológica do jogador de futebol com boa validade científica, sendo indicada sua relativização na forma de porcentagem da FCM ou FCres; ii) em condições competitivas entre profissionais, a intensidade média do jogo é de 70-80% do $V0_{2MAX}$ ou de 80-90% da FCM, sendo semelhante nos demais níveis competitivos, inclusive entre jogadores recreacionais; iii) quando se consideram as zonas de intensidade, aproximadamente 65% do tempo de jogo é despedido na intensidade de 70-90% da FCM e, raramente, abaixo de 65% da FCM; iv) os jogadores de meio-campo têm média de IE maior, seguidos pelos jogadores do ataque e da defesa; v) no segundo tempo de jogo, a IE é menor e essa redução pode estar correlacionada com o nível de especialização de condicionamento atlético do jogador; e vi) os minijogos podem ser estratégias efetivas de treinamentos, porém os estímulos ideais devem ser definidos a partir de avaliação prévia na modelação e equipe em questão. Dessa forma, o controle da intensidade do treinamento de equipes de futebol pela FC, por ser uma ferramenta de fácil utilização, deveria ser uma ação permanente, visando aprimoramento na preparação das equipes.

O segundo artigo permitiu concluir que há similaridade entre a intensidade de exercício dos jogadores jovens avaliados com o padrão apresentado por jogadores profissionais, sendo uma atividade de alta intensidade. Semelhantemente, houve diminuição na intensidade de exercício após o intervalo e na média do segundo tempo de jogo, assim como depois dos períodos mais intensos da partida. A intensidade de exercício foi especializada por posição de jogo com maiores taxas significativa nos meio-campistas e laterais em relação a zagueiros e atacantes.

Os resultados encontrados no terceiro artigo demonstraram que o Yo-Yo IR2 apresenta-se como mais válido do que o Teste de Margaria, obtendo alta correlação entre o desempenho nesse protocolo e o desempenho em alta intensidade de exercício durante os jogos em jogadores jovens. No entanto, esse protocolo apresentou a maior variabilidade, reportando a necessidade de adoção de padronização rigorosa entre os procedimentos de avaliação para não comprometer sua confiabilidade. O maior valor de FCM foi encontrado nos jogos em comparação aos dois testes de campo, demonstrando que a situação competitiva pode ser o melhor referencial para obtenção dessa variável.

O quarto artigo revelou que os minijogos permitem respostas seguras e satisfatórias de intensidade de exercício para aprimorar resistência aeróbica de jogador de futebol. A intensidade de exercício aumenta enquanto o número de jogadores diminui. As mudanças de número de jogadores para mesma dimensão de campo não alteraram a freqüência de ocorrência da maioria das demandas técnicas. Há uma grande variabilidade intra-sujeito para as demandas técnicas e os treinadores devem prestar atenção a isso pela dificuldade de repetir o estímulo técnico em treinamentos subseqüentes. Formato de minijogos com número maior de jogadores (ex. 5 contra 5) demonstrou menor variabilidade para demandas técnicas, porém com intensidade de exercício menor. O IPE demonstrou não ser uma medida confiável de IE nos MJs nessa categoria.

Esses aspectos, em conjunto, devem ser respeitados na formulação de treinamentos mais efetivos para melhorar o desempenho em competição de alta demanda e na escolha dos testes para avaliação da aptidão física em jogadores da categoria Sub-15. Sugere-se um número maior de estudos com jogadores aqui no Brasil, utilizando indicadores complementares a FC para estabelecimento da carga fisiológica em situação competitiva e de diversas modelações de treinamentos a fim de ampliar a base de conhecimento sobre este tema.

ANEXOS

ANEXO 1

MINISTÉRIO DA EDUCAÇÃO
UNIVERSIDADE FEDERAL DE VIÇOSA
COMITÊ DE ÉTICA EM PESQUISA COM SERES HUMANOS

Campus Universitário - Viçosa, MG - 36570-000 - Telefone: (31) 3899-1269

Of. Ref. Nº 046/2007/Comitê de Ética

Viçosa, 20 de julho de 2007.

