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PROGRAMA DE PÓS-GRADUAÇÃO EM CIÊNCIAS DA MOTRICIDADE

RESPOSTAS DE UMA TEMPORADA COMPETITIVA DE JOGADORES DE FUTSAL SOBRE MARCADORES BIOQUÍMICOS, NEUROMUSCULARES E PERFORMANCES AERÓBIA E ANAERÓBIA

RICARDO AUGUSTO BARBIERI

Tese apresentada ao Instituto de Biociências do Câmpus de Rio Claro, Universidade Estadual Paulista, como parte dos requisitos para obtenção do título de doutor em Ciências da Motricidade.

Julho – 2016

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DEDICATÓRIA

Dedico esta tese de doutorado aos meus pais (Augusto e Fatima Barbieri) e irmão (Fabio Augusto Barbieri) por todo o apoio e base para meus estudos.

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RESUMO

Um programa de treinamento deve ter como base uma boa avaliação do desempenho físico para posterior prescrição do treinamento e um conhecimento das relações entre as distribuições das cargas de treinamento ao longo da temporada. Contudo, para o futsal ainda existem poucos protocolos de avaliação do desempenho físico específicos que levam em conta os movimentos técnicos e as constantes mudanças de direção, e o conhecimento da relação dose-resposta entre a carga interna e as adaptações fisiológicas nos diferentes períodos de treinamento ainda não é clara. Portanto, os objetivos da presente tese foram: i. Padronizar e validar um protocolo de avaliação específico da performance anaeróbia e aeróbia para jogadores de futsal; ii. Investigar a resposta de uma temporada de treinamento sobre os parâmetros antropométricos, neuromusculares, hormonais, bioquímicos, hematológicos e performances aeróbia e anaeróbias monitoradas através do protocolo específico proposto. Para isso, 44 atletas profissionais de futsal foram recrutados e três trabalhos foram desenvolvidos. O primeiro estudo teve como objetivo verificar a reprodutibilidade e validade do teste de lactato mínimo realizado com condução de bola num circuito específico para o futsal. A intensidade correspondente ao lactato mínimo (LM) mostrou ser concordante e reprodutível (teste = 7,7 ± 0,3 $km.h^{-1}$; reteste = 7,7 ± 0,4 $km.h^{-1;}$ CV = 4,13; ET = 0,32), e não apresentou diferenças significativas com a máxima fase estável de lactato (MFEL) (LM = 7,5 ± 0,5 $km.h^{-1}$; MFEL = 7,5 ± 0,4 $km.h^{-1}$). O segundo trabalho teve como objetivo verificar a relação entre o desempenho físico no teste de laboratório e teste de campo específico para o futsal (1º trabalho) com jogos oficiais e simulados. Ambos os protocolos de campo e laboratório apresentaram fortes correlações (r < 0,7) com a demanda física exigida durante o jogo oficial. No entanto, para o teste de campo as intensidades associadas com o limiar anaeróbio e VO_2max apresentaram fortes correlações com a demanda física do jogo (r=0,81 com o número de sprints no jogo e r=0,74 com a distância total percorrida no jogo, respectivamente), indicando uma maior especificidade com o jogo. Já o terceiro trabalho teve como objetivo investigar as respostas da pré-temporada e do período competitivo sobre os parâmetros antropométricos, neuromusculares, hormonais, bioquímicos, hematológicos e performances aeróbia e anaeróbias monitoradas através do protocolo específico proposto no primeiro trabalho. Doze atletas foram avaliados ao longo da pré-temporada e outros onze durante o período competitivo. A pré-temporada com elevada carga interna (8038.8.2 ± 1124.1 a.u.) reduziu significativamente o percentual de gordura (-18,8%), porém com aumento do marcador de dano muscular creatina quinase (69%). No entanto, não melhorou significantemente a capacidade aeróbia (3,6%), importante fator para a temporada competitiva. Já a carga interna imposta durante o período competitivo (9910.2 ± 1820.3 a.u.) foi capaz de melhorar significantemente a capacidade aeróbia (9,0%) e anaeróbia (5,8%), importante para o desempenho nos jogos. Contudo, em ambos os períodos os deltas de melhoras das variáveis investigadas apresentam uma forte correlação negativa (r < 0,70) com a monotonia e strain. Baseado nisso, se pode concluir que os parâmetros monitorados ao longo da temporada foram modulados a partir das diferentes distribuições de carga nos diferentes períodos de treinamento (pré-temporada e período competitivo). Ainda, independente do período de treinamento, um treinamento com elevado índice de monotonia e Strain afetaram negativamente os marcadores de lesão muscular e estresse metabólico, e parece não ter sido uma estratégia adequada para melhora o desempenho físico. Além disso, o teste específico para avaliação da capacidade aeróbia de atletas de futsal proposto se mostrou ser uma ferramenta sensível para monitorar o desempenho dos atletas ao longo da temporada competitiva, além de ser uma ferramenta atrativa para a prescrição de treinamento físico.

ABSTRACT

Training program should be based on a good evaluation of physical performance for subsequent prescription of training and knowledge of the relationship between the distribution of training loads throughout the season. However, for the futsal there are few evaluation protocols of specific physical performance that consider the technical movements and the constant changes of direction, and the knowledge of the dose-response relationship between the internal load and physiological adaptations in different periods of training it is still unclear. Therefore, the aims of this work were: i. Standardize and validate a specific evaluation protocol of anaerobic and aerobic performance for futsal players; ii. To investigate the response of a training season on anthropometric, neuromuscular, hormonal, biochemical, hematological parameters, and aerobic and anaerobic performances monitored through specific protocol proposed. For this, 44 professional futsal athletes were recruited and were developed three studies. The first study aimed to verify the reproducibility and validity of the minimum lactate test with ball dribbling in a specific circuit for futsal. The intensity corresponding to the minimum lactate (ML) proved to be consistent and reproducible (test = 7.7 ± 0.3 km h^{-1}; retest = 7.7 ± 0.4 km h^{-1}, CV = 4.13; ET = 0.32), and showed no significant differences with the maximum lactate steady state (MLSS) (LM = 7.5 ± 0.5 km h^{-1}; MLSS = 7.5 ± 0.4 km. h^{-1}). The second study aimed to investigate the relationship between physical performance in the lab test and field test specific for futsal (study 1) with official and simulated matches. Both field and laboratory protocols showed strong correlations ($r < 0.7$) with the physical demands required during the official match. However, for the field test the intensities associated with the anaerobic threshold and VO_{2max} showed strong correlations with the physical demand of match (r = 0.81 with the number of sprints in r = 0.74 with the total distance traveled on the match, respectively), indicating a higher specificity of the match. The third study aimed to investigate the responses of the pre-season and competitive period on the anthropometric, neuromuscular, hormonal, biochemical, hematological parameters, and aerobic and anaerobic performances monitored through specific protocol proposed in the first paper. In this study, twelve athletes were evaluated during the pre-season and eleven others during the competition period. The pre-season with high internal load (8038.8.2 ± 1124.1 a.u.) reduced the percentage of fat significantly (-18.8%), though, with increased the creatine kinase muscle damage marker (69%). However, it not improved aerobic capacity significantly (3.6%), an important factor for the competitive season. Already the internal load improved during the competitive period (9910.2 ± 1820.3 a.u.) was able to improve significantly the aerobic capacity (9.0%) and anaerobic capacity (5.8%), important for gaming performance. However, in both periods the deltas of improvement of the variables have a strong negative correlation ($r < 0.70$) with the monotony and strain. Based on this, concluded that the parameters monitored throughout the season were modulated from the different distributions of training load during the periods of training (pre-season and competitive period). Moreover, regardless of the training period, training with high monotony and Strain index affected negatively the markers of muscle damage and metabolic stress, and seems to have been an appropriate strategy to improve physical performance. In addition, specific test for assessing the aerobic capacity of the proposed futsal players showed to be a sensitive tool to monitor the performance of athletes throughout the competitive season as well as being an attractive tool for the prescription of physical training.

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LISTA DE ABREVIATURAS

Sessão-PSE – Sessão de esforço percebido;

CT – Carga de treinamento;

BPM – Batimentos por minuto;

VO_2 – Consumo de oxigênio;

VO_2max – Máximo consumo de oxigênio;

CK – Creatina Quinase;

LDH – Lactato desidrogenasse;

IL-6 – Interleocina 6;

Sprint – Corrida em alta intensidade;

Yo-Yo IR1 – Yo-Yo intermittent recovery test level 1;

FIET – Futsal intermittent endurance test;

Carminati’s test – Teste específico para o futsal proposto por Carminatti;

PSE – Percepção subjetiva de esforço;

Futsal_circuit – Specific-futsal circuit;

LM – Test of lactate minimum;

MLSS – Maximal lactate steady state;

BMI – Body mass index;

RAST - Running-based Anaerobic Sprint Test;

RPE – Rated perceived exertion;

$[La^-]$ – Blood lactate concentration;

ES – Effect size;

CV – Coefficients of variation;

TE – Typical error;

ICC – Intraclass correlations;

PP – Peak Power;

PMed – Mean Power;

PMin – Low Power;

IF – Index of Fatigue;

sMax – Maximal speed in the test;

sLM – Lactate minimum intensity;

%sLM – Percentage of the lactate minimum velocity relative to the maximum speed;

$[La^-]$ peak – Peak of blood lactate concentration;

$[La^-]$ sLM – Blood lactate concentration related to lactate minimum intensity;

HR Max – Maximum heart rate;

HRsLM – Heart rate at lactate minimum intensity;

%HRsLM – Percentage of HR lactate minimum relative to maximum HR;

R^2 – Coefficient of determination;

sMLSS – Intensities of MLSS;

sLM – Intensity of lactate minimum;

HR – Heart rate;

sVO_{2Max} – Intensity of maximal oxygen uptake;

session-RPE - Rating of perceived exertion;

VCO_2 – Carbon dioxide uptake;

RER – Respiratory exchange ratio;

HR_{MAX} – Maximal heart rate;

vVO_2max – Velocity of maximal oxygen uptake;

AT – Anaerobic Threshold;

Peak $[La^-]$ – Peak blood lactate concentration;

SD – Standard derivation;

Distance (m) – Distance covered in meters;

Distance ($m.min^{-1}$) – Distance per minute;

Peak – Peak of velocity on the match;

Vmean – velocity mean on the match;

NS – Number of sprints;

% above 15.5 km.h^{-1} – Percentage distance covered in high intensity;

TL – Internal training load;

MVC – Maximal voluntary isometric contraction;

Dexa – Dual-energy x-ray absorptiometry scan;

Flex 1 – Static flexibility;

Flex 2 – Dynamic training flexibility;

AT1 – Moderate intensity domain;

AT2 – Heavy intensity domain;

Tactical 1 – Defense systems;

Tactical 2 – Attacking systems;

Tactical 3 – Attack with goalkeeper;

Technical – Technical training;

ST 1 – Resistance strength;

ST 2 – Explosive strength;

s-match – Simulated match;

match – Official match;

Δ% - Percentage of change;

ANOVA – Analysis of variance;

BMC – Bone mineral component;

P. Max – Maximal Power on the RAST;

P. Mean – Mean Power on the RAST;

vMax – Maximal velocity on the 35 meters;

vMean – Mean velocity on the 35 meters;

IF – Fatigue index on the RAST;

AT – Anaerobic threshold;

vMax – Maximal velocity on the incremental test at Futsal_Circuit;

RMS – Root mean square;

MPF –Mean power frequency;

VL – Vastus lateralis;

BF – Biceps femoris;

RBC – Red blood cell;

T/C Ratio – Testosterone.Cortisol^{-1};

SUMÁRIO

1. INTRODUÇÃO

O futsal é uma modalidade coletiva de característica intermitente com mudanças de atividade motora em média a cada 3,28 s (DOĞRAMACI e WATSFORD, 2006), exigindo força, velocidade e utilização intensa dos sistemas aeróbio e anaeróbio durante as ações (BARBERO-ALVAREZ *et al.*, 2008; CASTAGNA *et al.*, 2009; GOROSTIAGA *et al.*, 2009), sendo o aeróbio responsável por aproximadamente 76% de toda a energia despendida durante o jogo (CASTAGNA *et al.*, 2009). Ainda, atletas de futsal percorrem em média 4 a 5 km por partida, gerando acúmulo médio de lactato sanguíneo de aproximadamente 5,3 $mmol.L^{-1}$ com picos de 80 a 85% relativos a concentração máxima de lactato sanguíneo obtido durante teste incremental em situação laboratorial (BARBERO-ALVAREZ *et al.*, 2008; CASTAGNA *et al.*, 2009).

Para a avaliação do desempenho físico dos atletas de futsal, diferentes protocolos tem sido empregados e dentre eles, destacam-se os protocolos com medida direta em laboratório (DE LIMA *et al.*, 2005; JUNIOR *et al.*, 2006; ALVAREZ *et al.*, 2009; CASTAGNA *et al.*, 2009; BARONI e LEAL, 2010; BARONI *et al.*, 2011; PEDRO *et al.*, 2013; DO NASCIMENTO SALVADOR *et al.*, 2016) ou por meio de protocolos no campo mas com medidas indiretas e/ou não específicos (DE LIMA *et al.*, 2005; BARBIERI *et al.*, 2012; BOULLOSA *et al.*, 2013; MILIONI *et al.*, 2013; NAKAMURA *et al.*, 2015; BARBIERI *et al.*, 2016).

BARBERO ALVARÉZ *et al.* (2005) e DITTRICH *et al.* (2011) se dedicaram a validar um teste de campo específico para atletas de futsal. Contudo, ambos os testes são baseados apenas em medidas indiretas (distância percorrida) para estimar a capacidade aeróbia, e o mais importante, não levam em conta a demanda técnica do jogo. Ainda, para o futsal, é pouco conhecido as relações dos resultados provenientes dos diferentes protocolos de avaliação com a demanda física do jogo.

Uma boa avaliação do desempenho físico é importante, pois, além de ser apenas uma "foto" da condição momentânea do atleta, pode ser utilizada para avaliar o resultado do período de treinamento e, por vezes para prescrever de forma específica a carga de treino (IMPELLIZZERI *et al.*, 2005; DITTRICH *et al.*, 2011; BOULLOSA *et al.*, 2013; PEDRO *et al.*, 2013; SOARES-CALDEIRA *et al.*, 2014; MILOSKI *et al.*, 2016). Porém, um problema comum para treinadores é de prescrever as cargas de treinamento apropriadas durante a fase de preparação e competição (KELLY e COUTTS, 2007), já que o controle das cargas de treinamento muitas vezes não apresentam uma grande precisão.

A classificação da sessão de esforço percebido (sessão-PSE) tem demonstrado ser um método simples e prático para a quantificação de carga de treinamento interno (CT) em esportes coletivos (FOSTER, 1998; FOSTER *et al.*, 2001; IMPELLIZZERI *et al.*, 2005), uma vez que, o conhecimento de como as CTs são distribuídas ao longo dos ciclos específicos e/ou em toda a temporada de treinamento, considerando magnitude, propósitos e como as respostas induzidas pelo treinamento podem estar relacionadas com as estratégias adotadas, tem se mostrado ser a chave para o sucesso do planejamento do treinamento esportivo (IMPELLIZZERI *et al.*, 2005; MILOSKI *et al.*, 2016).

Juntamente com uma boa avaliação do desempenho físico, a abordagem da quantificação das CTs pode fornecer dados objetivos para subsidiar os treinadores a avaliar e tomarem decisões durante a implementação do programa de treinamento (MILOSKI *et al.*, 2016). Alguns estudos verificaram a relação dose-resposta entre os marcadores de carga de treinamento e estresse metabólico (MOREIRA *et al.*, 2011; MILANEZ *et al.*, 2014; MILOSKI *et al.*, 2016), variabilidade da frequência cardíaca (OLIVEIRA *et al.*, 2013; NAKAMURA *et al.*, 2016) e com os parâmetros de desempenho físico (BOULLOSA *et al.*, 2013; SOARES-CALDEIRA *et al.*, 2014; MILOSKI *et al.*, 2016) durante a pré-temporada e/ou período competitivo. No entanto, esses estudos somente testaram a aplicação destes métodos durante a temporada sem, no entanto, investigarem as associações entre as cargas de treinamento e as alterações nos parâmetros fisiológicos e bioquímicos que sabidamente estão associados com ajustes (positivos e negativos) provenientes pelo treinamento e com o desempenho físico durante o jogo.

Portanto, os objetivos da presente tese foram: i. Padronizar e validar um protocolo de avaliação específico da performance anaeróbia e aeróbia para jogadores de futsal; ii. Investigar a resposta de uma temporada de treinamento sobre os parâmetros antropométricos, neuromusculares, hormonais, bioquímicos, hematológicos e performances aeróbia e anaeróbia monitoradas através do protocolo específico proposto.

2. REVISÃO DE LITERATURA:

Uma busca sistematizada na base de dados do *Pubmed* combinando os descritores "futsal" OR "indoor soccer" OR "indoor football", foi realizada ao longo do desenvolvimento desta tese (2012 a 2016), sendo, a última atualização em junho de 2016, resultando em um número de 141 artigos relacionado com o tema futsal. Ainda, uma busca nas referências dos artigos foi realizada e quando considerado de relevância foram incorporados no levantamento gerando um banco de referências final de 152 artigos. Destes trabalhos, uma seleção por conveniência baseado na temática da presente tese foi feita, sendo excluído trabalhos com as seguintes características: faixa etária abaixo de 16 anos; comparação entre categorias menores e adulto; estudo de cinética de consumo de oxigênio; amostra de árbitros de futsal; avaliação de flexibilidade; variabilidade da frequência cardíaca; incidência ou prevenção de lesões; análise biomecânica dos padrões de chute; futsal feminino; análises táticas e técnicas do jogo. Após esta triagem, restaram 44 artigos relacionados com a temática da presente tese. Os artigos foram divididos em 3 grandes grupos, sendo: 14 artigos de caracterização das demandas físicas do futsal; 16 artigos de avaliação do perfil físico dos atletas de futsal; 14 artigos de monitoramento do treinamento no futsal.

2.1. CARACTERIZAÇÃO FISIOLÓGICA DO FUTSAL

Baseado nas regras da FIFA (*Fédération Internationale de Football Association*), o futsal é disputado em dois tempos de 20 minutos, com um intervalo de dez minutos entre os tempos numa quadra de 40x20 m. Ainda, cada treinador tem o direito a um tempo técnico de 1 minuto em cada tempo de 20 minutos da partida. O tempo de partida é cronometrado sendo pausado a cada interrupção, como faltas, tiros de meta, cobranças de laterais e de escanteios, entre outras situações de jogo. Estas interrupções na cronometragem podem elevar o tempo total de jogo em até 80% do tempo pré-estabelecido (BARBERO-ALVAREZ *et al.*, 2008). É importante ressaltar que mesmo com o cronômetro parado, ainda existe deslocamento e ações por parte dos jogadores para tentar receber a bola que reentrará em jogo, fazendo com que os atletas tenham um tempo de atividade superior aos 40 minutos previstos de jogo (DE OLIVEIRA BUENO *et al.*, 2014).

O fato do futsal ser disputado com quatro jogadores de linha e um goleiro para cada time, e o número de substituições ser ilimitado, pode contribuir para o aumento da intensidade de partida. Estas características fazem com que o futsal tenha mais períodos de alta intensidade do que no futebol (BARBERO-ALVAREZ *et al.*, 2008).

Tem sido relatado que em média, um jogador de futsal percorre de 4000 a 5000 metros ao longo da partida (BARBERO-ALVAREZ *et al.*, 2008; CASTAGNA *et al.*, 2009), porém, existem diferenças entre jogos oficiais e amistosos. Foi demonstrado com jogadores profissionais brasileiros que durante um jogo amistoso os jogadores percorrem aproximadamente 2654,48 m, enquanto que no jogo oficial atingem uma distância aproximada de 3191,13 m, resultando num maior número de passes por minuto (jogo oficial: 1,9 ± 0,38; jogo amistoso: 0,9 ± 0,29 passes.min^{-1}) e envolvimento técnico dos jogadores durante o jogo oficial em relação ao amistoso (VIEIRA *et al.*, 2016). Essas diferenças entre jogos amistosos e oficiais parecem também resultar em diferenças nas demandas metabólicas.

DE OLIVEIRA BUENO *et al.* (2014), após monitorarem 5 jogos oficiais da liga brasileira de futsal, encontraram valores de distância percorrida (3133,2 ± 2248,5 m) próximo ao estudo citado acima, porém, com uma diminuição na distância percorrida entre o primeiro e segundo tempo da partida. Já VIEIRA *et al.* (2016), encontraram um aumento significativo na distância percorrida entre o primeiro e segundo tempo. Esta diferença pode ter ocorrido em função da alternância no placar no decorrer da partida, ou estratégia tática, porém, os trabalhos não relatam estas situações.

Em estudo com atletas profissionais de outras nacionalidades durante jogos oficiais (tabela 1), foi relatado uma distância total percorrida muito superior aos brasileiros, sendo de 4313 ± 2139 metros para espanhóis (BARBERO-ALVAREZ *et al.*, 2008), 5087 ± 1104 metros para Tailandeses (MAKAJE *et al.*, 2012) e 4384 ± 1033 metros para australianos (DOĞRAMACI e WATSFORD, 2006). Ainda durante jogos simulados, foi relatado para atletas profissionais australianos, uma distância de 4277 ± 1030 metros e 3011 ± 999 metros para atletas do País de Gales (DOĞRAMACI *et al.*, 2011). Porém, jogos simulados muitas vezes podem ter características diferentes de um jogo oficial, como mais paradas durante os tempos, uma maior rotatividade de atletas, ou uma permanência maior do atleta em quadra, fazendo com que as demandas físicas exigidas sejam diferentes do jogo oficial (DE OLIVEIRA BUENO *et al.*, 2014), contudo, nenhum estudo comparou as diferenças entre um jogo simulado e oficial no futsal.

Tabela 1. Distância percorrida por atletas de futsal de diferentes nacionalidades.

Estudo	Nacionalidade	n	Natureza do jogo	Distância percorrida		
				1° tempo	2° tempo	total
Doğramaci e Watsford(2006)	Australianos	8	-	-	-	4282±1033[a]
Barbero-Alvarez *et al*(2008)	Espanhóis	10	Oficial	2496±1025[a]	2596±932[a]	4313±2139[a]
				-	-	117.3±116[b]
Castagna *et al.*(2009)	Espanhóis	8	Simulado	-	-	121,0[b]
Doğramaci *et al.*(2011)	Australianos	8	Simulado	-	-	4277±1030[a]
	Galeses	10	Simulado	-	-	3011±999[a]
Makaje *et al.*(2012)	Tailandês	15	Oficial	-	-	5087±1004[a]
de Oliveira Bueno *et al.*(2014)	Brasileiros	93	Oficial	1711±888[a]	1636±1089[a]	3133,2±2248,5[a]
Vieira *et al.*(2016)	Brasileiros	10	Oficial	1734±1116[a]	1918±769[a]	3119±1455[a]
			Amistoso	1319±782[a]	1662±873[a]	2654±854[a]

[a] distância apresentada em metros (m)
[b] distância apresentada em metros por minuto ($m.min^{-1}$)

Pela característica de intermitência e pelas altas distâncias percorridas por minuto de jogo (~100 $m.min^{-1}$) durante a partida de futsal, a modalidade tem sido caracterizada como de alta intensidade e consequente uma modalidade como elevada carga interna. GONÇALVES e SANTANA (2013) relataram que durante um jogo amistoso, os atletas apresentaram uma frequência cardíaca média de 181 ± 7,57 bpm, correspondendo a aproximadamente 80% da frequência cardíaca máxima, mas não foram encontradas diferenças significativas entres as posições dos jogadores de linha (GONÇALVES e SANTANA, 2013). Este fato pode ser explicado pela característica tática do futsal, que apesar dos jogadores serem "escalados" por posição, durante a partida eles acabam realizando um "rodízio" e ocupando outras posições e ações, fazendo com que a intensidade média dos atletas seja parecida.

Na busca de determinar bons marcadores de intensidade para monitorar os jogos e os treinos, ÁLVAREZ-MEDINA *et al.* (2014) investigaram o uso da frequência cardíaca

(FC) como marcador de intensidade durante a partida de futsal e sessões de treinamentos, concluindo que esse parâmetro pode ser utilizado para prescrever e controlar as cargas de treinamento ao longo da temporada.

Durante partidas oficiais na liga brasileira de futsal, foi relatado valores de frequência cardíaca média de 86,4 ± 3,8% da frequência cardíaca máxima obtidas em testes laboratoriais, e valores de consumo de oxigênio (VO_2) de 79,2 ± 9.0% referentes ao VO_2max (RODRIGUES *et al.*, 2011). Estes valores estão de acordo com o encontrado em estudos com atletas de outras nacionalidades (85 – 92% da frequência cardíaca máxima e 75 a 85 % do VO_2max) (CASTAGNA *et al.*, 2007; BARBERO-ALVAREZ *et al.*, 2008; CASTAGNA *et al.*, 2009), indicando que, apesar das maiores distâncias percorridas pelos atletas nas diferentes ligas mundiais, a FC indica que as partidas possuem uma alta intensidade e parece que o futsal é uma modalidade com mais períodos de alta intensidade do que o futebol (BARBERO-ALVAREZ *et al.*, 2008).

COYLE (2000) demonstrou que elevada intensidade durante o jogo pode impor ao jogador um significativo nível de estresse, no qual o organismo responde a esse estresse fisiológico com alterações metabólicas e fisiológicas transitórias, cuja a magnitude parece ser relacionada e dependente da combinação de seguidas sessões de treinamento (ou jogos) de alta intensidade sem um intervalo de recuperação adequado. Portanto, o conhecimento destas respostas metabólicas é essencial para a efetividade do programa de treinamento (ARRUDA *et al.*, 2013). Para isso alguns marcadores imuno-endócrinos e inflamatórios têm sido investigados no esporte.

ARRUDA *et al.* (2013) após simularem um jogo com 3 tempos de 20 minutos com intervalo de 2 minutos entre os períodos, verificaram que o estresse da sessão foi capaz de aumentar significantemente as concentrações salivares de cortisol e reduzir as concentrações de imunoglobulina A em jogadores profissionais de futsal. Esta redução da imunoglobulina A está diretamente associada com o aumento do risco de infecção do trato respiratório superior (GLEESON *et al.*, 2012), indicando que uma partida simulada de futsal pode modular a resposta imuno-endócrina dos atletas de futsal (ARRUDA *et al.*, 2013).

Corroborando com os achados apresentados anteriormente, MOREIRA *et al.* (2011) após simulação de dois jogos num intervalo de 7 dias com jogadores profissionais brasileiros, verificaram uma redução significativa da imunoglobulina A, sugerindo um aumento da vulnerabilidade a infecções do trato respiratório superior pelo estímulo de treinamento

Também tem sido relatado que uma partida de futsal pode induzir um significativo aumento nas concentrações de testosterona e cortisol salivar, sendo que, após uma partida "em casa", foi observado um aumento ainda maior nas concentrações de cortisol e reduzindo a relação testosterona cortisol, em comparação com partidas jogadas "fora de casa". Esses resultados indicam que a pressão para um bom desempenho jogando "em casa" pode impor um maior nível de estresse sobre os jogadores, que pode estar associado com a presença da torcida, famílias e amigos (ARRUDA *et al.*, 2016)

Além da maior possibilidade de infecção do trato respiratório superior, o estresse causado pelo jogo pode também aumentar o dano muscular. DE MOURA *et al.* (2012) investigaram o efeito de um jogo de futsal em marcadores de lesão muscular (creatina quinase - CK e lactato desidrogenase - LDH), citocinas e proteína-C reativa em jogadores de elite. Esses autores relataram que a partida de futsal induziu a morte de neutrófilos, aumentou significantemente as concentrações de CK, LDH e proteína-C reativa. Ainda, dentre as citocinas, somente o IL-6 aumentou significantemente. Este resultado indica que uma partida de futsal induz a um quadro de inflamação aguda nos atletas de futsal (DE MOURA *et al.*, 2012). Ainda, os goleiros apresentaram maior LDH e IL-6 do que os jogadores de linha, levando à conclusão de que a posição de goleiro no futsal pode provocar mais inflamação e dano muscular do que outras posições. Porém, é importante ressaltar que esta posição é geralmente ocupado por atletas com maior massa corporal e percentual de gordura corporal e menor VO_2max do que jogadores das outras posições (DE MOURA *et al.*, 2013).

2.2. PERFIL FÍSICO DOS ATLETAS DE FUTSAL

Os metabolismos aeróbio e anaeróbio são de suma importância no desempenho do futsal, uma vez que a modalidade possui uma complexa gama de ações motoras (DOĞRAMACI e WATSFORD, 2006) e demanda energética mista, porém, com uma predominância aeróbia (CASTAGNA *et al.*, 2009). Ainda, durante uma partida simulada, atletas profissionais de futsal atingem um VO_2 médio de 48,6 (40,1-57,1) $mL.kg^{-1}.min^{-1}$, com picos acima de 80% do VO_2max avaliado em laboratório em momentos decisivos da partida, e realizam em média atividades de alta intensidade (Sprint) a cada ~79 segundos durante a partida (CASTAGNA *et al.*, 2009). Estas características demonstram que, para um bom desempenho durante a partida, o atleta de futsal necessita de uma alta capacidade física.

Do ponto de vista antropométrico, não foi encontrada diferenças significativas entre jogadores de futsal e futebol para altura, massa corporal e massa magra (GOROSTIAGA *et al.*, 2009). Contudo, do ponto de vista neuromuscular, atletas de futsal apresentaram menores valores de desempenho no teste de salto vertical, corrida de Sprint (15 metros) e força em meio agachamento em relação aos jogadores de futebol (GOROSTIAGA *et al.*, 2009).

Apesar de muitos atletas transitarem entre o futsal e futebol ao longo da carreira, é conhecido que existem diferenças no desempenho físico entre as modalidades (JUNIOR *et al.*, 2006; GOROSTIAGA *et al.*, 2009). Porém, quando comparado entre jogadores de futebol e futsal brasileiros o VO_2max e o limiar ventilatório obtidos em teste incremental ergoespirométrico no laboratório, não foi encontrado diferenças significativas para o VO_2max (futebol: 4,20 $L.min^{-1}$; futsal: 3,89 $L.min^{-1}$) (JUNIOR *et al.*, 2006). Entretanto, o limiar ventilatório dos atletas de futsal foi menor em relação aos jogadores de futebol (Futebol: 3,46 $L.min^{-1}$; Futsal: 2,97 $L.min^{-1}$ respectivamente) (JUNIOR *et al.*, 2006). BARONI *et al.* (2011) ao compararem a capacidade aeróbia entre atletas de futebol e futsal, porém, excluindo os goleiros da amostra, não observaram diferenças significativas para VO_2max e limiar ventilatório, evidenciando que ao menos sob o aspecto aeróbio, jogadores de ambas as modalidades parecem apresentar o mesmo nível de condicionamento.

Em contrapartida, ao compararem as respostas de aptidão aeróbia entre os diferentes níveis competitivos (profissionais e semiprofissionais) da modalidade futsal, ALVAREZ *et al.* (2009), verificaram uma diferença significativa no VO_2max de atletas espanhóis profissionais (62,8 ± 5,3 $mL.kg^{-1}.min^{-1}$) e semiprofissionais (55,2 ± 5,7 $mL.kg^{-1}.min^{-1}$). Essas diferenças também foram observadas para o limiar ventilatório (profissionais: 44,4 ± 4,6 $mL.kg^{-1}.min^{-1}$; semiprofissionais: 39,1 ± 4,0 $mL.kg^{-1}.min^{-1}$), demonstrando que a capacidade e potência aeróbia de atletas de futsal pode ser dependente do nível competitivo. ALVAREZ *et al.*, (2009) sugerem que valores de VO_2max acima de 60 $mL.kg^{-1}.min^{-1}$ são aconselháveis para jogadores profissionais de futsal (ALVAREZ *et al.*, 2009).

Tem sido relatado, para atletas brasileiros profissionais, um VO_2max (58,0 ± 6,4 $mL.kg^{-1}.min^{-}1$) inferior ao observado para os atletas espanhóis (BARONI e LEAL, 2010). Recentemente, MILIONI (2014) determinaram o VO_2max e o limiar anaeróbio de jogadores universitários (VO_2max: 46,93 ± 6,58 $ml.kg^{-1}.min^{-1}$; Limiar: 11,93 ± 1,34 $km.h^{-1}$) e profissionais (VO_2max: 50,57 ± 4,85 $ml.kg^{-1}.min^{-1}$; Limiar: 13,54 ± 0,80 $km.h^{-1}$), demonstrando que atletas amadores tem menores valores de capacidade aeróbia, ainda, os valores encontrados para atletas profissionais brasileiros, são menores dos que demonstrados para espanhóis. Finalmente, PEDRO *et al.* (2013), indicaram que as intensidades associadas com VO_2max e limiar ventilatório são mais adequadas para discriminar nível competitivo de atletas de futsal, do que simplesmente os valores das referidas intensidades.

Uma dificuldade de se utilizar avaliações laboratoriais, é que os protocolos não apresentam uma validade ecológica e muitas vezes tem apenas um caráter diagnóstico

(ZAGATTO *et al.*, 2016). Todavia, quando testado o VO_2max obtido por meio do laboratório e teste de campo com medida indireta (teste de 3200 metros), não foi encontrado diferenças significativas (62,8 ± 10,1 vs. 58,5 ± 8,5 $mL.kg^{-1}.min^{-1}$, respectivamente) (DE LIMA *et al.*, 2005).

O Yo-Yo intermittent recovery test level 1 (Yo-Yo IR1) proposto inicialmente para a avaliação do futebol (BANGSBO *et al.*, 2008), tem sido sendo utilizado para avaliação de atletas de futsal também. Jogadores profissionais de futsal brasileiros apresentaram uma distância percorrida de 1226 ± 282 metros no Yo-Yo IR1, com uma correlação de 0,64 (p=0,007) com a velocidade associada ao VO_2max obtido no laboratório (BOULLOSA *et al.*, 2013). Ainda, SOARES-CALDEIRA *et al.* (2014) apresentaram um valor médio de distância percorrida de 1280,0 ± 363,1 metros no Yo-Yo IR1. Porém, o Yo-Yo IR1 não foi validado para o futsal, não representa as demandas físicas do jogo como as constantes mudanças de direção e não leva em conta nenhuma demanda técnica durante o teste.

Em busca de maior especificidade, foi proposto por (BARBERO ALVARÉZ *et al.*, 2005) um teste intermitente de alta intensidade na quadra de futsal (Futsal intermitent endurance test – FIET). O teste consiste de corridas de vai e vem em uma distância de 15 metros com incremento de velocidade a cada 45 metros completos até a exaustão. Diferenças no valor de VO_2max foram encontradas quando comparado com o obtido no FIET (laboratório: 65,1 ± 6,2; FIET: 61,6 ± 4,6 $mL.kg^{-1}.min^{-1}$) (CASTAGNA e BARBERO ALVAREZ, 2010). Porém, os valores de VO_2max no FIET foram próximos do recomendado por BARBERO-ALVAREZ *et al.* (2008) para uma boa desempenho na partida de futsal. Além disso, a velocidade máxima no FIET foi correlacionada com a intensidade associada ao VO_2max e limiar ventilatório obtidos no laboratório, indicando que avaliar a capacidade aeróbia de atletas de futsal por meio do FIET possa ser uma maneira mais específica. Contudo, o teste não leva em conta nenhuma demanda técnica do jogo do futsal.

Ainda em busca de uma avaliação mais específica no futsal, foi proposto o Carminatti's test (DITTRICH *et al.*, 2011) também em corrida de vai e vem similar ao Yo-Yo IR1 e FIET, sendo encontrado uma correlação entre a velocidade máxima no Carminatti's test com a velocidade associada ao VO_2max (r=0,55) e valores de VO_2max (r=0,51) (DITTRICH *et al.*, 2011). Além das limitações apresentadas anteriormente, nenhum destes testes levaram em consideração a demanda técnica do jogo como, condução de bolas e a constante mudanças de direção além disso, não foi verificado as possíveis associações dos resultados obtidos nos testes com a demanda física do jogo.

2.3. MONITORAMENTO DO TREINAMENTO NO FUTSAL

Um programa de treinamento de sucesso tem como base a divisão dos períodos de treinamento por objetivos específicos comum, a constante variação da carga de treinamento (WILLOUGHBY, 1993; GAMBLE, 2006). Portanto, a prescrição de programas de treinamento requer um amplo conhecimento da especificidade de cada período (CYRINO *et al.*, 2002). Ainda, considerando que o processo de treinamento desportivo consiste em uma atividade sistematizada, visando o desenvolvimento do conjunto de fatores relacionados a preparação dos atletas e direcionados a obtenção do melhor desempenho (BORRESEN e LAMBERT, 2009; NAKAMURA *et al.*, 2010), o entendimento da relação dos períodos de treinamento (cargas de treino) com os desempenhos físicos, neuromusculares e bioquímicas são importantes para o melhor desenvolvimento dos modelos de treinamento.

Atualmente o modelo de quantificação da carga interna tem sido amplamente utilizado (BANISTER, 1991; SMITH, 2003; IMPELLIZZERI *et al.*, 2005). Existem diversos modelos de monitoramento das cargas de treinamento, como questionários e diários de treino, observações diretas, medidas fisiológicas como frequência cardíaca, consumo de oxigênio, lactato, dentre outras (SMITH, 2003; IMPELLIZZERI *et al.*, 2005).

BORRESEN e LAMBERT (2009) propuseram um modelo de quantificação da carga interna baseado na frequência cardíaca, onde, as intensidades de treino foram divididas em 5 zonas balizadas a partir do percentual da frequência cardíaca máxima. SEILER (2010) baseado no modelo citado acima, propõe um modelo com 3 zonas, sendo que neste caso, as zonas de intensidade são "ancoradas" a partir de outros marcadores fisiológicos além da frequência cardíaca, como limiar anaeróbio e consumo de oxigênio. Porém, pelo alto custo da utilização de marcadores fisiológicos e a baixa sensibilidade de frequência cardíaca para o monitoramento de atividades de alta intensidade, tem sido proposto a utilização da percepção subjetiva de esforço (PSE) (Figura 1) como método alternativo para a quantificação da carga interna, sendo bem aceito pelos treinadores, preparadores físicos e jogadores de modalidades coletivas (FOSTER, 1998; FOSTER *et al.*, 2001).

Classificação	**Descritor**
0	Repouso
1	Muito, Muito Fácil
2	Fácil
3	Moderado
4	Um Pouco Difícil
5	Difícil
6	-
7	Muito Difícil
8	-
9	-
10	Máximo

Figura 1. Tabela de percepção subjetiva de esforço (PSE) proposta por FOSTER et al. (2001).

Para a quantificação da carga da sessão do treinamento a partir da PSE é necessário que o atleta responda a seguinte questão: “Como foi a sua sessão de treino?”. FOSTER *et al.* (2001) recomenda que este questionamento seja realizado trinta minutos após o término da sessão de treino. Baseado no valor numérico apontado pelo atleta é possível então calcular a carga de treinamento multiplicando o escore da PSE pela duração total da sessão expressa em minutos (incluindo o aquecimento, a volta à calma e as pausas entre esforços) (FOSTER *et al.*, 2001). Além da magnitude da carga, a monotonia das cargas entre dias consecutivos de treinos pode ser calculada por meio da divisão média das cargas de treinamento das sessões de um determinado período (por exemplo, uma semana) pelo seu desvio padrão (FOSTER, 1998). Ainda, o tensão do treinamento pode ser calculado por meio da multiplicação da monotonia pelo somatório das cargas de treinamento acumuladas no período (FOSTER, 1998).

As adaptações induzidas pelo treinamento são altamente dependentes de uma carga interna de treinamento, que consiste no estresse real imposto no organismo dos atletas (IMPELLIZZERI *et al.*, 2005). Baseado nisso, foi demonstrado que a aptidão aeróbia e a capacidade de executar sprints repetidos de alta intensidade dos atletas de futsal pode influenciar as respostas de carga interna de treinamento em jogadores de futsal profissional.

Além disso, a capacidade dos jogadores para relatar o esforço percebido (PSE) pode variar tanto dentro da equipe e individualmente de acordo com diferentes cargas de treinamento, se tornando um desafio para os treinadores, pois acabam não tendo um retorno preciso da carga da sessão de treino (RABELO *et al.*, 2016). Portanto, a interpretação incorreta dos dados de PSE pode levar a erros no controle do treinamento e planejamento subsequente. Desse modo, o controle diário com feedback para os treinadores é a chave para melhorar o desempenho e diminuir o risco de lesões e cargas de treinamentos com efeitos deletérios (KIELY, 2012).

RABELO *et al.* (2016) compararam a carga de treinamento proposta pelo treinador com a carga de treinamento percebida pelos jogadores, ao longo de 45 semanas da temporada de atletas de futsal profissional, verificando que a PSE não parece ser uma ferramenta adequada quando usada pelo treinador para a carga de treino pretendida. Por outro lado, esses mesmos autores demonstraram que a PSE poderia ser sensível ao controle das cargas de treinamento diárias como “ancoragem” e controle das intensidades dos exercícios durante a sessão de treinamento. Em estudo com atletas semiprofissionais durante 12 semanas de treinamento com as intensidades dos exercícios sendo propostas por meio da PSE, observou-se significativas melhoras no índices de composição corporal, agilidade e capacidade aeróbia e anaeróbia dos atletas (BARBIERI *et al.*, 2016).