Prezado Professor:

Cientificamos Vossa Senhoria de que o Comitê de Ética em Pesquisa com Seres Humanos, em sua 5ª reunião de 2007, realizada em 19-7-07, analisou e *aprovou*, sob o aspecto ético, o projeto de pesquisa intitulado: *Determinação da carga fisiológica no jogador de futebol infantil.*

Atenciosamente,

Professor Gilberto Paixão Rosado
Comitê de Ética em Pesquisa com Seres Humanos
Presidente

Ao Professor
João Carlos Bouzas Marins
Departamento de Educação Física

/rhs

ANEXO 2

UNIVERSIDADE FEDERAL DE VIÇOSA
DEPARTAMENTO DE EDUCAÇÃO FÍSICA
LABORATÓRIO DE PERFORMANCE HUMANA

TERMO DE CONSENTIMENTO

Eu,____, R.G. nº ____________________, residente na rua____, nº__________, no bairro___________________________________ da cidade de ________________________________ do estado de__________, AUTORIZO o meu filho ______________________________, "a se submeter a uma pesquisa, que tem como finalidade avaliar as respostas da freqüência cardíaca de atletas de futebol da categoria infantil (sub-15) e identificar a demanda fisiológica desses indivíduos frente a uma partida oficial de futebol. Sou sabedor que este monitoramento da freqüência cardíaca será realizado durante os jogos de futebol no qual ele é de costume participar. Os demais procedimentos como medidas antropométricas; perimetria; Limiar Anaeróbico (V4mM); e determinações prévias da Freqüência Cardíaca Máxima serão realizadas nas dependências do clube, com possibilidade de aparecimentos de sintomas como sudorese, cansaço, elevada freqüência cardíaca, recuperando facilmente este quadro. Sou sabedor ainda que ele não irá receber nenhum tipo de vantagem econômica ou material por participar do estudo, além de poder abandonar a pesquisa em qualquer etapa de seu desenvolvimento. Estou em conformidade que os resultados obtidos, sejam divulgados no meio científico, sempre resguardando sua individualidade e identificação. Declaro ainda que ele não é possuidor de nenhum comprometimento metabólico ou orgânico que lhe impeça de realizar um exercício físico. Estou suficientemente informado pelos membros do presente estudo, sobre as condições em que irão ocorrer as provas experimentais, sobre responsabilidade do prof. Dr. João Carlos Bouzas Marins e sua equipe de trabalho. Se houver descumprimento de qualquer norma ética poderei recorrer ao Comitê de Ética na Pesquisa com Seres Humanos da UFV, dirigindo-me ao seu Presidente: Gilberto Paixão Rosado, pelo telefone: 3899-1269.

________________, ___ de ________________ de 2007.

____
Assinatura:

____________________________________ ____ ________________________________

Prof. Dr. João Carlos B. Marins
Orientador

Cristiano Diniz da Silva
Mestrando

ANEXO 3

MINISTÉRIO DA EDUCAÇÃO
UNIVERSIDADE FEDERAL DE VIÇOSA
COMITÊ DE ÉTICA EM PESQUISA COM SERES HUMANOS

Campus Universitário - Viçosa, MG - 36570-000 - Telefone: (31) 3899-1269

Of. Ref. Nº 004/2008/Comitê de Ética

Viçosa, 26 de Março de 2008.

Prezado Professor:

Cientificamos Vossa Senhoria de que o Comitê de Ética em Pesquisa com Seres Humanos, em sua 1ª reunião de 2008, realizada nesta data, analisou e aprovou, sob o aspecto ético, o projeto de pesquisa intitulado: *Carga fisiológica e indicadores técnicos de treinamentos específicos no jogador de futebol.*

Atenciosamente,

Professor Gilberto Paixão Rosado
Comitê de Ética em Pesquisa com Seres Humanos
Presidente