A compreensão da relação dose-reposta da distribuição das cargas de treinamento ao longo da temporada pode ser um importante fator para a melhora da performance (IMPELLIZZERI *et al.*, 2005). MILOSKI *et al.* (2016) descreveram a distribuição da carga de treinamento de uma equipe de futsal profissional e verificaram seus efeitos subsequentes sobre o desempenho físico, dano muscular e status hormonal, encontrando que durante a pré-temporada a carga de treinamento foi muito mais elevada, mas, a capacidade aeróbia foi melhorada neste período, e mantida ao longo do restante da temporada. Porém ao final da pré-temporada foi verificado uma alta concentração de creatina quinasse (CK) (215,6 ± 97,4 $U.L^{-1}$) e aumento da razão testosterona/cortisol (1,4 ± 0,3), indicando um alto stress metabólico e dano muscular (MILOSKI *et al.*, 2016).

Apesar disso, MILANEZ *et al.* (2014) verificaram que a relação dose-resposta entre a carga de treino e marcadores de estresse metabólico parece não ser linear, confirmando a necessidade de treinadores e preparadores físicos em monitorar as cargas de treinamento, monotonia e tensão em combinação com respostas fisiológicas durante períodos de treinamento.

Contudo, são poucos os estudos que se dedicaram a entender o complexo processo de treinamento do futsal, dentre eles FREITAS *et al.* (2012) investigaram o comportamento das cargas de treinamento em jogadores de futsal numa equipe profissional pertencente a liga nacional durante 14 semanas divididas em 3 mesociclos. Apesar da quantificação da carga de treino ter sido sensível as mudanças ao longo dos mesociclos e os indicadores de desempenho físico (VO_2max, velocidade máxima em 10 metros e agilidade através do shuttle-run de 9,14 metros e impulsão vertical) dos atletas terem respondido acompanhando estas mudanças, não foi verificada nenhuma correlação entre a carga de treino e os parâmetros de desempenho físico (FREITAS *et al.*, 2012).

Baseado nos estudos apresentados acima, fica evidente que as pesquisas com futsal ainda estão empenhadas em verificar a sensibilidade das aplicações dos métodos de monitoramento de carga, e não da relação dose-reposta fisiológica. Portanto, a presente tese esteve empenhada em investigar as relações da distribuição das cargas de treinamentos nos diferentes períodos com as repostas de desempenho físico, neuromusculares, hormonais e bioquímicos.

3. JUSTIFICATIVA

Uma boa avaliação do desempenho físico é importante, pois, além de ter apenas um caráter descritivo da condição física momentânea do atleta, pode ser utilizada para avaliar o resultado do período de treinamento e, por vezes para prescrever de forma específica a carga de treino(IMPELLIZZERI *et al.*, 2005; DITTRICH *et al.*, 2011; BOULLOSA *et al.*, 2013; PEDRO *et al.*, 2013; SOARES-CALDEIRA *et al.*, 2014; MILOSKI *et al.*, 2016). Porém, são escassos no futsal, protocolos de avaliação que consideram a demandas técnicas e física do jogo, o que tornaria a avaliação mais fidedigna e aplicável na rotina do treinamento.

Juntamente com uma boa avaliação do desempenho físico, a prescrição das cargas apropriadas de treinamento ao longo da temporada também é um problema para os treinadores, já que muitas vezes não planejadas ou apresentam elevada diferença entre as cargas entre planejadas e as executadas (KELLY e COUTTS, 2007; RABELO *et al.*, 2016). Contudo, a classificação da sessão de esforço percebido (sessão-PSE) tem demonstrado ser um método simples e prático para a quantificação da carga de treinamento interno em esportes coletivos (FOSTER, 1998; FOSTER *et al.*, 2001; IMPELLIZZERI *et al.*, 2005), uma vez que, o conhecimento de como as cargas são distribuídas ao longo dos ciclos específicos e/ou em toda a temporada de treinamento, considerando magnitude, propósitos e como as respostas induzidas pelo treinamento podem estar relacionados com as estratégias adotadas, tem se mostrado ser a chave para o sucesso do planeamento do treinamento esportivo(IMPELLIZZERI *et al.*, 2005; MILOSKI *et al.*, 2016).

Apesar de existir um grande número de estudos que verificaram a relação da carga interna no treinamento de futsal com algum parâmetro fisiológico (NAKAMURA *et al.*, 2010; MOREIRA *et al.*, 2011; BARBIERI *et al.*, 2012; DE MOURA *et al.*, 2012; ARRUDA *et al.*, 2013; DE MOURA *et al.*, 2013; MOREIRA *et al.*, 2013; OLIVEIRA *et al.*, 2013;

ÁLVAREZ-MEDINA *et al.*, 2014; DE OLIVEIRA BUENO *et al.*, 2014; MILANEZ *et al.*, 2014; MILOSKI *et al.*, 2014; NAKAMURA *et al.*, 2015; ARRUDA *et al.*, 2016; MILOSKI *et al.*, 2016), a maioria destes estudos tiveram como objetivo testar o método, e não necessariamente, estudar a relação dose-resposta entre a carga interna e a adaptação fisiológica dos atletas de futsal.

A partir do exposto, foi elaborado a seguinte pergunta central:

Os parâmetros neuromusculares, hormonais, bioquímicos, hematológicos e performances aeróbia e anaeróbias monitoradas, por meio de protocolo específico, estão associadas com a distribuição da carga interna de treinamento ao longo da temporada competitiva no futsal?

4. OBJETIVO

Padronizar e validar um protocolo de avaliação específico da performance aeróbia e anaeróbia para jogadores de futsal.

Investigar as respostas de uma temporada de treinamento sobre os parâmetros antropométricos, neuromusculares, hormonais, bioquímicos, hematológicos e performances aeróbia e anaeróbias monitoradas através do protocolo específico proposto.

4.1. OBJETIVOS ESPECÍFICOS

1. Padronizar e validar um protocolo específico para avaliação da performance anaeróbia e aeróbia que seja realizado na área de jogo e leve em consideração a demanda técnica do jogo.
2. Verificar a relação dos índices obtidos no teste de campo e laboratório com o desempenho físico durante uma partida de futsal.
3. Apresentar a dinâmica de carga interna utilizados durante a pré-temporada o período competitivo de atletas profissionais de futsal.
4. Verificar as possíveis associações entre as variáveis antropométricas, bioquímicas, hormonais, performances aeróbias, anaeróbia e neuromusculares com a carga interna de treinamento.

5. PLANO DE TRABALHO

A presente tese de doutorado foi composta por três trabalhos científicos de modo a responder à pergunta central. De maneira geral, cada trabalho apresentado contempla pelo menos um objetivo específico apresentado na seção anterior. Sendo assim, a tese foi dividida em duas etapas (Figura 2), que, consistiu em primeira etapa de validar uma ferramenta de avaliação da capacidade aeróbia na quadra, que levasse em conta a demanda técnica do jogo (1ª Etapa), e utilizando a ferramenta proposta anteriormente, monitorar a carga interna e a relação dose-reposta dos parâmetros neuromusculares, hormonais, bioquímicos, hematológicos e performances aeróbia e anaeróbias durante a pré-temporada e temporada competitiva. (2ª Etapa).

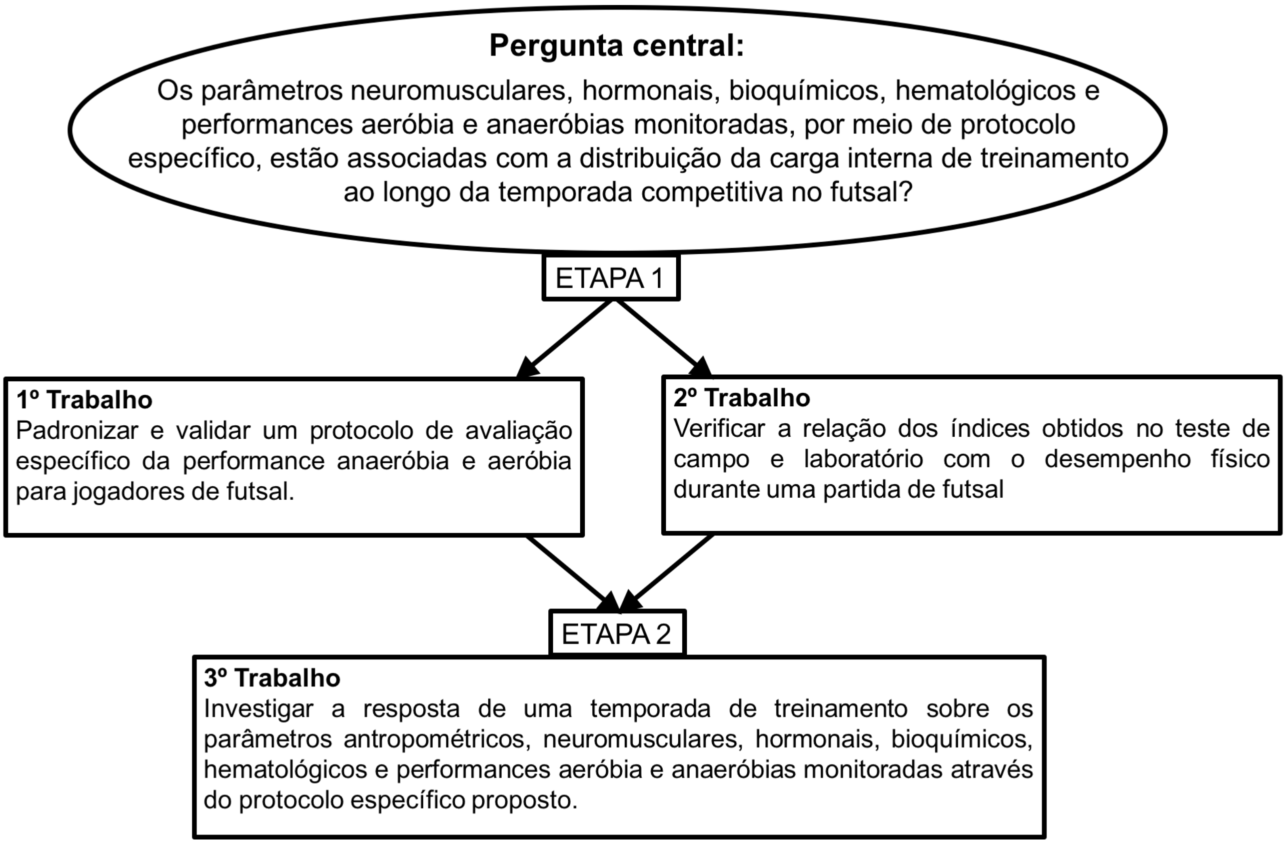

Figura 2. Desenho experimental da série de trabalhos que compõem a presente tese de doutorado.

1º Trabalho:

CONFIABILIDADE E VALIDADE DE UM NOVO TESTE ESPECÍFICO DE CAMPO PARA AVALIAR A CAPACIDADE AERÓBIA COM A BOLA EM JOGADORES DE FUTSAL.

Pergunta Central:

Um teste para avaliar a capacidade aeróbia adaptado a partir do circuito proposto por HOFF *et al.* (2002) é valido em comparação com a máxima fase estável de lactato?

Justificativa:

Existem alguns protocolos de avaliação que consideram as exigências técnicas impostas pelo jogo, expressa em passes, chutes, constantes mudanças de direção e condução de bola, porém, apenas para o futebol. Entre esses estudos, o circuito de treinamento aeróbio proposto por HOFF *et al.* (2002)e posteriormente utilizado por CHAMARI et ai. (2005), Loures et al. (2014) e ZAGATTO et al., (2016) para avaliar a capacidade aeróbia de jogadores de futebol, se destaca por sua aproximação com as características do jogo. No entanto, ao contrário de futebol, ainda não foi observado para o futsal protocolos de avaliação de parâmetros aeróbios e anaeróbios que tenham considerado a exigência técnica, por meio da inclusão da bola durante o teste para avaliar a capacidade aeróbia.

RELIABILITY AND VALIDITY OF A NEW SPECIFIC FIELD TEST OF AEROBIC CAPACITY WITH THE BALL FOR FUTSAL PLAYERS

INTRODUCTION

Futsal is an intermittent sport with high intensity efforts (CASTAGNA *et al.*, 2009; CASTAGNA e ALVAREZ, 2010) a complex range of motor actions (DOĞRAMACI e WATSFORD, 2006) and mixed energetic demand, where the oxidative phosphorylation pathway is responsible for 76% of all energy resynthesized in the match (CASTAGNA *et al.*, 2009; CASTAGNA e ALVAREZ, 2010). Therefore, evaluation of aerobic capacity is essential for performance optimization (MCMILLAN *et al.*, 2005), enhancement of the oxidative phosphorylation pathway has a strong association with increases in the number of sprints and the distance covered during a match (HELGERUD *et al.*, 2001; KRUSTRUP *et al.*, 2006), improves technical performance and promotes more ball involvement during the soccer game (HELGERUD *et al.*, 2001; MCMILLAN *et al.*, 2005). The gold standard protocol to evaluate aerobic capacity is the maximal lactate steady state (MLSS) that can be defined as the highest exercise intensity which is an equilibrium between lactate transport into the blood and lactate removal from the blood (BILLAT *et al.*, 2002; BENEKE, 2003). This intensity has a close relationship with endurance sport performance (BENEKE e VON DUVILLARD, 1996; BILLAT *et al.*, 2002; BENEKE, 2003).

Despite the existence of some futsal specific protocols to assess aerobic fitness (ALVAREZ *et al.*, 2009; DITTRICH *et al.*, 2011), futsal athletes are often evaluated through non-specific tests for the modality, such as laboratory measurements fitness (LIMA *et al.*, 2005; ALVAREZ *et al.*, 2009), indirect measurements (BARBIERI *et al.*, 2012; LOURES *et al.*, 2015), and the use of protocols specific to soccer (BANGSBO, 1994; KRUSTRUP *et al.*, 2006; DITTRICH *et al.*, 2011; LOURES *et al.*, 2015; ZAGATTO *et al.*, 2015). Therefore, the specificity of the motor pattern is not considered in these protocols (LOURES *et al.*, 2015), which is not attractive for futsal evaluations (HOFF *et al.*, 2002).

There are few evaluation protocols that consider the technical demands imposed by the match, expressed as passes, kicks, specific movements and ball dribbling (HOFF *et al.*, 2002; CHAMARI *et al.*, 2005; LOURES *et al.*, 2015; ZAGATTO *et al.*, 2015; ZAGATTO *et al.*, 2016). Among these studies, the aerobic training circuit proposed by HOFF *et al.* (2002) can be highlighted. Stands out, composed of a route that includes jumps, running backwards, and changes in direction, all carried out with the soccer ball. This factor contributes to the motivation of the volunteer to participate in the test as well as the evaluation approaching the conditions of the game, thus increasing the ecological validity of the test, since beyond the physical requirements, the circuit also covers the technical requirements. Subsequently, this circuit was used by CHAMARI *et al.* (2005) and ZAGATTO *et al.* (2015) to evaluate maximal oxygen uptake (VO_{2max}) in soccer players and by LOURES *et al.* (2015) to MLSS. Nevertheless, unlike soccer has some studies take in consideration the technical demands through the inclusion of the ball during the test (CHAMARI *et al.*, 2005; LOURES *et al.*, 2015; ZAGATTO *et al.*, 2015; ZAGATTO *et al.*, 2016), for the futsal are not any test take into account the technical demand through the inclusion of the ball during the test to assess the aerobic capacity.

Therefore, the aim of this study was to establish the validity and verify the reproducibility of an adapted lactate minimum protocol (LM) on the specific-futsal circuit (Futsal_circuit) and its association with MLSS. Since the proposed test is a mix of metabolic plus technical skills, we hypothesized that it would be possible to determine the functional aerobic capacity on the Futsal_circuit through the lactate minimum protocol, and this method would be reliable and valid to predict MLSS in futsal players. To verify these hypotheses, the present research was designed as an experimental cross-sectional study divided into two studies (study A and B), where study A aimed to determine the functional aerobic capacity on the specific-futsal circuit (Futsal_circuit) adapted from the Hoff circuit proposed to the soccer (HOFF *et al.*, 2002), and to verify the reliability and reproducibility of the test, while, study B aimed to assess the concurrent validity of the LM test on the Futsal_circuit with the MLSS.

The lactate minimum test is a good To assess the aerobic capacity through the protocols with blood lactate concentration (i.e. anaerobic threshold and MLSS) presents advantages over other tests that determine aerobic capacity, i.e., VO_{2max} test, because; (i) the indices depend more on peripheral adaptations (muscle oxidative phosphorylation capacity) [10], (ii) it is highly sensitive to the effects of training, especially in moderately or highly trained individuals in whom VO_{2max} could be little or unmodified after training [28] and (iii) it presents high correlation with aerobic performance in events of medium and long duration [9].

METHODS

Study Design

Considering the inclusion of the ball to approach the conditions of the real game and the technical requirement demands during the aerobic assessment, a specific circuit for futsal adapted from the Hoff circuit for soccer (HOFF *et al.*, 2002), was created. The Hoff circuit for soccer showed to be validity to assess the functional aerobic capacity through the MLSS and to be more specific than incremental treadmill on the laboratory (ZAGATTO *et al.*, 2016). The circuit for soccer was designed taking into account the measures of an official soccer field and the more movements performed during a match (HOFF *et al.*, 2002), because this, the adaptation (figure 1) of the specific futsal circuit was performed in proportion to the original circuit, however, taking into consideration the equivalents magnitudes of an official futsal court 40 × 20 meters, culminating in a rectangle area to perform the test of 22 × 9 meters. The displacement in each lap on the circuit is approximately 94 meters. The circuit could divide in five parts with different technical demands.

Due to the reduction in the circuit size and in order to highlight the specific demands of futsal, the study of (CASTAGNA *et al.*, 2009) was used with reference to the necessary adjustments. Therefore, the number of offsets with the ball between the cones on the first part of the circuit was decreased from nine to four, since the displacements in soccer are more extensive compared to futsal (CASTAGNA *et al.*, 2009). The jumps over the hurdles (second part of the circuit) were replaced by ball dribbling on the hurdles (1.0 m x 1.0 m) due to the low frequency of jumps in futsal (CASTAGNA *et al.*, 2009). The others parts (third, fourth and fifth parts) of the circuit were kept the same, but, with lower displacement distance between the cones. It is important to highlight the displacement between points A and B (fourth part of the circuit) was performed the running backwards. The specific circuit for futsal is described in Figure 1, taking into consideration the changes indicated above. During all circuit, athletes need dribbling the ball along the path indicated by the arrows. To control the running speed, the circuit was divided into four equal parts (23.5 meters each part) by means of demarcations on the floor, through which the participants had to run at a speed synchronized with a sound signal (beep) from a metronome.

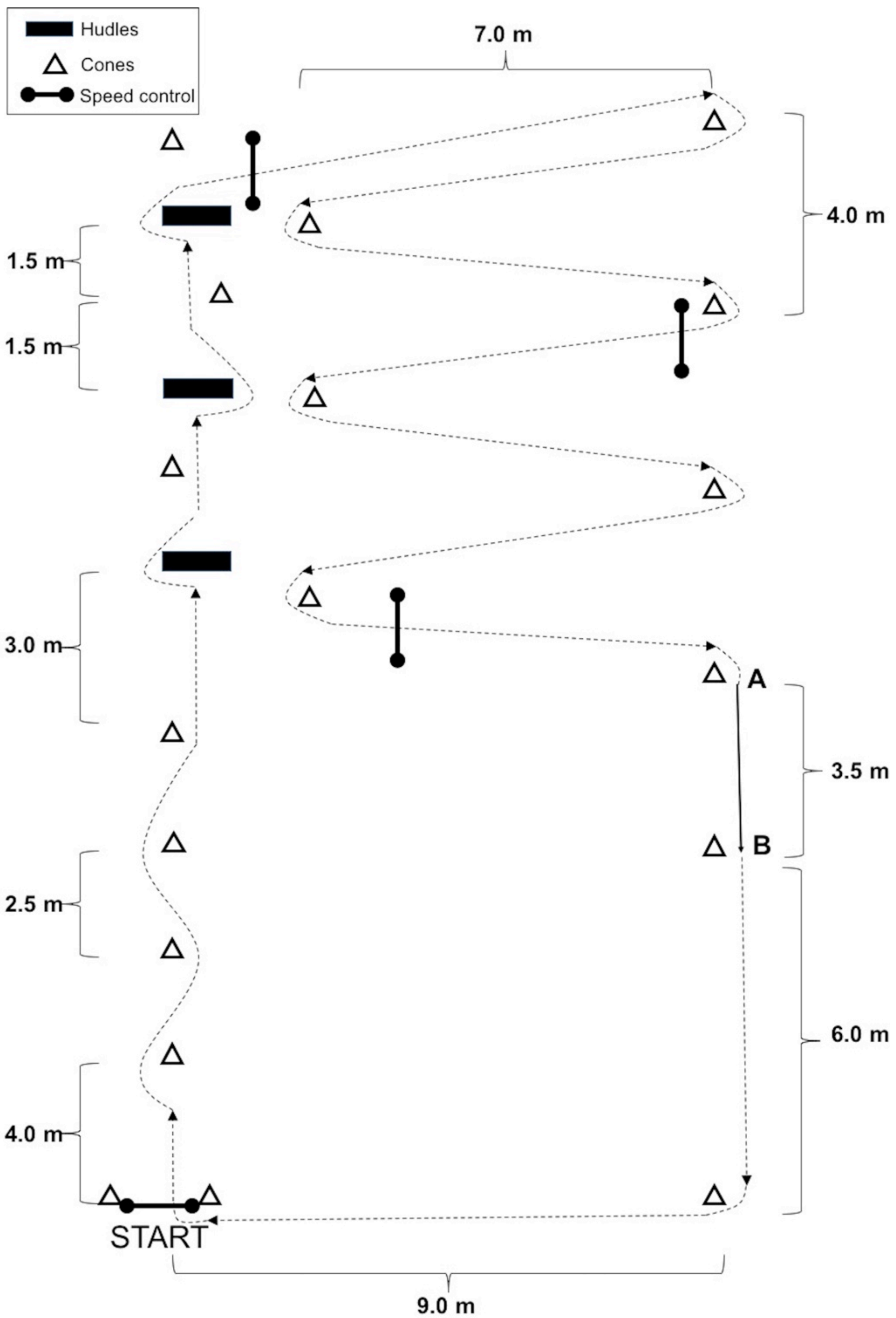

Figure 1. Specific circuit for futsal for measuring the aerobic capacity. The ball is dribbled in the direction of the arrows, with backward running between points A and B. Speed control marks on the floor was used to control the running speed.

To perform a good assessment, it is necessary that the participant give their maximal performance during the test, however, sometimes the protocols are unattractive and do not stimulate the athlete to give their maximal effort. Based on this, the proposal to include a ball, thus increasing motivation during the aerobic assessment, as well as approaching the conditions of the real game, seems to be a great strategy, which could cover the technical requirement demands of the match in addition to the physical requirements.

Participants

Sixteen male Brazilian professional futsal players were recruited and distributed for convenience into two studies, whereby in study A, the reliability and reproducibility test of the lactate minimum (LM) was performed (GREP, n = 8) and study B the maximal lactate steady state test (MLSS) was performed on the Futsal_circuit to assess concurrent validity (GMLSS. N = 8). The groups did not present statistical differences in anthropometric characteristics or age (Table 1).

Athletes were informed about the experimental design, and agreeing with proposed protocol it was signed a free and informed consent term approved by the Institutional Ethical Committee (Case No. 076/2011), which was conducted in accordance with the Declaration of Helsinki, and complied with the ethical standards of the International Journal of Sports Medicine (HARRISS e ATKINSON, 2015).

Table 1. Means and standard derivations of anthropometric characteristics and age of the athletes.

	Age (years)	**Body Mass (kg)**	**Height (m)**	**BMI ($kg.m^{-2}$)**
All Athletes (n=16)	22.56±5.19	67.73±8.37	1.73±0.05	22.60±2.51
Study A (n=8)	21.75±2.05	70.48±8.63	1.75±0.03	22.87±2.47
Study B (n=8)	23.38±7.21	64.98±7.65	1.70±0.07	22.32±2.69

Study A - performed reproducibility test; Study B - performed maximal lactate steady state test

The sample size was calculated based on the results of LOURES *et al.* (2015), where the analysis of test-retest and de comparison of anaerobic threshold with the MLSS on the Hoff circuit with soccer players were performed. The analysis with the G*Power software (Düsseldorf, Germany) showed to study A the minimum sample size required to provide a statistical power of 85% with an alpha of 0.05 for the analysis was 8 individuals. To the study B, the minimum sample size required to provide a statistical power of 95% with an alpha of 0.05 for the analysis was 5 individuals.

Lactate minimum test on the Futsal_circuit

Prior to the LM test, a period of familiarization with the Futsal_circuit was performed with progressive bouts (2 laps at each intensity) at intensities of 5.0; 6.0; 7.0; 8.0; 9.0; 10.0; 11.0 $km.h^{-1}$ and maximal speed, lasting a total of about 15 minutes, on four different days. During the familiarization with the proposed circuit and the test, an metronome with a beep was used to control the running speed of the athletes through the speeds marks.

For the specific induction of acidosis, the Running-based Anaerobic Sprint Test (RAST) (ZACHAROGIANNIS *et al.*, 2004; ZAGATTO *et al.*, 2009; ANDRADE *et al.*, 2013; DE ARAUJO *et al.,* 2014) was utilized. The test consists of six 35m all out sprints with passive intervals of 10s. Blood samples (25µL earlobe) were collected 3, 5 and 7 minutes after the RAST. Eight minutes after the specific induction of acidosis, the progressive phase loads on the Futsal_circuit was started with an initial intensity of 6.0 $km.h^{-1}$ and increasing 1.0 $km.h^{-1}$ each three laps on the circuit until exhaustion. Test was interrupted when the athlete cannot sustain the intensity or the participant committed three consecutive errors, such as not arriving with the ball in the corresponding beep demarcations, running an incorrect route or losing control of the ball and not recovering the pace. Heart rate was monitored during the test using a Polar ® RS300x monitor (Polar® Electro Oy) and blood samples were collected at the end of each step to assess the blood lactate concentration.

The minimum lactate intensity was obtained from the derived equal zero of the second order polynomial fit of the ‘U-shaped” curve of blood lactate concentration versus intensity of the incremental phase of the lactate minimum test [17].

To verify the reproducibility of the protocol, participants in the GREP repeated the LM (test) after seven days (re-test), while the participants in the GMLSS performed the maximum lactate steady state test for the concurrent validity.

Maximal Lactate Steady State on the Futsal_circuit

To determine the MLSS, participants of the GMLSS were submitted, seven days after performing the LM, to between three and five random bouts lasting 30 minutes, of which the first bout was at the speed corresponding to 100% of LM, and, when necessary, adjustments of 3% up or down were performed based on the lactatemia response (BENEKE e VON DUVILLARD, 1996; BENEKE, 2003). bouts were separated by a minimum of 24 and maximum of 72 hours. At rest, 5, 10, 15, 20, 25 and 30 minutes after the test, the rated perceived exertion (RPE – 0 to 10) (FOSTER, 1998), heart rate (HR) and blood samples were collected to analyze the blood lactate concentration ($[La^-]$). The MLSS was assumed as the highest exercise intensity where the $[La^-]$ showed a variation equal or lower than $1mmol.L^{-1}$ between the 10^{th} and 30^{th} minute of the test (BENEKE, 2003).

Blood Sampling and Analysis

Prior to blood collections, the asepsis of the earlobe was cleaned with alcohol and manually punctured with a sterile lancet. The venous blood was collect in 25μL heparinized capillary tubes.

The samples were stored in Eppendorf tubes containing 400 (TCA–4%) for deprotonation of the blood. The analysis was performed in duplicate using the ELISA method. The samples were stirred and centrifuged to remove 50μl of the supernatant, which was transferred to test tubes where 250µl of reagent was added, prepared on the basis of stock of glycine/EDTA and hydrazine hydrate, NAD (Beta-nicotinamide dinucleotide–SIGMA), and LDH (L–Bovine Heart Lactic Dehydrogenase – 1000 units/ml SIGMA). Next, the samples were stirred and incubated for 60 minutes at 37ºC. The lactate concentration was measured by absorbance at 340nm.

Statistical Analysis

Normality and Homogeneity of the data were verified with the Shapiro-Wilk and Levene's tests respectively. To compare the groups (GREP vs GMLSS), the independent student's t-test was performed. For study A (reliability and reproducibility) the dependent student's t-test for paired samples was performed to compare the results between test and re-test was accompanied by the effect size (ES), classified as negligible (<0.35), small (0.35 to 0.79), moderate (0.80 - 1.5) and large (> 1.5). Furthermore, the coefficients of variation (CV) and typical error (TE) and intraclass correlation (ICC) were also calculated according to HOPKINS *et al.* (2001). For study B (concurrent validity) the dependent student's t-test for paired samples was performed to compare the results between the LM and MLSS variables, Bland-Altman graphical analysis was performed and the Bland-Altman limits of agreement were used to determine the limits of agreement between the LM and MLSS. In addition, the Pearson correlation test for concurrent validity of the test was performed. In all cases the level of significance was $p < 0.05$.

RESULTS

In study A no significant differences were observed in the variables in the test and retest conditions of LM on the Hoff circuit for futsal, confirming the reproducibility of the proposed protocol. Coefficients of variation, effect size and typical error enhanced the reproducibility and confirmed the reliability (Figure 2, Table 2). Furthermore, the intraclass correlation were significant to mean power, lactate concentration related to lactate minimum intensity, maximum heart rate and heart rate at lactate minimum intensity.

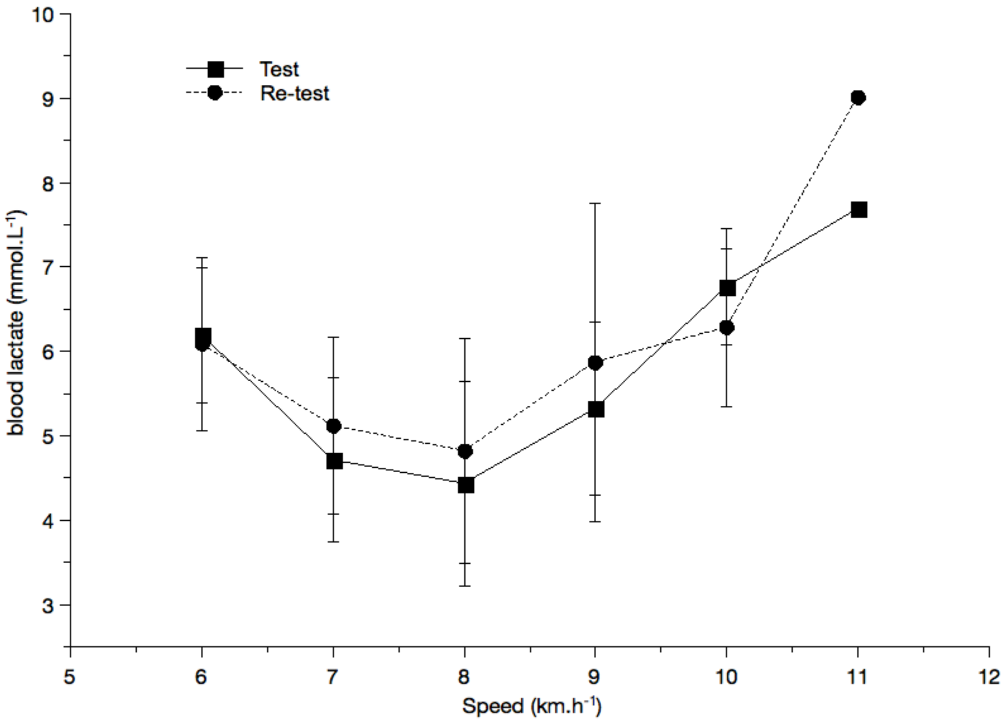

Figure 2. Means and standard deviation of the blood lactate concertation during the lactate minimum on the test and re-test condition.

Table 2. Means and standard deviations, coefficients of variation (CV), typical error (TE), effect size (ES) and Intraclass Correlations (ICC) for comparison between test and re-test.

	Test	Re-test	CV (%)	TE	ES	ICC
RAST (GREP)						
PP (Watts)	604.04±82.91	641.67±80.25	9.68	60.29	0.46	-0.88
PMed (W)	503.10±54.89	525.08±63.26	5.58	28.71	0.37	0.87*
PMin (W)	403.28±46.79	414.89±50.65	9.26	37.87	0.24	0.57
IF (%)	32.65±8.09	34.82±8.68	26.77	9.03	0.26	-0.37
Incremental Phase (GREP)						
sMax ($km.h^{-1}$)	9.88±0.64	9.75±0.70	4.62	0.45	0.15	0.71
sLM ($km.h^{-1}$)	7.75±0.29	7.69±0.42	4.13	0.32	0.19	0.28
%sLM (% of sLM)	78.69±3.64	79.18±6.78	6.98	5.51	0.12	-0.01
$[La^-]$ peak ($mmol.L^{-1}$)	7.87±0.70	7.68±0.84	8.53	0.66	0.24	0.42
$[La^-]$ sLM ($mmol.L^{-1}$)	4.44±1.21	4.63±0.90	11.41	0.51	0.18	0.87*
HR Max (BPM)	198.50±8.00	196.37±9.90	1.88	3.71	0.24	0.91*
HR sLM (BPM)	187.00±9.61	183.88±12.32	3.28	8.61	0.28	0.82*
%HR sLM (%)	94.22±3.40	93.60±2.92	3.81	3.58	0.29	-0.76
R^2 (%)	0.94±0.09	0.86±0.10	12.05	0.10	0.84	-0.34

***p<0.01**

PP (Peak Power), PMed (mean Power), PMin (Low Power), IF (Index of Fatigue), sMax (Maximal speed in the test), sLM (lactate minimum intensity), %sLM (Percentage of the lactate minimum velocity relative to the maximum speed), $[La^-]$ peak (peak of blood lactate concentration), $[La^-]$ sLM (blood lactate concentration related to lactate minimum intensity) HR Max (maximum heart rate), HRsLM (heart rate at lactate minimum intensity), %HRsLM (Percentage of HR lactate minimum relative to maximum HR), R^2 (coefficient of determination).

For study B, the behavior of blood lactate $[La^-]$, heart rate and perceived exertion (Figure 3) for different intensities of MLSS (sMLSS) are presented in figure 2.2 A, B and C. The sMLSS was 100.75 ± 4.16% of sLM, and no statistical difference was found between the two speeds (i.e., LM speed and MLSS speed).

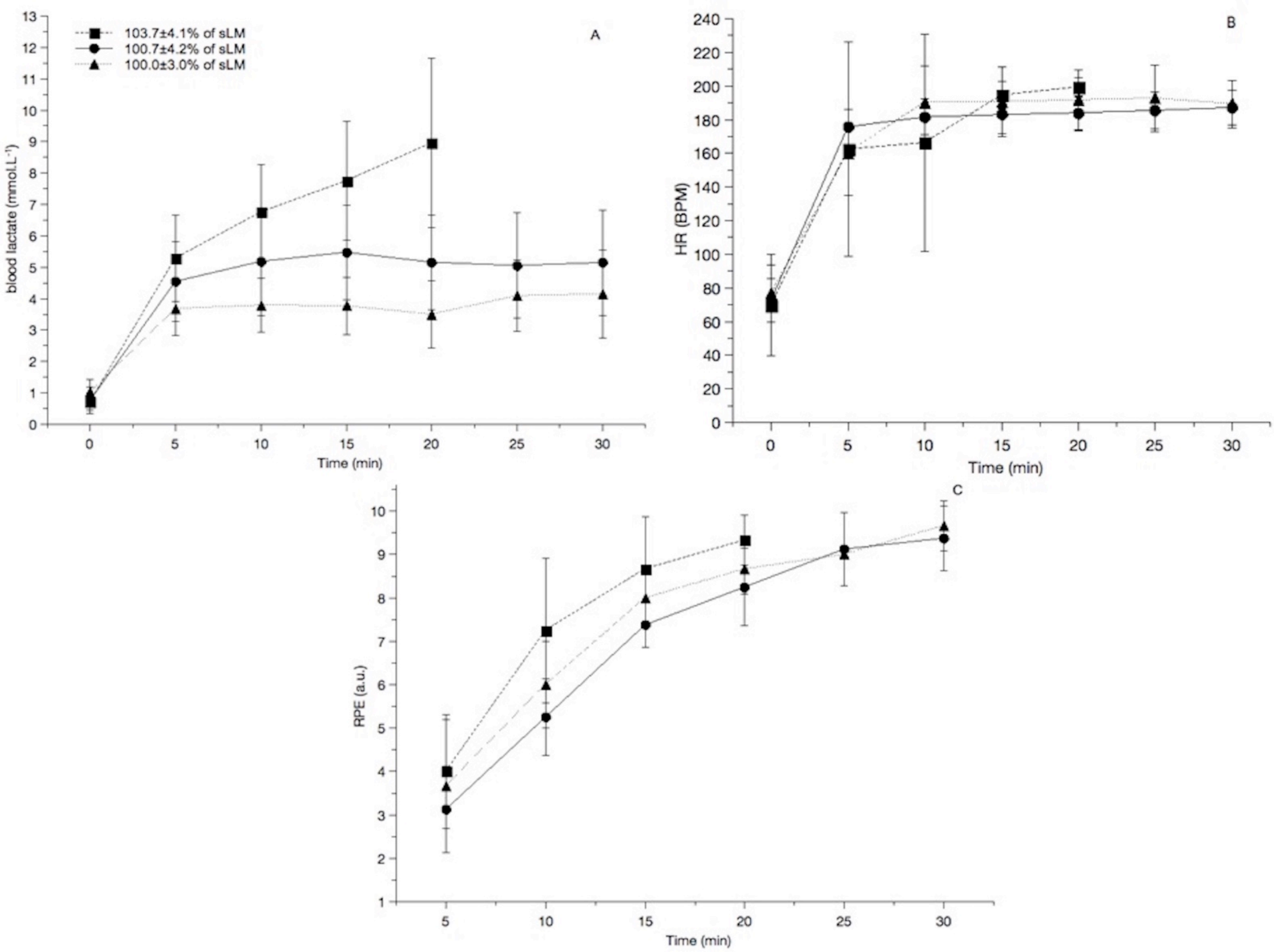

Figure 3. Means and standard deviations of blood lactate concentration (A), heart rate (HR) (B) and rated of perceived exertion(RPE) (C) during the MLSS test at, above and below the MLSS intensity.

For the results corresponding to the sLM and sMLSS intensity, no significant differences between speed and heart rate were observed, with a strong correlation. However, perceived exertion demonstrated a significant difference with a strong negative correlation (Table 3). In addition, a significant statistical difference was found for the response of [La$^-$] in the sLM vs sMLSS [La$^-$] obtained from the mean of the concentrations between the 10th and 30th minute during the MLSS protocol.

Table 3. Means and standard deviations of intensity (Speed), heart rate (HR), blood lactate concentration ([la$^-$]) and rated perceived exertion (RPE) of lactate minimum (LM) and maximal lactate steady state (MLSS) and correlation-values between them.

Correlations (GMLSS)	**LM**	**MLSS**	**r (LM vs MLSS)**
Speed (km.h^{-1})	7.47±0.48	7.51±0.38	0.80*
HR (BPM)	180.75±13.55	184.40±10.23	0.85$^{\#}$
[la$^-$] (mmol.L^{-1})	8.23±0.97	5.03±0.58*	0.02
RPE (a.u.)	5,62±1,19	7,77±0,61*	-0,81*

***P<0.05; $^{\#}$P<0.01;**

The concordance test through the Bland & Altman graphical analysis for study B showed an aleatory distribution of the data and confirmed the concordance between the sLM vs sMLSS (IC 95%: lower limits: -0.71 – -0.38 km.h^{-1}; upper limits: 0.74 – 0.41 km.h-1) (Figure 4).

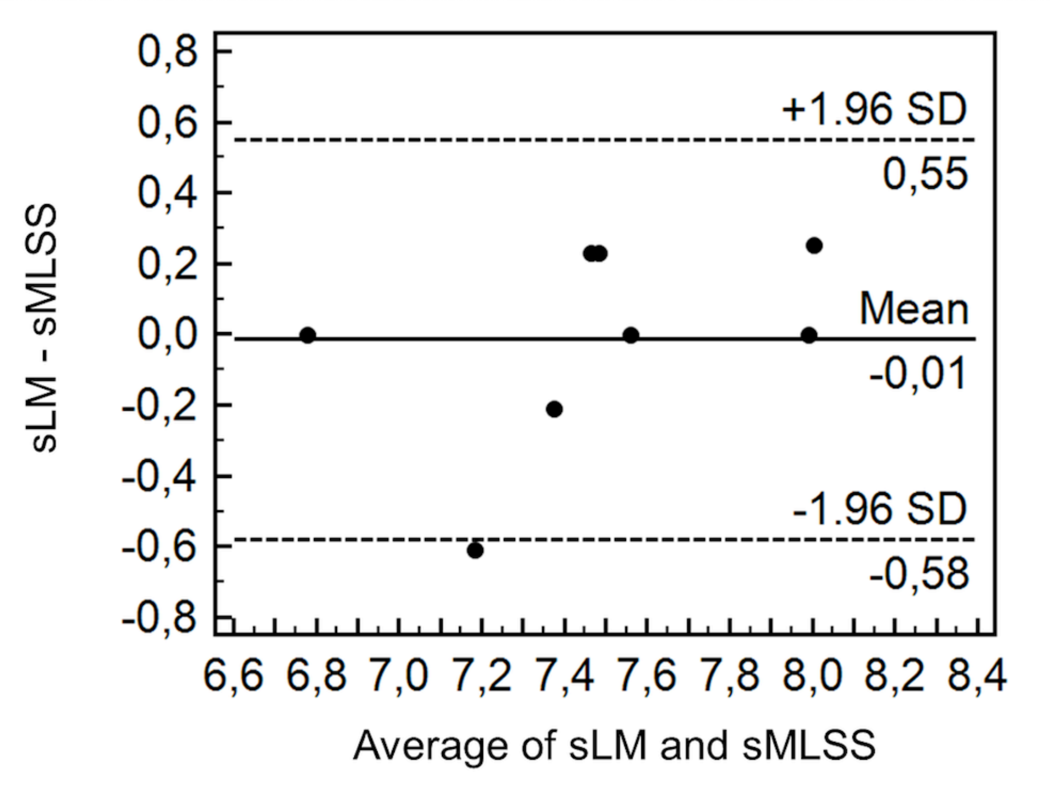

Figure 4. Bland & Altman graphical analysis between lactate minimum speed and maximal lactate steady state.