Ao
Professor João Carlos Bouzas Marins
Departamento de Educação Física

/rhs

ANEXO 4

UNIVERSIDADE FEDERAL DE VIÇOSA
DEPARTAMENTO DE EDUCAÇÃO FÍSICA
LABORATÓRIO DE PERFORMANCE HUMANA

TERMO DE CONSENTIMENTO

Eu,____, R.G. nº ____________________, residente na rua____, nº_________, no bairro__________________________________ da cidade de _______________________________ do estado de_________, AUTORIZO o meu filho ____________________________, "a se submeter a uma pesquisa, que tem como finalidade avaliar as respostas da freqüência cardíaca, do IPE e do lactato sangüíneo de atletas de futebol da categoria infantil (sub-15) e identificar a intensidade de esforço desses indivíduos frente aos treinamentos chamados "mini-jogos". Sou sabedor que este monitoramento da freqüência cardíaca será realizado durante essas situações no qual ele é de costume participar. Os demais procedimentos como medidas antropométricas; perimetria; e determinações prévias da Freqüência Cardíaca Máxima serão realizadas nas dependências do clube, com possibilidade de aparecimentos de sintomas como sudorese, cansaço, elevada freqüência cardíaca, recuperando facilmente este quadro. Sou sabedor ainda que ele não irá receber nenhum tipo de vantagem econômica ou material por participar do estudo, além de poder abandonar a pesquisa em qualquer etapa de seu desenvolvimento. Estou em conformidade que os resultados obtidos, sejam divulgados no meio científico, sempre resguardando sua individualidade e identificação. Declaro ainda que ele não é possuidor de nenhum comprometimento metabólico ou orgânico que lhe impeça de realizar um exercício físico. Estou suficientemente informado pelos membros do presente estudo, sobre as condições em que irão ocorrer as provas experimentais, sobre responsabilidade do prof. Dr. João Carlos Bouzas Marins e sua equipe de trabalho. Se houver descumprimento de qualquer norma ética poderei recorrer ao Comitê de Ética na Pesquisa com Seres Humanos da UFV, dirigindo-me ao seu Presidente: Gilberto Paixão Rosado, pelo telefone: 3899-1269.

________________, ___ de _______________ de 2008.

____
Assinatura:

____________________________________ ____   ________________________________

Prof. Dr. João Carlos B. Marins Orientador	Cristiano Diniz da Silva Mestrando

ANEXO 5

UNIVERSIDADE FEDERAL DE VIÇOSA
DEPARTAMENTO DE EDUCAÇÃO FÍSICA
LABORATÓRIO DE PERFORMANCE HUMANA

FORMULÁRIO PARA REGISTRO DE JOGOS

EQUIPE:___________________________

DIA:____/____/____ **JOGO Nº:___** **DIMENSÃO DO CAMPO:____X____**

CONFRONTO:____________ [ ] x [ ] ____________ SISTEMA TÁTICO:______________

LOCAL:____

POLAR	JOGADOR	CAMISA	POSIÇÃO	OBSERVAÇÕE S	TEMPO	JOGO COMPELTO?
1					: :	
2					: :	
3					: :	
4					: :	
5					: :	
6					: :	
7					: :	
8					: :	
9					: :	
10					: :	

INÍCIO AQUECIMENTO	: :	FINAL AQUECIMENTO	: :
INÍCIO 1º TEMPO	: :	FINAL 1º TEMPO	: :
INÍCIO 2º TEMPO	: :	FINAL 2º TEMPO	: :

AVALIADORES

OBSERVAÇÕES GERAIS:

ANEXO 6

UNIVERSIDADE FEDERAL DE VIÇOSA
DEPARTAMENTO DE EDUCAÇÃO FÍSICA
LABORATÓRIO DE PERFORMANCE HUMANA

FORMULÁRIO PARA REGISTRO DE JOGOS - IBUTG

EQUIPE:___________________________

DIA:____/____/____ **JOGO Nº:___** **DIMENSÃO DO CAMPO:____X____**

CONFRONTO:____________ [ ] x [ ] ____________ SISTEMA TÁTICO:______________

LOCAL:____

MEDIÇÃO	TEMPO	SITUAÇÃO	SE	HU	GL
1	00:00	AQUECIMENTO			
2	08:45	AQUECIMENTO			
3	17:30	AQUECIMENTO			
4	35:00	AQUECIMENTO			
5	00:00	1º TEMPO			
6	08:45	1º TEMPO			
7	17:30	1º TEMPO			
8	26:15	1º TEMPO			
9	35:00	1º TEMPO			
10	00:00	2º TEMPO			
11	08:45	2º TEMPO			
12	17:30	2º TEMPO			
13	26:15	2º TEMPO			
14	35:00	2º TEMPO			