DISCUSSION

The main findings of the study were that the lactate minimum test on the Futsal_circuit was reliable and reproducible (study A) and shown to be valid for prediction of MLSS in futsal players (study B). Confirmation of the reliability and reproducibility of an assessment procedure is important for it to be scientifically accepted (MCMILLAN *et al.*, 2005) and reliable in practice (HOPKINS *et al.*, 2001; CURRELL e JEUKENDRUP, 2008), however few studies have investigated the reproducibility of the lactate minimum test. MACINTOSH *et al.* (2002) found satisfactory reproducibility for the lactate minimum intensity determined on a cycle ergometer, but the authors did not show the typical error or coefficients of variation. In addition, STRUPLER *et al.* (2009) tested the reproducibility of the lactate minimum intensity by performing four-cycle ergometer tests and showed low values of coefficient of variation (6.8%), indicating the high reproducibility of this variable. Our findings were in agreement with the above mentioned, since the velocity of the lactate minimum was not significantly different, presented a low coefficient of variation and standard error (HOPKINS *et al.*, 2001). In addition, the curves of minimum lactate showed similar behavior and no statistical differences in the coefficient of determination (R^2). Finally, sLM and heart rate showed low levels of ET (0.32 $km.h^{-1}$and 8.61 BPM), which demonstrated the potential of these variables to be sensitive for small adaptation from aerobic training. Despite intraclass correlation was not significant to the lactate minimum intensity, probably because the coefficient of variation of test (3.40 %) and re-test (5.43 %) were low, hence small variations in the group may have a direct effect on athletes' ranking when compared pre vs post moments.

For the specific induction of acidosis, the RAST (ZACHAROGIANNIS *et al.*, 2004; ZAGATTO *et al.*, 2009; ANDRADE *et al.*, 2013) was performed, demonstrating the advantage of the proposed protocol, as it is possible to measure anaerobic fitness (ZACHAROGIANNIS *et al.*, 2004; ZAGATTO *et al.*, 2009) followed by a precise measurement of aerobic capacity [40] in the same test. The RAST variables demonstrated no statistical differences for the test and retest condition, presenting reproducibility for all variables with a low coefficient of variation for the power variables, except for the fatigue index that showed a high value for coefficient of variation, thus collaborating with the findings of ZAGATTO *et al.* (2009) and (ANDRADE *et al.*, 2013) who, besides verifying the reproducibility of the test, performed concurrent validation. Furthermore, this study was the first to verify the reproducibility in futsal players, since, ZAGATTO *et al.* (2009) and ANDRADE *et al.* (2013) studied runners at Track field and soccer players respectively.

Although there are a few validated protocols specifically for evaluating aerobic fitness in futsal (BARBERO ALVARÉZ *et al.*, 2005; DITTRICH *et al.*, 2011) which aims to determine only maximal aerobic capacity (VO_{2Max}). However, using VO_{2Max} as the main parameter to monitor training in futsal or soccer players, must be used with caution, since short, medium or long term aerobic performance depends on several factors, not only VO_{2Max} (BRANDON, 1995). In addition, for moderately or highly trained individuals, VO_{2Max} seems to have none or modest modifications, although aerobic performance may present large adaptations and improvements throughout the season (KOHRT *et al.*, 1989; BARBERO ALVARÉZ *et al.*, 2005). Tests using blood lactate concentrations are highly sensitive to peripheral adaptations, training and presents strong correlations with medium and long duration aerobic performance when compared with VO_{2Max} (BILLAT *et al.*, 2002). Therefore, the proposed protocol seems to have advantage when compared to common protocols that evaluated aerobic fitness in futsal.

The sLM values were low when compared to previous studies with a lactate minimum protocol. DOTAN *et al.* (2011) found values of speed around 13 $km.h^{-1}$ in adult runners and LOURES *et al.* (2015) found anaerobic threshold values of approximately 12 $km.h^{-1}$ and 9 $km.h^{-1}$ for soccer players, obtained in an incremental treadmill running test and on the Hoff circuit respectively. The values in the present study were 7.75 ± 0.29 $km.h^{-1}$ for test and 7.69 ± 0.42 $km.h^{-1}$ for re-test. The lower values of anaerobic threshold observed in the present study may be related to the reduction in circuit size and consequent smaller distance between the obstacles and technical demand, resulting in lower speed (DOTAN *et al.*, 2011). When observing the results of the anaerobic threshold on the Hoff circuit for soccer compared to values of stationary running in the laboratory, we observed a 25% reduction in velocity related to the anaerobic threshold on the Hoff circuit (LOURES *et al.*, 2015; ZAGATTO *et al.*, 2015; ZAGATTO *et al.*, 2016). However, the value of the anaerobic threshold is even lower when comparing the results of futsal with soccer athletes. This fact may be explained by the characteristics of futsal that is composed of a complex range of motor actions (DOĞRAMACI e WATSFORD, 2006), demonstrating a mixed energy demand, presenting a minor contribution (85% soccer and 76% in futsal) of the aerobic system (CASTAGNA *et al.*, 2009) and being practiced in small spaces (RUSSELL e KINGSLEY, 2011) in comparison to soccer. Moreover, the physical capacity in special to the soccer players influence their technical performance and tactical choices that has a high aerobic capacity in comparison with futsal (STØLEN *et al.*, 2005). Thus, futsal seems to present more complex technical demands, which are possibly the most determinant on total energy expenditure during the match.

The motor and technical characteristics of the sport included in our test positively affected the increase in heart rate. Heart rate is directly related to cardiac output and energy demand, which regulates the oxygen supply for the exercise (SALTIN e STRANGE, 1992). Therefore, the increased energy expenditure on the Futsal_circuit justifies the high values of HR related to the anaerobic threshold intensity. In addition, the values of speed and HR concerning the anaerobic threshold of this study (7.43 to 7.75 $km.h^{-1}$ and HR between 93-94% of maximum) were similar to values found in a game. CASTAGNA *et al.* (2009) showed that the mean speed during a game of futsal is 7.26 $km.h^{-1}$ (6.30 to 8.22 $km.h^{-1}$), and heart rate 90% of maximum (84-96%). MAKAJE *et al.* (2012) found that for the majority of the game, futsal athletes remain at intensities between 5 and 7.9 $km.h^{-1}$ (26.1 ± 1.8% of the total time) and mean values of heart rate of approximately 89.8% of the maximum. Furthermore, BARBERO-ALVAREZ *et al.* (2008) also found similar values for speed and HR (7.04 $km.h^{-1}$ - range 6.16 to 8.72 $km.h^{-1}$ - and 90% of HRmax - range of 86 - 93%). Moreover, a study with Brazilian futsal players showed during official matches o first division league, the players remain most time of the match (~39%) on the velocity range between 6.1 to 12.0 $km.h^{-1}$[18]. Therefore, the results of the present study seem to reflect the mean intensities found in the game. Finally, the heart rate from the LM compared with the MLSS demonstrated no statistical differences with strong correlation, which seems to indicate that heart rate is a good parameter for intensity control on the proposed circuit. However, perceived exertion presented a significant difference between the LM vs MLSS test with a strong negative correlation. This finding may be explained by the difference in protocols. The MLSS test had a greater duration in comparison to the lactate minimum test prompting an increase in the mean perceived exertion. Therefore, perceived exertion may not be a good indicator of intensity control for the Futsal_circuit.

An interesting advance proposed by the present study was the use of the lactate minimum test (LM). It has recognized robustness and is not susceptible to significant alterations in the relative intensity of LM due to nutritional status (pre glycogen stock) (MACINTOSH *et al.*, 2002) and also ensures anaerobic (induction phase) and aerobic evaluations in only one evaluation session. Although the literature indicates that the value of the intensity relating to sLM may be dependent on the induction protocol and the initial charge of the incremental phase (CARTER *et al.*, 1999), SMITH *et al.* (2002) argue that the effect of different induction protocols that precede the incremental phase do not cause significant differences in determining the intensity of exercise corresponding to the LM. In this sense, our findings corroborate the results obtained by Smith et al. (SMITH *et al.*, 2002) who also did not find an influence of the induction protocol on sLM ($r = 0.10$ and $p = 0.82$, Re-test: $r = -0.07$ and $p = 0.87$).

The Futsal_circuit is an interesting futsal specific assessment tool, which takes into consideration the technical demands, in addition which its indices reflect mean values during the match. Moreover, it could be used to prescribe specific training (based on the physiological indices - aerobic threshold or sVO_{2Max} for example) for aerobic capacity, improving the motivation of athletes due to the ball abilities included in the test. In this direction, ZAGATTO *et al.* (2016) showed the Hoff-Test circuit is more specific than an incremental treadmill test to assess aerobic capacity with the ball in youth soccer players. Nevertheless, Since the Hoff circuit requires high technical skills, the peak speed may was limited by the inability of subjects to cover the circuit dribbling the ball (ZAGATTO *et al.*, 2016), however, more studies need to be performed. In addition, for future studies, measure the pulmonary gas exchange during the effort on the circuit to measure the energetic demands of the proposed protocol, as well as, comparison with laboratory tests will be necessary.

In conclusion, the Futsal_circuit was reliable, reproducible and valid for assessing functional aerobic capacity in futsal players. In addition, heart rate seemed to be a good indicator of intensity control for training on the circuit, however, the perceived exertion seemed not to reliably reflect the intensity of exercise.

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2º Trabalho:

TESTE ESPECÍFICO PARA O FUTSAL APRESENTA MELHOR VALIDADE ECOLÓGICA COM O JOGO DO QUE TESTE EM LABORATÓRIO PARA JOGADORES PROFISSIONAIS DE FUTSAL

Pergunta Central:

O teste de campo proposto para o futsal que possui movimentos e específicos como condução de bola e constante mudanças de direção (trabalho 1) apresenta uma melhor correlação com a demanda física em jogos simulados e oficiais quando comparados aos testes laboratoriais?

Justificativa:

Diferentemente do futebol que apresenta uma série de testes de campo com alta correlação com a demanda física durante as partidas de futebol, no futsal estas relações ainda não são claras, já que apenas CASTAGNA *et al.* (2009) tentaram verificar a relação do VO_2max com a demanda física do jogo, mas não encontraram nenhuma correlação. Portanto, nossa hipótese é que o teste de campo proposto no trabalho 1 apresenta fortes correlações com as demandas físicas do jogo de futsal.

SPECIFIC FIELD TEST FOR FUTSAL HAS BETTER ECOLOGICAL VALIDITY WITH THE MATCH THAN LABORATORY TEST IN PROFESSIONAL FUTSAL PLAYERS.

INTRODUCTION

Futsal match is characterized by intermittent efforts with high intensity and mixed energetic demands (BARBERO-ALVAREZ *et al.*, 2008; CASTAGNA *et al.*, 2009; DOGRAMAC *et al.*, 2011; DOGRAMACI *et al.*, 2011). Therefore, physiological tests are commonly used to assess training outcome and sometimes used on the training process to prescribe the load training session (IMPELLIZZERI *et al.*, 2005; DITTRICH *et al.*, 2011; BOULLOSA *et al.*, 2013; PEDRO *et al.*, 2013; SOARES-CALDEIRA *et al.*, 2014; MILOSKI *et al.*, 2016). In addition, to understand of the physical demands on the match, and the relationship with physiological profile is required to improve the training and preparation strategies during the season (CARLING *et al.*, 2008).

The parameters of endurance assessment traditionally are performed through laboratory test to assess the VO_2max (CASTAGNA *et al.*, 2007; CASTAGNA *et al.*, 2009; CASTAGNA e BARBERO ALVAREZ, 2010; DITTRICH *et al.*, 2011; PEDRO *et al.*, 2013; WILKE *et al.*, 2016), non-specific field tests (CASTAGNA *et al.*, 2007; BOULLOSA *et al.*, 2013; SOARES-CALDEIRA *et al.*, 2014) and specific field tests for futsal player (BARBERO ALVARÉZ *et al.*, 2005; ALVAREZ *et al.*, 2009; DITTRICH *et al.*, 2011). However, the specificity of the motor pattern (e.g. dribbling the ball and continuous change of directions) are not considered in these protocols, moreover, they are not attractive for athletes' evaluations (HOFF *et al.*, 2002). Based on this, BARBIERI et al (2016b), proposed a field test in a specific circuit for futsal players adapted from (HOFF *et al.*, 2002; CHAMARI *et al.*, 2005) to assess the endurance parameters, and the test presented similar results of the heart rate and velocity associated with anaerobic threshold with the values on the match BARBIERI et al. (2016b) (BARBERO-ALVAREZ *et al.*, 2008; CASTAGNA *et al.*, 2009; DOGRAMAC *et al.*, 2011; DOGRAMACI *et al.*, 2011).

Differently from futsal, on the soccer the laboratory and field tests were compared with the match physical demands (CASTAGNA e ABT, 2003; CASTAGNA *et al.*, 2010; NAZARALI *et al.*, 2013; ALPAY, 2016). CASTAGNA *et al.* (2009) proposed a simulated match to determine the match demands of professional futsal players and compare with the physiological parameters (e.g. VO_2max) assessed on the laboratory. During simulated game, players attained 75% (59–92) and 90% (84–96) of VO_2max and maximal heart rate, respectively, however, any statistical correlations were found with the physiological parameters assessed on the laboratory. Although, enhance of the level of aerobic capacity can improve the performance on the match in soccer players with higher involvement with the ball, number of sprints, and a longer distance covered during a game (WISLOEFF *et al.*, 1998; HELGERUD *et al.*, 2001), these relationships are unclear on the futsal.

Therefore, the aim of the present study was to examine the relationship between laboratory test performance and specific field test for futsal with an official and simulated matches in professional futsal players. In additional, to verify the ecological validity of the specific field test for futsal with the official match. The hypothesis of the study was the specific field test to futsal present better correlations with the match in comparison with the laboratory test.

METHODS

Experimental Approach to the Problem

Traditionally, the parameters of endurance assessment of futsal players are assessed through laboratory (CASTAGNA *et al.*, 2007; CASTAGNA *et al.*, 2009; CASTAGNA e BARBERO ALVAREZ, 2010; DITTRICH *et al.*, 2011; PEDRO *et al.*, 2013; WILKE *et al.*, 2016), however, the laboratory protocols are characterized by a continuous running on the motorized treadmill without any specificity with the motion patterns on the game, having only a diagnostic character (ZAGATTO *et al.*, 2016). Although there is some specific field test for futsal players (BARBERO ALVARÉZ *et al.*, 2005; ALVAREZ *et al.*, 2009; DITTRICH *et al.*, 2011), this test not take into account the technical demands of the match. However, a test proposed by BARBIERI et al. (2016b) respect the motor patterns of the match through the inclusion of the dribbling the ball and continuous change of directions during the assessment. Therefore, a better understand of the relationship between the laboratory test and the specific field test for futsal players with the match time-motion patterns will be a valuable information to the coaches, to assess training outcome, prescribe specific training session and monitoring the season adaptations.

Participants

Fifteen professional futsal players (age: 25.5 ± 2.2 years; body mass: 75.7 ± 8.1 kg; height: 174.4 ± 6.0 cm; lean body mass 75.6 ± 5.8 kg; 18.3 ± 3.4 %; VO_2max: 51.4 ± 3.3 $ml.kg^{-1}.min^{-1}$) affiliated to the Brazilian Confederation of Futsal were recruited. Athletes are during busy competitive period with a routine of 6 – 10 training sessions and 1-2 official game weekly. Moreover, players received recommendations from team staff (i.e., physiologist and nutritionist) to rest between the tests, keep a sleep routine (more than 8 hours per day) and follow a balanced diet. All athletes were instructed not to change their eating habits during the test period and not drink alcohol or any kind of stimulant drink. This study was approved by the Ethical Board of the of the local institute (Ref. 7828) and conducted in accordance with the Declaration of Helsinki. The athletes were informed about the risks and benefits of the experiments, and signed a free informed consent before the study.

Procedures

All tests were completed in a period of 10 days. Firstly, the players performed on the laboratory an incremental test with blood collected and expired gases collected breath-by-breath and analyzed by a ergo spirometer (Metalyzer 3B - Cortex®, Leipzig, Germany).

Subsequently an interval of 24h, a field test specific for futsal proposed by BARBIERI et al. (2016) was performed. Both tests had the rating of perceived exertion (session-RPE) through Portuguese version of rated perceived exertion CR – 10 (Borg, 1982) modified by FOSTER (1998) assessed between the steps of the tests. After 48h, the simulated match was performed and consisted of two halves of 20 min with 10 min of rest between the halves. Each half was divided in two periods of 10 min with 5 min rest between the periods. The simulated match was adapted from of CASTAGNA *et al.* (2009). Athletes played all the time (40 min) and the proposed game system and objective were the same. Then, after 72h the simulated match, an official match was played Moreover, it is important to highlight the simulated match was used to preparation for the official match of the competitive period. The matches were integrally record by a video camera for later computerized automatic tracking and time-motion analysis.

Laboratory incremental test. The incremental treadmill-running test was initiated at 10 $km.h^{-1}$ with increments of 1 $km.h^{-1}$ each 3 min, performed on a motorized treadmill (ATL, Inbramed, Porto Alegre - Brazil) at 1% of inclination until exhaustion. The oxygen uptake (VO_2) and carbon dioxide (VCO_2) production were monitored breath by breath using a ergospirometer (Metalyzer 3B - Cortex®, Leipzig, Germany). Before the beginning of the evaluation, the ergospirometer was calibrated according to the manufacturer specifications. The VO_2max was assumed as the highest VO_2 average obtained in the last 30 s of the step exercise, when at least two of the follow criteria were checked: i. VO_2 stabilization of the last two stages of exercise (range < 2.1 $mL·kg^{-1}·min^{-1}$); ii. respiratory exchange ratio (RER) > 1.1; iii. maximum HR (HR_{MAX}) > 90% of maximum heart rate predicted (HOWLEY *et al.*, 1995). The velocity corresponded to the VO_2max (vVO_2max) was assumed as the lowest speed of the incremental stages that the VO_2max was reached. The incremental protocol lasted 14.06 ± 3.45 min, achieved the time proposed by MIDGLEY et al. (2008) for precise determination of VO_2max. Blood samples was collected from the earlobe to analysis the blood lactate concentration ($[La^-]$). The points from the

[La^{-1}] of each step and intensity was adjusted by bi-segmented model and the anaerobic threshold was assumed as the intensity corresponding to the intersection of two linear regressions (PAPOTI *et al.*, 2009). Heart rate was monitored during the test using a Polar ® RS300x monitor.

Field test specific for futsal. The aerobic and anaerobic parameters were assessed through a lactate minimum (LM) -test in a specific circuit (Futsal_circuit) for the futsal proposed by BARBIERI et al. (2016b). The test was performed on the court and consisted firstly of a specific induction of acidosis through to the Running-based Anaerobic Sprint Test (RAST) (ZACHAROGIANNIS *et al.*, 2004; ZAGATTO *et al.*, 2009; ANDRADE *et al.*, 2013; DE ARAUJO *et al.* 2014), and eight minutes after the specific induction of acidosis, it was started an progressive bouts on the Futsal_circuit with an initial intensity of 6.0 $km.h^{-1}$ and increasing 1.0 $km.h^{-1}$ each three laps on the circuit until the exhaustion of the player. During all progressive bouts the athletes need to dribbling the ball. Test was interrupted when the athlete cannot sustain the intensity or the participant committed three consecutive errors, such as not arriving with the ball in the corresponding beep demarcations, running an incorrect route or losing control of the ball and not recovering the pace. Blood samples (25µL earlobe) were collected 3, 5 and 7 minutes after the RAST and at the end of each step on the progressive phase loads to assess the blood lactate concentration. Heart rate was monitored during the test using a Polar ® RS300x monitor (Polar® Electro Oy). The RAST parameters was calculated based on the studies of ANDRADE *et al.* (2013) and ZAGATTO *et al.* (2009).

Automatic tracking. Two video cameras (SONY® DCD-SR21) adjusted to a frequency of 30 Hz were allocated at highest points of the gym to recorded integrally by three digital the matches. The kinematic procedures (synchronization, calibration, tracking and 2-D reconstruction) (FIGUEROA *et al.*, 2006) was performed through DVIDEOW® software (BARROS *et al.*, 2007; DE OLIVEIRA BUENO *et al.*, 2014; VIEIRA *et al.*, 2016). The coordinate values were subsequently filtered by Butterworth filter 3rd order, adopting a cutoff frequency of 0.4 Hz (DE OLIVEIRA BUENO et al., 2014). Using specific algorithms to MATLAB® (The Math Works Inc., Natick, MA, USA) were individually calculated the time-motion patterns: distance covered, distance per minute, peak of velocity, velocity mean, number of sprints and percentage distance covered in high intensity (above 15.5 $km.h^{-1}$).

Statistical analyses

Results are presented as mean ± standard deviation. The normality was verified by Shapiro-Wilk test. Differences on the time-motion patterns between Simulated and official match was analyzed using Independent-measures t-test. Differences between first and second half on the match and laboratory test vs field test were analyzed by paired t-test. The effect size (ES) of the difference between variables was calculated according (HOPKINS, 2000) and classified as negligible (<0.35), small (0.35 to 0.79), moderate (0.80 - 1.5) and large (> 1.5). Relationships between variables were assessed using Pearson's product moment correlation and classified as very weak to negligible (0.0–0.2), weak (0.2–0.4), moderate (0.4–0.7), strong (0.7–0.9) and very strong (0.9–1.0) (ROWNTREE, 1987). In all cases the level of significance was $p < 0.05$.

RESULTS

During the laboratory test the players archived significantly higher values ($p < 0.05$) to intensity of anaerobic threshold (AT) and velocity corresponded to the VO_2max (vVO_2max) than on the field test, and low values to peak blood lactate concentration. Moreover, heart rate and RPE correspondent to AT and vVO_2max was not different between the laboratory and field test (Table 1).

Table 1. Mean, SD, coefficient of variation (CV) and effect size (EF) of the parameters from the incremental test on the laboratory and the lactate minimum test on the Futsal_circuit (field test). (n=10).

	Laboratory test	***Field test***	***CV %***	***EF***
AT (km.h^{-1})	*13.2±1.2*	*8.2±0.6**	*8.61*	*5.4*
Peak [La$^-$] (mmol.dL^{-1})	*6.1±1.3*	*8.1±1.8**	*73.95*	*1.4*
vVO$_2$max (Km.h^{-1})	*14.9±1.1*	*9.6±0.7**	*7.24*	*5.6*
HR AT (BPM) (Km.h^{-1})	*175.6±5.1*	*178.3±6.1*	*36.61*	*0.6*
HR Max (BPM)	*188.0±11.3*	*190±8.8*	*46.44*	*0.2*
RPE AT (a.u.)	*5.3±2.2*	*5.8±1.3*	*71.3*	*0.5*
RPE Max (a.u.)	*10.0±0.1*	*9.6±1.1*	*10.8*	*0.7*
VO$_2$max (mL.kg.min^{-1})	*51.4±3.3*	-	-	-

*AT: Anaerobic Threshold; Peak [La$^-$]: peak blood lactate concentration; vVO$_2$max: velocity corresponded to the VO$_2$max HR: Heart rate; RPE rated perceived exertion. * different from laboratory test ($p < 0.05$).*

In addition, the vVO$_2$max assessed on the laboratory showed a strong correlation with intensity of anaerobic threshold (AT) on the field test (r=0.86; p = 0.01). In addition, the Players on the Running-based Anaerobic Sprint Test (RAST) (specific induction of acidosis) archived a peak and mean power of 10.6 ± 1.6 and 8.5 ± 1.0 W.kg^{-1}, with a peak and mean velocity of 7.2 ± 0.4 and 6.6 ± 0.2 m.s^{-1}.

On the simulated match, players covered higher distance in comparison to official match (36.7%, $p < 0.01$). Moreover, the simulated match showed significantly higher values to peak velocity, numbers of sprints and percentage of distance covered above 15.5 km.h^{-1} than official match ($p < 0.05$) (table 2). The participation time of the players on the simulated and official match was 38.9 ± 0.1 min and 31.7 ± 16.6 min respectively. The mean velocity was not different between the matches (Table 2). Moreover, during the second half on the simulated match the players covered significantly less distance (-6.6%, p = 0.01). However, during the second half on the official match the players covered significantly high distance (35.4% p = 0.03).

Table 2. Mean and SD of the time-motion patterns on the simulated and official match.

	Simulated match (n=10)			Official match (n=13)		
	1st	2nd	Total	1st	2nd	Total
Distance (m)	1986±74	1856±130+	3843±200	1358±696*	1840±664+	2810±1501*
Vpeak ($km.h^{-1}$)	28.4±2.1	29.9±5.0	31.5±3.6	26.7±5.0	26.3±2.8	27.5±4.3*
Vmean ($km.h^{-1}$)	6.1±0.2	5.7±0.4+	5.9±0.3	5.7±1.6	5.5±1.7	5.4±1.7
NS (a.u.)	20.1±6.0	17.2±7.2	37.3±10.2	11.8±8.8*	16.2±7.1	24.6±16.5*
% above 15.5 $km.h^{-1}$	13.5±2.9	19.3±2.2+	32.8±3.9	12.2±5.8	13.0±6.1*	22.3±12.7*

Distance (m): distance covered in meters; Distance ($m.min^{-1}$): distance per minute; Vpeak: peak of velocity on the match; Vmean: velocity mean on the match; NS: number of sprints; % above 15.5 $km.h^{-1}$: percentage distance covered in high intensity. * different from simulated match ($p < 0.05$). + different from 1st half ($p < 0.05$).

When compared the time-motion patterns of the simulated match with the tests was found a strong correlation ($p < 0.05$) of the vVO_2max on the field test with number of sprints on the first half and percentage distance covered in high intensity (above 15.5 $km.h^{-1}$**).** The laboratory test showed a moderate correlation of the VO_2max index with the number of sprints on the first half and on the whole match and percentage distance covered in high intensity on the second half and on the whole match (Table 3). Moreover, the RAST index (Peak power, mean power, Peak velocity and mean velocity) showed strong correlations with peak velocity on the first half (0.76, 0.85, 0.77 and 0.85 respectively; $p < 0.05$).

Table 3. Correlation matrix of the relationship between field and laboratory tests and simulated match activities (n=10). (*$p < 0.05$).

Simulated match	Field test vVO_2max ($km.h^{-1}$)	Laboratory test VO_2max ($mL.kg.min^{-1}$)
NS - 1st	0.37	0.67*
NS - 2nd	0.73*	0.34
NS - Total	0.71	0.64*
% above 15.5 $km.h^{-1}$ - 1st	0.74*	0.62
% above 15.5 $km.h^{-1}$ – 2nd	0.37	0.65*
% above 15.5 $km.h^{-1}$ - Total	0.56	0.70*

NS: number of sprints; % above 15.5 $km.h^{-}1$: percentage distance covered in high intensity; vVO_2max: velocity corresponded to the VO_2max.

The intensity parameters (AT, peak blood lactate concentration and vVO_2max: velocity corresponded to the VO_2max) related to the field test showed significantly strong correlation ($p < 0.05$) with several time-motion patterns of the official match. The parameters from the laboratory test showed significantly strong correlation ($p < 0.05$) with several time-motion patterns of the official match (Table 4). Moreover, the Peak and mean power showed a strong correlation with peak power on the first half (0.77 and 0.82 respectively; $p < 0.01$), second half (0.72 and 0.84 respectively; $p < 0.05$), on the whole match (0.67 and 0.70 respectively; $p < 0.01$) and moderate correlations with the number of sprints on the first half (0.69 and 0.68 respectively; $p < 0.05$). In addition, the peak and mean velocity showed strong correlation with peak power on the first half (0.77 and 0.81 respectively; $p < 0.01$), second half (0.67 and 0.72 respectively; $p < 0.01$), on the whole match (0.73 and 0.85 respectively; $p < 0.01$) and moderate correlations with the number of sprints on the first half (0.69 and 0.67 respectively; $p < 0.05$).

Table 4. Correlation matrix of the relationship between field and laboratory tests and official match activities (n=13). (*$p < 0.05$).

Official match	Field test AT ($km.h^{-1}$)	Field test Peak [La^-]	Field test vVO_2max ($km.h^{-1}$)	Laboratory test AT ($km.h^{-1}$)	Laboratory test Peak [La^-]	Laboratory test vVO_2max ($km.h^{-1}$)	Laboratory test VO_2max ($mL.kg.min^{-1}$)
Distance (m) - 1st	0.37	-0.62	0.27	0.65	-0.64	0.66	0.69*
Distance (m) - 2nd	-0.20	-0.72*	-0.24	0.10	-57	0.09	0.19
Distance (m) - Total	0.19	-0.71*	0.08	0.52	-0.81*	0.62	0.54
Vpeak ($km.h^{-1}$) - 1st	0.45	-0.03	0.28	0.64	-0.26	0.52	0.90*
Vpeak ($km.h^{-1}$) - 2nd	0.72*	-0.37	0.56	0.35	-0.54	0.70	0.69
Vpeak ($km.h^{-1}$) - Total	0.57	-0.14	0.34	0.77*	-0.24	0.68*	0.87*
Vmean ($km.h^{-1}$) - 1st	0.44	0.28	0.71*	0.37	-0.46	0.30	0.90*
Vmean ($km.h^{-1}$) - 2nd	0.48	0.19	0.74*	-0.03	-0.52	-0.09	0.92*
Vmean ($km.h^{-1}$) - Total	0.48	0.22	0.74*	0.36	-0.46	0.31	0.91*
NS - 1st	0.84*	-0.25	0.74*	0.73*	-0.48	0.68*	0.85*
NS - 2nd	0.64	-0.54	0.74*	0.19	-0.49	0.12	0.84*
NS - Total	0.81*	-0.39	0.76*	0.59	-0.68	0.62	0.81*
% above 15.5 $km.h^{-1}$ - 1st	0.65*	0.09	0.64*	0.15	-0.35	0.02	0.81*
% above 15.5 $km.h^{-1}$ - 2nd	0.56	0.26	0.59	0.52	-0.07	0.38	0.79*
% above 15.5 $km.h^{-1}$ - Total	0.66*	0.22	0.66*	0.41	-0.19	0.26	0.78*

Distance (m): distance covered in meters; Distance ($m.min^{-1}$): distance per minute; Vpeak: peak of velocity on the match; Vmean: velocity mean on the match; NS: number of sprints; % above 15.5 $km.h^{-1}$: percentage distance covered in high intensity; AT: Anaerobic Threshold; Peak [La^-]: peak blood lactate concentration; vVO_2max: velocity corresponded to the VO_2max.

DISCUSSION

This is the first study with futsal to compare the simulated with the official match and verify the relationship between laboratorial and field specific tests with the matches. The main finding of this study were the parameters from laboratory and specific field test to futsal showed significantly strong to very-strong correlations (see tables 3 and 4) with several physical index from the official match. On the other hand, the tests (laboratory and field) showed few correlations with the simulated match. In addition, VO_2max was the index from the laboratory test that presented more correlation with the simulated and official matches, while, the velocity corresponded to the VO_2max and anaerobic threshold on the field test showed several correlations with the time-motion partners of the matches confirming the ecological validity. Furthermore, the time-motion patterns between the simulated and official match were different to distance covered, peak velocity and high intensity activities (number of sprints and percentage of the distance covered in intensity above 15.5 $km.h^{-1}$ – see table 2).

The simulated match was adapted from CASTAGNA *et al.* (2009), however, the present study showed lower distance covered on match than on the study of CASTAGNA *et al.* (2009). The model of simulated futsal matches with four bouts of 10 min each, interspersed with 5-min recovery periods are not in accordance with official futsal rules and may favoring the players to archived a higher intensity on the activities because of the shorter work periods, which allows them to cover greater distances (DE OLIVEIRA BUENO *et al.*, 2014). Based on this, the players on the simulated matches proposed by CASTAGNA *et al.* (2009), DOGRAMACI *et al.* (2011) and MAKAJE *et al.* (2012) covered higher distance (~4840.0 m, 4277.0 ± 1030.0 m and 5087.0 ± 1104.0 m respectively) than on the matches on the present study (simulated: 3843±200 m; official: 2810±1501 m). Although, the results on the present study are in concordance with found in official matches with Brazilian professional futsal players (~94.1 $m.min^{-1}$; 3133.2 m) (DE OLIVEIRA BUENO *et al.*, 2014). Conversely, when compared the results of Brazilian players in official match with the Spanish professional players (BARBERO-ALVAREZ *et al.*, 2008), the Brazilian players covered lower distances (Spanish: 4313.2 ± 2138.6 m). This difference may be explaining since the Brazilian players reported low performance in field tests (Yo-Yo Intermittent Recovery Test) compared with European Players (DE OLIVEIRA BUENO *et al.*, 2014; SOARES-CALDEIRA *et al.*, 2014).

The anaerobic threshold, vVO_2max and peak blood lactate concentration (Peak $[La^-]$) were significantly different ($p < 0.05$) between the field and laboratory test. Differently from the field test that was performed on a specific circuit for futsal that imposed a technical demand (dribbling the ball) and continuous changes of direction, the laboratory test is characterized by a continuous running on the motorized treadmill without any specificity with the motion patterns on the match. In this direction, for soccer player the Hoff test showed to be more specific than an incremental treadmill test to assess endurance with the ball in youth soccer players (ZAGATTO *et al.*, 2016). The authors suggested the proposed test may be used in soccer since it respects the sport specificity and takes into account the technical demands of football (ZAGATTO *et al.*, 2016). The specific field test to futsal (BARBIERI et al. 2016b) was adapted from the Hoff test for soccer (HOFF *et al.*, 2002) and BARBIERI et al. (2016b) showed similar results to anaerobic threshold (7.43 to 7.75 $km.h^{-1}$ and HR between 93-94% of maximum) with the present study (6.85 to 9.22 $km.h^{-1}$ and HR ~ 95% of maximum), and these results were similar to values found during a game (BARBERO-ALVAREZ *et al.*, 2008; CASTAGNA *et al.*, 2009; MAKAJE *et al.*, 2012).

For the simulated match, the vVO_2max on the field test showed strong correlations with the number of sprints and percentage of the distance covered in high intensity (% above 15.5 $km.h^{-1}$**)** (r= 0.73 and 0.74; $p < 0.05$) on the first half. The VO_2max on the laboratory test had moderate correlations ($p < 0.05$) with number of sprints and percentage of the distance covered in high intensity. These results demonstrate the laboratory and field test is related to physical match performance in high performance on the simulated match, and this models of simulated matches are commonly used during the training programs (WILKE *et al.*, 2016). Instead, the parameters from the field test showed strong correlations with the official match, especially the velocity correspondent to the anaerobic threshold and the vVO_2max with the distance covered per minute and the high intensity time-motion patterns. In addition, vVO_2max on the field test showed strong correlations with the distance covered per minute on the match.

Moreover, the laboratory test had few correlations between the velocity correspondent to anaerobic threshold and vVO_2max with the time-motion partners on the match. However, the VO_2max index presented strong to very-strong correlations with distance covered and high intensity time-motion partners ($p < 0.05$). in contrast our findings, CASTAGNA *et al.* (2009) did not find any correlations between the simulated match and physiological variables to futsal players. PEDRO *et al.* (2013) with futsal players, indicated the intensity associate with VO_2max and ventilatory threshold during the assessment of cardiorespiratory fitness of futsal players should be considered because it is a able tool to discriminate the competitive level of futsal players, whereas the VO_2max was not. Furthermore, the use of laboratory evaluations for soccer players should have a diagnostic character, since they do not seem to be accurate for training prescription (ZAGATTO *et al.*, 2016). However, any of these studies (PEDRO *et al.*, 2013; ZAGATTO *et al.*, 2016) evaluated the potential relationships among cardiorespiratory variables running treadmill speeds and the field test with the match activities of elite and sub elite futsal players. Therefore, this is the first study in the futsal to evaluated the relationships of the field and laboratory tests with the simulated (training) and official match.

An understanding of the physical demands through information on player work rates of the players is required so that optimal training and preparation strategies can be constructed (CARLING *et al.*, 2008). Therefore, Since the field specific test for futsal had strong correlations of the velocity associate with VO_2max and anaerobic threshold with the matches indicating a support to the ecological validity of the proposed test. In addition, to assess the physiological parameters of professional futsal players through laboratory or specific field tests showed strong correlation with the time-motion partner. However, since the laboratory test has an unspecific motion partner with the match, and the best parameter from the laboratory test associated with the match was the VO_2max index, and this parameter do not have accurate for training prescription on the field (ZAGATTO *et al.*, 2016), thus, to assess the physiological parameters on the laboratory has only a diagnostic character (ZAGATTO *et al.*, 2016). However, the parameters from the specific field test for futsal players takes into consideration the technical demands (dribbling ball) and his indexes are correlations with the match. In addition, since the field test protocol used on the present study need a specific induction of acidosis before the incremental bouts of the test, and this induction was performed through Running-based Anaerobic

Sprint Test (RAST), test commonly applied on the sport (ZAGATTO *et al.*, 2009; ANDRADE *et al.*, 2013; DE ARAUJO *et al.*, 2014; BARBIERI *et al.*, 2016a; BARBIERI et al. 2016b), this test gave a evaluate the anaerobic power. Therefore, these index from the RAST (Peak and mean power and velocity on the 35 meters) showed strong correlations with the peak power on the match and number of sprints on the first half ($p < 0.05$), indicating a greater advantage of the field test on the laboratory tests.

In Conclusion, the laboratory and field specific futsal test showed strongly correlations with the time-motion partners and seems to reflect the physical performance of the match, however, since the field test was performed on the game area with technical demands (dribbling ball) and continuous changes of direction, to prescribe the training in the specific circuit for futsal based on the velocity associate with the VO_2max and/or anaerobic threshold could be a good strategy to improve the aerobic performance in specific way. Furthermore, the specific field has an ecological validity with the match.

PRACTICAL APPLICATIONS

The laboratory and field test present a good correlation with the match. However, physiological parameters (in specially VO_2max) assessed through laboratory do not have accurate for training prescription of the training session, thus, it can be considerate only a diagnostic character. However, the parameters from the specific field test for futsal showed a good ecological validity and can be used to prescribe specific training during the season on the different zones of intensity based on the physiological indices (anaerobic threshold or vVO_2max). Moreover, the field test can improve the motivation of athletes due to ball abilities is include during in the test and this could be a good factor during the training session on the Futsal_circuit.

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3º Trabalho:

CARGA INTERNA DE TREINAMENTO, PARÂMETROS FÍSICOS E BIOQUÍMICOS APRESENTAM RESPOSTAS DIFERENTES ENTRE A PRÉ-TEMPORADA E PERÍODO COMPETITIVO EM JOGADORES DE FUTSAL PROFISSIONAIS

Pergunta Central:

Qual é a relação entre as alterações dos parâmetros neuromusculares, bioquímicos, hematológicos, hormonais e de performance aeróbia e anaeróbia com a distribuição da carga interna da pré-temporada e durante o período competitivo?

Justificativa:

Apesar de existir um grande número de estudos que verificaram a relação da carga interna no treinamento de futsal com algum parâmetro fisiológico (NAKAMURA *et al.*, 2010; MOREIRA *et al.*, 2011; BARBIERI *et al.*, 2012; DE MOURA *et al.*, 2012; ARRUDA *et al.*, 2013; DE MOURA *et al.*, 2013; MOREIRA *et al.*, 2013; OLIVEIRA *et al.*, 2013; ÁLVAREZ-MEDINA *et al.*, 2014; DE OLIVEIRA BUENO *et al.*, 2014; MILANEZ *et al.*, 2014; MILOSKI *et al.*, 2014; NAKAMURA *et al.*, 2015; ARRUDA *et al.*, 2016; MILOSKI *et al.*, 2016), a maioria deles teve como objetivo verificar a sensibilidade do método, e não necessariamente a relação entre a carga interna e a adaptação fisiológica dos atletas de futsal.

INTERNAL TRAINING LOAD, PHYSICAL AND BIOCHEMICAL PARAMETERS SHOW DIFFERENT RESPONSES BETWEEN PRE-SEASON AND COMPETITIVE PERIOD IN PROFESSIONAL FUTSAL PLAYERS.

Introduction

Specifics periods of training like pre-season has an important role on the preparation of athletes, once, this period usually focuses on the rebuilding of fitness in players following the off-season and develop fitness in preparation for the impending competition season (WILLOUGHBY, 1993; GAMBLE, 2006; JEONG *et al.*, 2011).

Training variation is increasingly acknowledged as serving a key function in successful training prescriptions (WILLOUGHBY, 1993; GAMBLE, 2006), and the aim of in-season training is focused on the maintenance of the specific capacities developed during pre-season (WILLOUGHBY, 1993; GAMBLE, 2006; JEONG *et al.*, 2011). Moreover, the playoffs period (in-season) is the period that will define the success of the training program.

However, a common problem for coaches is to prescribe the appropriated training loads during the preparation and competition phase of the season (KELLY e COUTTS, 2007), as known, the number of training sessions and intensity may affect the perception of effort by the players and thereafter modulate the physical adaptations (IMPELLIZZERI *et al.*, 2004; MILANEZ *et al.*, 2011; SOARES-CALDEIRA *et al.*, 2014; MILOSKI *et al.*, 2016).