AVALIADORES

OBSERVAÇÕES GERAIS:

ANEXO 7

UNIVERSIDADE FEDERAL DE VIÇOSA
DEPARTAMENTO DE EDUCAÇÃO FÍSICA
LABORATÓRIO DE PERFORMANCE HUMANA

FORMULÁRIO PARA YO-YO IR2

Test scheme: Intermittent recovery test - level 2

Date: **Name:**

Speed level	Repetitions							
11.	1 (40)							
15.	1 (80)							
17.	1 (120)	2 (160)						
18.	1 (200)	2 (240)	3 (280)					
19.	1 (320)	2 (360)	3 (400)	4 (440)				
20.	1 (480)	2 (520)	3 (560)	4 (600)	5 (640)	6 (680)	7 (720)	8 (760)
21.	1 (800)	2 (840)	3 (880)	4 (920)	5 (960)	6 (1000)	7 (1040)	8 (1080)
22.	1 (1120)	2 (1160)	3 (1200)	4 (1240)	5 (1280)	6 (1320)	7 (1360)	8 (1400)
23.	1 (1440)	2 (1480)	3 (1520)	4 (1560)	5 (1600)	6 (1640)	7 (1680)	8 (1720)
24.	1 (1760)	2 (1800)	3 (1840)	4 (1880)	5 (1920)	6 (1960)	7 (2000)	8 (2040)
25.	1 (2080)	2 (2120)	3 (2160)	4 (2200)	5 (2240)	6 (2280)	7 (2320)	8 (2360)
26.	1 (2400)	2 (2440)	3 (2480)	4 (2520)	5 (2560)	6 (2600)	7 (2640)	8 (2680)

In parenthesis is shown the distance covered.
Note: The last 2 x 20 metres should be included in the result.

 Printdate: 22/12/2008

AVALIADORES

OBSERVAÇÕES GERAIS:

ANEXO 8

UNIVERSIDADE FEDERAL DE VIÇOSA
DEPARTAMENTO DE EDUCAÇÃO FÍSICA
LABORATÓRIO DE PERFORMANCE HUMANA

FORMULÁRIO PARA REGISTRO DE MINI-JOGOS - IBUTG

DIA:___/___/___ **MINI-JOGO:____x____**

MINI-JOGO: ___

LOCAL:____

MEDIDA	MOMENTO	SE	HU	GL	ºC
1	AQUECIMENTO				
2	INÍCIO 1ª (0 min)				
3	METADE 1ª (9 min)				
4	FINAL 1ª (18 min)				
5	INÍCIO 2ª (0 min)				
6	METADE 2ª (9 min)				
7	FINAL 2ª (18 min)				
8	INÍCIO 3ª (0 min)				
9	METADE 3ª (9 min)				
10	FINAL 3ª (18 min)				

INÍCIO AQUECIMENTO	: :	FINAL AQUECIMENTO	: :
INÍCIO 1º SET	: :	FINAL 1º SET	: :
INÍCIO 2º SET	: :	FINAL 2º SET	: :
INÍCIO 3º SET	: :	FINAL 3º SET	: :

AVALIADORES

OBSERVAÇÕES GERAIS:

ANEXO 9

UNIVERSIDADE FEDERAL DE VIÇOSA
DEPARTAMENTO DE EDUCAÇÃO FÍSICA
LABORATÓRIO DE PERFORMANCE HUMANA

FORMULÁRIO PARA REGISTRO DE MINI-JOGOS - IBUTG

DIA:___/___/___ **MINI-JOGO:____x____**

MINI-JOGO: ___

Jogador	Tackles	Headers	Shot	Crosses	Pass	Target Pass	Involvement with ball	Drible
Jogador	Tackles	Headers	Shot	Crosses	Pass	Target Pass	Involvement with ball	Drible
Jogador	Tackles	Headers	Shot	Crosses	Pass	Target Pass	Involvement with ball	Drible