The session rating of perceived exertion (i.e. session-RPE) has been demonstrated to be a simple and practical method for quantifying internal training load (TL) in team sports (FOSTER, 1998; IMPELLIZZERI *et al.*, 2005), since the knowledge of how TLs are distributed into specific cycles throughout an entire season considering magnitude, purposes and how the training-induced responses related to the adopted strategies can be the key to the success of training planning (IMPELLIZZERI *et al.*, 2005; MILOSKI *et al.*, 2016).

This approach may provide objective data to help coaches evaluate implementation of the training program on a daily basis and decision-making processes (MILOSKI *et al.*, 2016). Some studies verified the dose-response relationship between training load and stress markers (MOREIRA *et al.*, 2011; MILANEZ *et al.*, 2014; MILOSKI *et al.*, 2016), heart rate variability (OLIVEIRA *et al.*, 2013; NAKAMURA, PEREIRA, RABELO, FLATT*, et al.*, 2016) and physical fitness parameters (BOULLOSA *et al.*, 2013; SOARES-CALDEIRA *et al.*, 2014; MILOSKI *et al.*, 2016) during the pre-season and/or competitive period. However, the main focus of these studies were only test the methods application during the pre-season and/or competitive period.

Based on this, the aim of present study was to clarify the responses of the pre-season and the last phase of the competitive period on internal training load, body composition, neuromuscular, hematologic, biochemical, hormonal, anaerobic and aerobic parameters. Since the pre-season and competitive period have different objectives, the present study was divided in two parts (Study A – pre-season; Study B – last phase of the competitive period). Our hypotheses were the pre-season is enough to enhance the performance of the athletes with a maintenance during competitive period, however with a reduction on the biochemical parameters during the playoffs.

Methods

study design

The Brazilian competitive calendar start in March with regional championships, state and national futsal league which last until the beginning of December. Therefore, this study recruited professional futsal players of club affiliated to the Brazilian Confederation of Futsal to monitoring the body composition, neuromuscular, hematologic, biochemical, hormonal, aerobic and anaerobic parameters during the pre-season (first 3 weeks of the season – study A) and the last phase on the competitive period (last 6 weeks of the season – study B). During all assessments (study A and B), on the first day of each assessment, blood samples were collected to the hematologic, biochemical and hormonal analysis, and in the afternoon, body composition parameters were assessed. The second assessment day (Tuesday), firstly neuromuscular parameters by three maximal voluntary isometric contraction (MVC) were assessed, and in sequence, the aerobic and anaerobic parameters were assessed through a lactate minimum test in a specific circuit for the futsal. Training program (see figure 1 and 2) was prescribed by coaches without any interference of the researchers, and the player’s internal load was quantified using the session rating of perceived exertion (session-RPE) through Portuguese version of rated perceived exertion CR – 10 (Borg, 1982) modified by Foster et al. (2001). Players were instructed to not to ingest alcohol or caffeine for 24 hours before the days corresponding to tests assessments.

Subjects

Twenty-eight professional futsal players were recruited and divided in two studies, study A (pre-season) and B (competitive period). However, to the analysis of the studies were included only the players participated on the assessments and attended at least 75% of monitored training sessions during the study period. Therefore, to the study A was recruited fourteen players, however, the analysis was based on the remaining twelve players (3 goalkeepers, 2 defenders, 5 wings and 2 pivots; age: 22 ± 2 years; height: 173 ± 7 cm; Weight: 76.3 ±8.9 kg). To the Study B was recruited fourteen players, however, the analysis was based on the remaining eleven players (2 goalkeepers, 2 defenders, 5 wings and 2 pivots; age: 23 ± 1 years; height: 173 ± 6 cm; Weight: 75.1 ±8.6 kg). Moreover, players of both studies received recommendations from team staff (i.e., physiologist and nutritionist) to rest between the training sessions, keep a sleep routine (more than 8 hours per day) and follow a balanced diet.

This study was approved by the Ethical Board of the of the Institute of Biosciences of the São Paulo state University (Ref. 7828) and conducted in accordance with the Declaration of Helsinki. The athletes were informed about the risks and benefits of the experiments, and signed a free informed consent before the study.

Body composition parameters

For the body composition, the Dual-energy x-ray absorptiometry scan using Lunar – DPX-NT Medical Systems hardware (DEXA) was used for the measurement of whole and regional body composition, including a three compartment model estimating body composition in terms of fat, bone mineral, and all other fat-free mass that does not include bone. The subjects were laid in a supine position on the scanner table, with straight-legs and their arms close to the body positioned for whole-body scans according to the manufacturer’s protocol.

Neuromuscular parameters

Athletes were positioned in a chair designed to maintaining knee and hip flexion at 90º specifically to performing the three maximal isometric voluntary contractions (MVC) of 5 s length and 1 min interval between them. An inextensible steel wire was attached to a Velcro strap coupled to the ankle of the dominant leg, pierced by a pulley with negligible resistance and connected to a load cell (Miotec® - Porto Alegre - Brazil) with sample rate 1000 Hz, positioned at the back of the chair seat, so that the wire assumed a 90° angle between the participant ankle and the load cell. The signal from the load cell was digitally filtered by a fourth-order Butterworth filter with 15 Hz cutoff frequency, assumed after residue analysis of the signal. The mean and peak force was calculated, which, peak force was assumed as the mean of 100 ms of the force plateau. To EMG data acquisition, the electrode placement sites were shaved and cleaned by abrasion with fine sandpaper and alcohol 70% at the anatomical point of the vastus lateralis and biceps femoris muscles and demarcated with specific pen (SENIAM, 1999). The data was collected through of Miotool 400 (Miotec® - Porto Alegre - Brazil) and bipolar electrodes of Ag/AgCl (diameter: 1 cm and Centre-to-Centre distance: 3 cm; 3M® - São José do Rio Preto - Brazil) was aligned with the muscle fibers and positioned at distance of 3 cm center to center. The EMG signal was acquired using a sample rate of 2000 Hz, an amplifier gain of 1000 X and a band pass filter of 20-500 Hz. The Root Mean Square (RMS) and mean power frequency (MPF) of the 1-s force plateau, force impulse and the rate of force development of 50ms were calculated. Moreover, the co-activation ratio between vastus lateralis and biceps femoris was calculated divided the RMS of biceps femoris by the RMS of vastus laterais.

Blood parameters

For all assessments, blood samples were collected after 48h of rest (Monday morning around 8 a.m.) in fasting state (twelve hours) from an antecubital vein using vacutainer tubes (Vacutainer Becton Dickinson Company, Plymouth, UK) to analyze the complete blood cell count (Flow Cytometer for Blood Cell Counting - BD Accuri C6 Plus New Jersey, USA); , c-reactive protein, creatine kinase, creatinine, urea, lactate-acid dehydrogenase (UV kinetic method – BeckmanCoulter, Brea, CA, USA), cortisol, testosterone (radioimmunoassay and chemiluminescence methods - Beckman Coulter respectively) and the testosterone / cortisol ratio. All procedures were performed in a laboratory with a quality system certified.

Lactate minimum test

The aerobic and anaerobic parameters were assessed through a lactate minimum (LM) test in a specific circuit (Futsal_circuit) for the futsal proposed by BARBIERI et al. (2016a).The test consisted firstly of a specific induction of acidosis through to the Running-based Anaerobic Sprint Test (RAST) (ZACHAROGIANNIS *et al.*, 2004; ZAGATTO *et al.*, 2009; ANDRADE *et al.*, 2013; DE ARAUJO *et al.*, 2014), and eight minutes after the specific induction of acidosis, the progressive phase loads on the Futsal_circuit was started with an initial intensity of 6.0 $km.h^{-1}$ and increasing 1.0 $km.h^{-1}$ each three laps on the circuit until exhaustion. Test was interrupted when the athlete cannot sustain the intensity or the participant committed three consecutive errors, such as not arriving with the ball in the corresponding beep demarcations, running an incorrect route or losing control of the ball and not recovering the pace. Blood samples (25µL earlobe) were collected 3, 5 and 7 minutes after the RAST and at the end of each step on the progressive phase loads to assess the blood lactate concentration. Heart rate was monitored during the test using a Polar ® RS300x monitor (Polar® Electro Oy). The RAST parameters was calculated based on the studies from ANDRADE *et al.* (2013) and ZAGATTO *et al.* (2009).

Training program

The training program (study A and B) was composed of static flexibility (Flex 1), dynamic training flexibility (Flex 2), moderate intensity domain (AT1) (~70% of maximal heart rate), heavy intensity domain (AT 2) (above 90% of maximal heart rate), sprint training (Sprint), defense systems (Tactical 1), attacking systems (Tactical 2), attack with goalkeeper (Tactical 3), technical training (Technical), resistance strength (ST 1), explosive strength (ST 2), Core, simulated match (s-match), official match (match) and friendly match.

Study A. Pre-season was comprised of 3 weeks with 20 days of training with two sessions each day which one in the morning and other in the final of the afternoon (Table 1). In total, the pre-season had 32 sessions distributed during 17 days of training (included 1 friendly match) and 3 days-off. The training program was divided in 3 mesocycles, which the first mesocycle was composed by six days of training and the others composed by seven days of training.

Table 1. Training program overview of the study A during the 3-week pre-season.

Week		Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
1	**Morning**	**Assessment (Pre)**	**Assessment (Pre)**	Flex1/Core Flex 2 / Agility	Coordination / ST 1	Flex1/ Core Flex 2 / Agility	Coordination / ST 1	
	Afternoon	**Assessment (Pre)**	Flex1/ Coordination / ST 1	Flex1/ AT1 and AT2	Technical / Tactical 1	Flex1/ AT1 / AT2	Technical / Tactical 1	
2	**Morning**		Coordination / ST 1	ST1 / Agility	Flex 1 / Core / AT1 and AT2	Flex1/Core Flex 2 / Agility	Coordination / ST 2	
	Afternoon	Flex1/Core /Flex 2 / Agility	Flex1/Core /s-Match	Tactical 1 / Tactical 2	Flex 2 / Coordination Tactical 2	**Friendly Match**	Technical / Tactical 2	
3	**Morning**	Flex1/Core /Flex 2 / Sprint	Coordination / ST 2 / Tactical 2	Flex1/Core /Flex 2 / Sprint	Coordination / ST 2 / Sprint	Flex1/Core /Flex 2 / Sprint / AT1	Coordination / ST 2 / Tactical 3	
	Afternoon	Flex1/s-Match / Flex 2	Flex1/Core Flex 2 /AT 2	Technical / Agility /Tactical 3	Tactical 2 / s-Match	Tactical 1 / Tactical 2	Tactical 1 / Tactical 2 / -s-Match	
4	**Morning**	**Assessment (Post)**	**Assessment (Post)**	**Start Competitive Season**				
	Afternoon	**Assessment (Post)**						

Study B. Competitive period was collected during the final of the competitive period comprised the playoffs matches. Therefore, this period composed of 41 days of training and 13 competitive matches (two playoff matches) based on the competitive calendar (Table 2). In total, the competitive period had 38 sessions, 13 competitive matches distributed during 32 days of training (included the 13 official matches) and 9 days-off. The training program was divided in 6 mesocycles, which the first mesocycle was composed by six days of training and the others composed by seven days of training.

Table 2. Training program overview of the study B during the 6-week competitive period.

Week		Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
1	**Morning**	**Assessment (Pre)**	**Assessment (Pre)**	Flexibility /Tactical	Flexibility / Coordination	Flexibility / Core / s-match		
	Afternoon	**Assessment (Pre)**	Aerobic / Tactical	**Match (Home)**	Tactical		**Match (out)**	
2	**Morning**	Flexibility / Core / Sprint	Coordination /Muscular Strength / Sprint	Tactical	Flexibility / Core / Sprint			
	Afternoon	Technical / Tactical	Tactical / s-match	**Match (Home)**	Tactical		**Match (out)**	
3	**Morning**	Tactical / s-match	Coordination/ Muscular Strength	Tactical / s-match	Flexibility / Coordination	Coordination/ Muscular Strength	Flexibility / Coordination	
	Afternoon	**Match (Home)**	Flexibility / Aerobic	Tactical s-match	**Match (Home)**	Tactical	**Match (out)**	
4	**Morning**	Muscular Strength / Sprint	Flexibility / Core Aerobic	Tactical	Coordination/ Muscular Strength	s-match		
	Afternoon	Flexibility / s-match	Coordination/Muscular Strength/ Tactical	Technical / Tactical		**Match (out)**	**Match (out)**	
5	**Morning**	Tactical / s-match	Coordination/ Muscular Strength	Flexibility / Core / Sprint	Tactical / s-match	S-match		
	Afternoon	**Match (Home)**	Technical / Tactical	Core / Tactical			**Match (Home)**	
6	**Morning**	Tactical	Tactical / s-match					
	Afternoon			**Playoff Match (out)**		**Playoff Match (Home)**		
7	**Morning**	**Assessment (Post)**	**Assessment (Post)**	**End Competitive Season**				
	Afternoon	**Assessment (Post)**						

Quantification of training load

Training load for each session on the both studies (A and B) were calculated using the session-RPE method in accordance with previous work on futsal (MOREIRA *et al.*, 2013; OLIVEIRA *et al.*, 2013; MILANEZ *et al.*, 2014; SOARES-CALDEIRA *et al.*, 2014; MILOSKI *et al.*, 2016; NAKAMURA, PEREIRA, RABELO, RAMIREZ-CAMPILLO*, et al.*, 2016) for each player. This method consisted multiplying the training duration in minutes by the training intensity that was measured through rated perceived exertion CR – 10 (BORG, 1982) modified by Foster (FOSTER, 1998). Thirty minutes after each session the players were asked "How intense was your session?" and were requested to make certain that their RPE referred to the intensity of the whole session rather than to the most recent exercise intensity. The players were familiarized with the scale, the data were collected individually and they did not have access to either the training load intended by the coach nor the perceived exertion of their teammates, avoiding an interference of the training intensity judgment. The parameters of internal load training were calculated following the instructions of FOSTER *et al.* (2001), therefore, the load training was calculated multiplying the RPE score for the total duration of the session by minutes (including warm-up, cold-down and the pauses between efforts). Monotony was calculated divided the average of the sessions of the week by their standard derivation. Strain was calculated multiplying the monotony by the sum of the loads training on the week.

Statistical analysis

For the study A and B the same statistical analysis was performed. The distribution and homogeneity of the data were analyzed by Shapiro-Wilk's and Levene's tests respectively. All variables are presented as mean ± standard deviation (SD). Furthermore, percentage of change (Δ%) taking into account the relative change between pre and post of the period investigated (3-week pre-season and 6-week competitive period) was calculated. All the variables pre and post the pre-season (study A) and competitive period (study B) were compared by the dependent student's t-test for paired samples. The load training over the weeks on the studies A and B were compared by means of repeated measures analysis of variance (ANOVA). Post-hoc analyses were carried out using Bonferroni test. The correlation between the delta of variation of all variables and training load variables was verified by the Pearson Correlation test. In all cases the level of significance was $p < 0.05$.

Results

Study A.

Training load. Intensity, volume, overall training load, monotony and strain on the 3-week pre-season were 4.4 ± 0.2 a.u., 658.8 ± 17.4 min, 8038.8.2±1124.1 a.u., 1.7 ± 0.1 a.u. and 4954.9 ± 160.9 a.u. respectively (figure 1). The mean weekly training intensity was 4.5 ± 0.3, 4.6 ± 0.4 and 4.0 ± 0.4 a.u. respectively, with a significantly reduction of the intensity on the third mesocycle (week 3). The weekly accumulated training load (TL) between the weeks was respectively 2514.6 ± 146.1, 2963.8 ± 265.1 and 2947.3 ±294.3 a.u.. Moreover, the overall mean training load was 403.7.3 ± 20.6 a.u.. However, the training load on the week 1 was different from the week 3 ($p < 0.01$). In addition, the weekly monotony (1.2 ± 0.1, 1.8 ± 0.2 and 2.1 ± 0.1 a.u.) and strain (3082.6 ± 392.3, 5455.9 ± 678.8 and 6326.3 ± 662.6 a.u.) had a significantly increase between the mesocycles ($p < 0.05$).

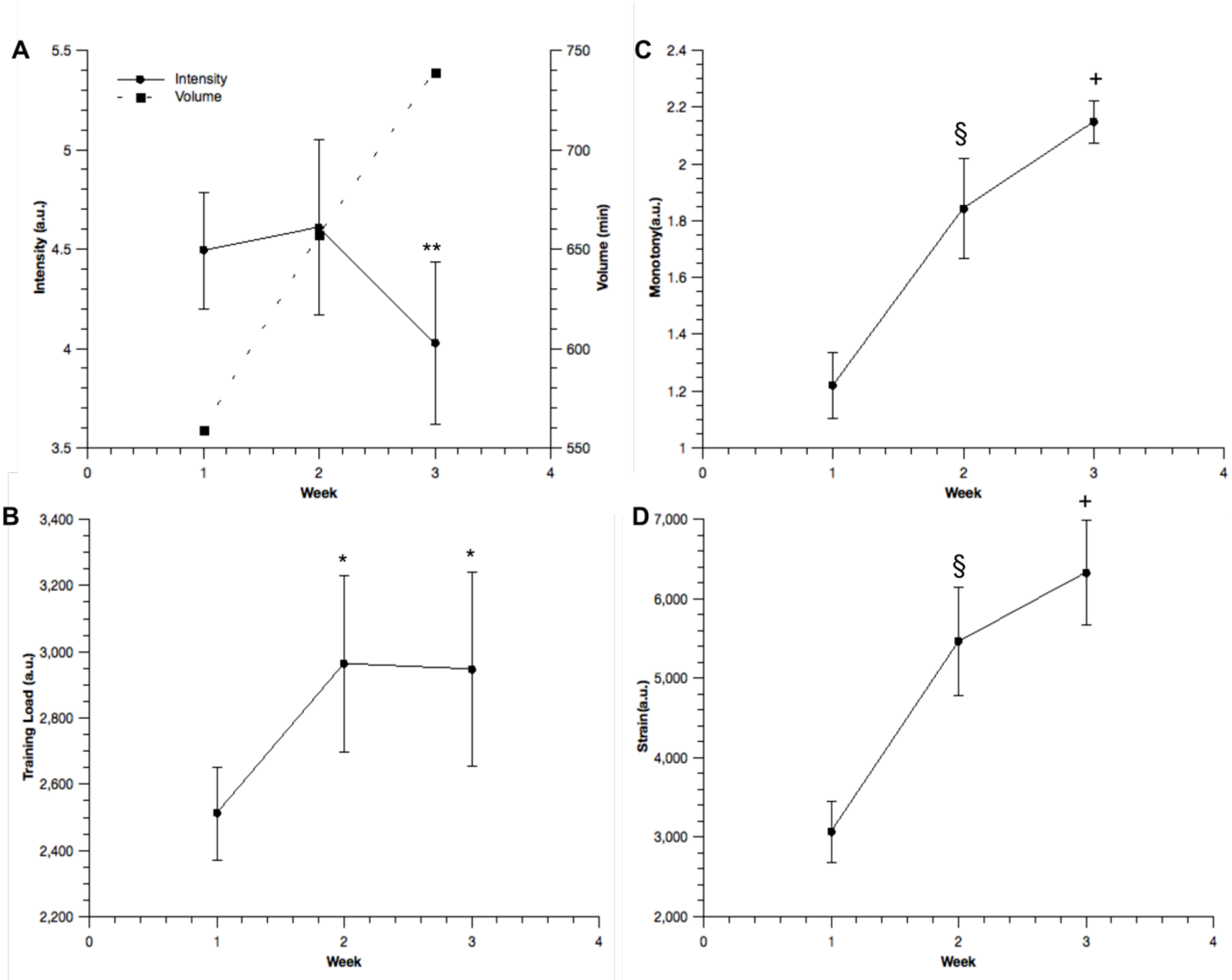

Figure 1. Mean and SD of the Volume and intensity (A), overall training load (B), monotony (C) and Strain (D) of 3-week pre-season. * different from week 1; ** different from week 2; + different form week 1 and 2; § different from week 1 and 3.

Anaerobic and aerobic parameters. The anaerobic and aerobic parameters from the lactate minimum test on the Futsal_Circuit did not have any change after 3 weeks of the pre-season (Table 3).

Neuromuscular parameters and body composition. The neuromuscular parameters did have any changes, however the body composition showed a significantly increase on the Bone mineral content, lean mass total and of the legs ($p < 0.05$). In addition, there were a significantly reduction on the fat mass absolute and percentage ($p < 0.05$) during the 3 weeks of the pre-season (Table 3).

Table 3. Mean, SD and percentage change (Δ%) of body composition, anaerobic, aerobic and neuromuscular parameters pre and post 6 weeks of training during the pre-season (* p < 0.05).

	Pre	Post	Δ%
Body Composition			
Body Mass (kg)	76.2±8.9	75.8±9.2	-0.6
BMI (kg.m^2)	25.2±1.6	25.1±1.8	-0.6
BMC (kg)	2.9±0.3	3.0±0.3*	0.9
Fat mass (kg)	17.4±4.7	14.1±4.3*	-19.3
Lean Mass total (kg)	54.7±5.0	57.4±6.0*	4.9
Lean Mass legs(kg)	20.3±1.66	21.7±2.2*	6.7
Fat mass (%)	22.9±4.2	18.7±4.2*	-18.8
Anaerobic			
P. Max (W.kg^{-1})	9.5±1.0	10.0±1.5	5.8
P. Mean (W.kg^{-1})	7.6±0.9	7.8±0.8	2.8
vMax (m.s^{-1})	6.9±0.2	7.0±0.4	1.6
vMean (m.s^{-1})	6.4±0.2	6.9±1.3	7.0
Impulse (N.s^{-1})	1887.0±73.5	1918.6±70.7	1.1
FI (%)	8.7±2.6	10.2±3.7	22.8
Aerobic			
AT (km.h^{-1})	7.4±0.5	7.7±0.6	3.6
vMax (km.h^{-1})	8.9±0.7	9.0±0.6	1.4
[lac^{-1}] peak (mmol.L^{-1})	9.8±1.9	10.2±1.8	6.0
[lac^{-1}] AT (mmol.L^{-1})	8.0±1.5	7.7±0.6	2.9
%AT (%vMax)	91.5±22.1	91.4±26.4	2.9
HR_AT (BPM)	183.3±6.7	179.9±12.6	-0.3
HR Max (BPM)	192.3±4.5	190.7±3.8	-0.3
%HR_AT (%FC Max)	95.3±2.1	94.3±6.4	-01
RPE AT (a.u)	6.4±14	7.0±1.9	8.9
RPE MAX (a.u)	10.0±0.0	9.7±0.5	-2.2
Neuromuscular			
Peak Force (N)	902.6±187.2	629.2±153.9*	-28.2
Mean Force (N)	599.8±136.2	582.12±147.5	0.7
Force development50ms (N.m.s^{-1})	0.98±0.2	0.98±0.3	-18.6
Force impulse(N.s^{-1})	411.8±86.2	286.6±69.7*	-28.0
RMS VL (% RMS)	100.0±0.0	109.8±35.7	9.8
MPF VL (mV)	73.8±8.9	78.1±15.2	6.8
RMS BF (% RMS)	100.0±0.0	106.1±55.5	6.1
MPF BF (mV)	79.2±10.6	87.3±18.0	11.0
Coactivation index (a.u.)	0.2±0.1	0.1±0.1	-3.3

BMI: Body mass Index; BMC: Bone mineral component; P. Max: Maximal Power on the RAST; P. Mean: Mean Power on the RAST; vMax: maximal velocity on the 35 meters; vMean: mean velocity on the 35 meters; IF: fatigue index on the RAST; AT: Anaerobic threshold; vMax: maximal velocity on the incremental test at Futsal_Circuit; HR: Heart rate; RPE: rated perceived exertion; RMS: root mean square; MPF: Mean power frequency; VL: Vastus lateralis; BF: Biceps femoris.

Blood parameters. On the hematologic parameters, leukocytes and CHCM showed a significantly increase after 3 weeks on the competitive period. However, basophils had a reduction on the same period ($p < 0.05$). Furthermore, C protein, lactate-acid dehydrogenase (LDH) and creatinine showed a reduction ($p < 0.05$) after 3 weeks on the pre-season. Nevertheless, the creatine kinase had a significantly increase during the pre-season ($p < 0.05$). However, the hormonal parameters did not change during the competitive period (Table 4).

Table 4. Mean, SD and percentage change (Δ%) of hematologic, biochemical and hormonal parameters pre and post 6 weeks of training during the pre-season (*p < 0.05).

	Pre	**Post**	**Δ%**
Hematologic			
Leukocytes (/mm^3)	5744.4±1013.4	6603.3±1188.1*	15.6
Neutrophils (%)	48.9±9.7	49.3±8.9	2.3
Eosinophils (%)	2.9±1.3	3.1±1.6	5.1
Basophils (%)	2.5±1.2	0.4±0.2*	-79.1
Lymphocytes (%)	38.9±7.3	39.1±9.1	0.2
Monocytes (%)	6.8±2.1	8.1±1.1	26.5
RBC (million/mm^3)	5.1±0.2	5.0±0.2	-1.5
Hemoglobin (g.dL^{-1})	14.7±0.5	14.9±0.4	1.1
Hematocrit (%)	45.9±1.8	45.4±1.7	-1.0
MVC (fl)	89.8±2.8	90.2±3.4	0.5
MCH (pg)	28.8±0.9	29.6±1.0	2.6
MCHC (g.dL^{-1})	32.1±0.4	32.8±0.7*	2.1
RDW (%)	17.1±1.3	13.4±0.6	-21.3
Platelets (/mm^3)	234888.9±47755.7	247333.3±49769.5	6.4
Biochemical			
C protein (mg.dL^{-1})	3.7±3.5	0.8±-0.7*	-61.7
CK (u.L^{-1})	241.2±93.1	375.8±176.2*	69.0
LDH (u.L^{-1})	452.4±28.8	375.8±51.4*	-16.9
Creatinine (mg.dL^{-1})	1.1±0.2	0.9±0.1*	-16.2
Urea (mg.dL^{-1})	27.0±5.4	28.8±4.2	8.6
Hormonal			
Testosterone (ng.dL^{-1})	530.1±117.9	502.6±102.7	-4.1
Cortisol (mcg.dL^{-1})	13.6±2.3	13.9±3.4	4.4
T/C Ratio	40.7±14.5	38.6±13.7	-23.0

RBC: Red blood cell; CK: Creatine Kinase; LDH: Lactate-acid dehydrogenase; T/C Ratio: Testosterone.Cortisol^{-1}.

The correlation between of the delta of percentage change of the parameters with the training variables (Table 5) showed significantly results to some hematologic, biochemical, body composition aerobic and neuromuscular parameters.

Table 5. Correlation between the percentage change (Δ%) of the parameters and the training variables on the pre-season (*p < 0.05).

	Intensity	**Overall TL**	**Mean TL**	**Monotony**	**Strain**
Δ AT (%)	-0.29	-0.24	-0.24	-0.90*	-0.90*
Δ HR Max (%)	-0.62	-0.76*	-0.76*	-0.55	-0.57
Δ MCH (%)	0.64	0.71*	0.71*	0.31	0.35
Δ LDH (%)	0.77*	0.70	0.70	0.17	0.22

AT: Anaerobic threshold; HR: Heart rate; LDH: Lactate-acid dehydrogenase; TL: Training load.

Study B.

Training load. Intensity, volume and total training load, on the 6-week competitive period was 5.7 ± 0.5 a.u., 333.2 ± 31.9 min and 9910.2±1820.3 a.u. respectively (figure 2). The mean weekly training intensity was 4.7 ± 1.2, 6.6 ± 0.9, 5.7 ± 0.5, 4.8 ± 0.6, 4.7 ± 1.1 and 7.8 ± 1.1 a.u. respectively, with a significantly increase on the second mesocycle in relationship of the first mesocycle following significantly reduction on the mesocycle number 3, 4 and 5 and an increase on the last monocycle (week 6). The weekly accumulated training load (TL) between the weeks was respectively 1397.1 ± 420.6, 2284.3 ± 557.1, 2618.6 ± 498.7, 1878.8 ± 713.4, 1480.0 ± 560.6 and 540.0 ± 124.8 a.u., with a significantly reduction on the last two mesocylce (weeks 5 and 6). Moreover, the mean training load was 248.3 ± 33.9 a.u.. However, the training load on the week 1 was different from the week 2, 3 and 6 (p < 0.01). Week 2 was different from week 6 (p < 0.01). Week 3 was different from week 1, 5 and 6 (p < 0.01). Week 4 was different only week 5 and 6 (p < 0.01). Finally, week 6 was different from all others weeks (p < 0.01). In addition, the monotony and strain was 0.9 ± 0.1 and 1608 ± 379.6 a.u., with significantly (p < 0.05) difference between the weeks (figure 4).

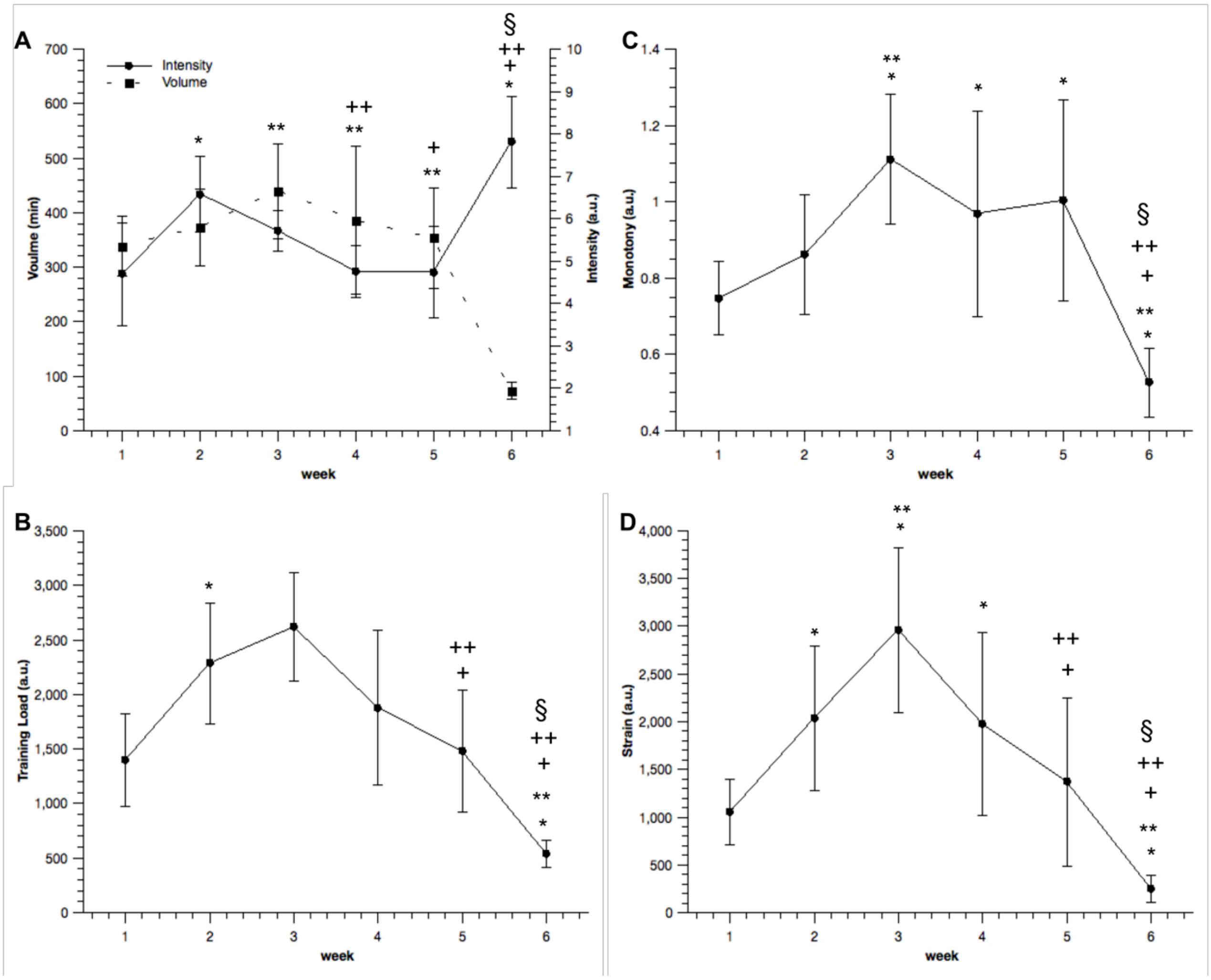

Figure 2. Mean and SD of the Volume and intensity (A), total training load (B), monotony (C) and Strain (D) of the 6-week competitive period. * different from week 1; ** different from week 2; + different from week 3; ++ different from week 4; § different from week 5.

Anaerobic and aerobic parameters. The anaerobic and aerobic parameters from the lactate minimum test on the Futsal_Circuit had a significant improvement after 6 weeks of training during the competitive period (Table 6).

Neuromuscular parameters and body composition. The neuromuscular parameters and the body composition did not change during the 6 weeks of the competitive period (Table 3).

Table 6. Mean, SD and percentage change (Δ%) of body composition, anaerobic, aerobic and neuromuscular parameters pre and post 6 weeks of training during the competitive period (* $p < 0.05$).

	Pre	Post	Δ%
Body Composition			
Body Mass (kg)	75.1±8.6	74.6±9.0	-0.7
BMI (kg.m^2)	25.0±1.7	24.8±1.8	-0.7
BMC (kg)	2.9±0.3	3.0±0.4*	0.9
Fat mass (kg)	20.6±3.6	18.9±3.7	-11.4
Lean Mass total (kg)	55.6±5.3	55.7±6.5	0.1
Lean Mass legs(kg)	21.8±3.7	20.9±2.3	-3.3
Fat mass (%)	20.3±3.5	19.9±3.4	-1.7
Anaerobic			
P. Max (W.kg^{-1})	9.7±1.7	10.9±1.3*	14.8
P. Mean (W.kg^{-1})	7.8±0.8	8.6±1.0*	9.7
vMax (m.s^{-1})	6.9±0.4	7.2±0.3*	4.5
vMean (m.s^{-1})	6.5±0.2	6.7±0.3*	3.2
Impulse (N.s^{-1})	1885.2±95.7	1991.8±76.4*	7.2
FI (%)	7.8±3.5	9.0±2.2	34.6
Aerobic			
AT (km.h^{-1})	7.4±0.3	8.1±0.6*	9.0
vMax (km.h^{-1})	8.6±0.9	9.7±0.7*	13.5
[lac^{-1}] peak (mmol.L^{-1})	8.5±1.2	7.5±2.0	8.9
[lac^{-1}] AT (mmol.L^{-1})	7.3±2.1	6.3±2.2	-13.5
%AT (%vMax)	87.9±30.1	64.0±24.5*	-22.7
HR_AT (BPM)	179.9±6.2	178.4±7.3	-1.2
HR Max (BPM)	188.9±8.3	190.1±7.8	0.2
%HR_AT (%FC Max)	95.3±2.6	93.9±2.5	-1.3
RPE AT (a.u)	6.6±1.5	7.1±1.4	11.9
RPE MAX (a.u)	9.4±1.1	9.7±1.0	2.8
Neuromuscular			
Peak Force (N)	793.8±241.1	765.4±142.1	-2.0
Mean Force (N)	596.78±216.6	725±155.8	12.9
Force development50ms (N.m.s^{-1})	0.9 ±0.3	1.0±0.3	39.4
Force impulse(N.s^{-1})	360.0±113.2	345.2±67.9	2.1
RMS VL (% RMS)	100.0±0.0	112.6±21.8	12.6
MPF VL (mV)	79.6±9.1	80.5±8.9	1.4
RMS BF (% RMS)	100.0±0.0	90.5±40.6	-9.5
MPF BF (mV)	82.9±14.5	80.5±13.1	-1.6
Coactivation index (a.u.)	0.2±0.1	0.1±0.1	-16.4

BMI: Body mass Index; BMC: Bone mineral component; P. Max: Maximal Power on the RAST; P. Mean: Mean Power on the RAST; vMax: maximal velocity on the 35 meters; vMean: mean velocity on the 35 meters; IF: fatigue index on the RAST; AT: Anaerobic threshold; vMax: maximal velocity on the incremental test at Futsal_Circuit; HR: Heart rate; RPE: rated perceived exertion; RMS: root mean square; MPF: Mean power frequency; VL: Vastus lateralis; BF: Biceps femoris.

Blood parameters. On the hematologic parameters, Basophils and monocytes showed a significantly reduction after 6 weeks on the competitive period. Furthermore, the lactate dehydrogenase (LDH) and creatinine (biochemical) also had a significantly reduction during the competitive period. However, the hormonal parameters did not change during the competitive period (Table 7).

Table 7. Mean, SD and percentage change (Δ%) of hematologic, biochemical and hormonal parameters pre and post 6 weeks of training during the competitive period (*p < 0.05).

	Pre	Post	Δ%
Hematologic			
Leukocytes (/mm^3)	7452.5±1998.5	7446.3±2122.0	2.7
Neutrophils (%)	51.6±11.1	53.8±10.7	6.2
Eosinophils (%)	2.8±1.5	2.5±1.3	4.0
Basophils (%)	0.3±0.2	0.2±0.2*	-30.6
Lymphocytes (%)	34.7±10.1	34.4±9.7	7.4
Monocytes (%)	10.5±1.7	9.0±1.8*	-14.2
RBC (million/mm^3)	5.2±0.3	5,2±0.3	0.9
Hemoglobin (g.dL^{-1})	15.5±0.9	15.6±1.0	0.5
Hematocrit (%)	46.5±2.3	46.5±3.4	0.1
MVC (fl)	89.7±1.7	88.9±2.4	-0.9
MCH (pg)	29.9±0.8	29.8±0.9	-0.4
MCHC (g.dL^{-1})	33.4±0.4	33.6±0.7	0.6
RDW (%)	13.7±0.7	13.5±0.6	-1.2
Platelets (/mm^3)	24275.0±61409.1	241000.0±60761.8	-0.4
Biochemical			
C protein (mg.dL^{-1})	2.7±2.5	1.0±-1.0	-33.3
CK (u.L^{-1})	394.8±106.5	317.6±160.8	-19.8
LDH (u.L^{-1})	410.0±87.8	340.2±62.8*	-15.9
Creatinine (mg.dL^{-1})	1.1±0.1	1.0±0.2*	-11.6
Urea (mg.dL^{-1})	32.3±7.0	34.6±10.8	9.7
Hormonal			
Testosterone (ng.dL^{-1})	601.3±155.7	561.7±93.3	-3.6
Cortisol (mcg.dL^{-1})	15.7±2.0	14.6±5.1	-5.7
T/C Ratio	39.2±12.4	47.3±34.6	19.6

RBC: Red blood cell; CK: Creatine Kinase; LDH: Lactate dehydrogenase; T/C Ratio: Testosterone.Cortisol^{-1}.

The correlation between of the delta of percentage change of the parameters with the training variables (Table 8) showed significantly results to biochemical and parameters.

Table 8. Correlation between the percentage change (Δ%) of the variables and the training parameters ($p < 0.05$).

.	Overall TL (a.u.)	Mean TL (a.u.)	Monotony (a.u.)	Strain (a.u.)
Δ Creatine Kinase(%)	-0.50	-0.50	-0.65	-0.96*
Δ vMax (%)	0.04	0.04	-0.65	-0.71*

vMax: maximal velocity on the incremental test at Futsal_Circuit.

Discussion

Study A. Three weeks of training during the pre-season in professional futsal players reduced the fat mass and increased the lean mass. However, the pre-season period was not enough to change positively the anaerobic, aerobic and neuromuscular parameters. Moreover, the 3-week pre-season increase the leukocytes, MCHC and creatine kinase, but reduced the C-protein reactive and lactate-acid dehydrogenase.

Since during the 3-week pre-season was proposed by the coaches and the players had only 3 days-off, the mean volume was high (658.8 ± 17.4 min) with increase between the mesocycles. In addition, the first mesocycle had one day less in relation of the others, leading a lower volume in comparison with the second and third mesocycle. Furthermore, the intensity on the first and second mesocycle were similar (~4.5 a.u.) with a significant reduction of the intensity training (~4.03 a.u.) on the third mesocycle. Probably, this reduction happened because the third mesocycle had higher volume (~739.0 min) than the first and second mesocycle. The combination of intensity versus volume generated a high total training load of 8038.8.2±1124.1 a.u. during the pre-season with a significantly low value of TL on the first mesocycle in relation of second and third mesocycle indicating a crescent TL along the pre-season.

MILANEZ *et al.* (2014) showed an overall weekly TL (3057 a.u.), monotony (1.6 a.u.) and training strain (4186 a.u.) during 5-week preparation training program prior to the main national competition of the players higher than the present study. However, in a study with 4-week pre-season with Brazilian futsal player the mean weekly load and the strain were higher than the present study (723.5 a.u. and 6991.9 a.u. respectively), but with similar monotony (~1.5 a.u.) (SOARES-CALDEIRA *et al.*, 2014). In addition, still with Brazilian futsal players, during a 5-week pre-season the overall TLs was higher than the present study, with TL above of 4000 a.u. (MILOSKI *et al.*, 2014; NAKAMURA, PEREIRA, RABELO, FLATT*, et al.*, 2016).

On the other hand, the training values on the present study are higher than those presented in Australian rugby (1391±160 to 3107±289 a.u.) (COUTTS *et al.*, 2007) and professional basketball players (2791±239 to 3334±256 a.u.) (MANZI *et al.*, 2010). This difference may be explained by a higher intensity in futsal demands compared with other team sports (BARBERO-ALVAREZ *et al.*, 2008).

The perceived TL can be influenced by innate characteristics, quantity and the nature of external TL and fitness level of the athletes (IMPELLIZZERI *et al.*, 2004; MILANEZ *et al.*, 2011). In male futsal, for example, players with a higher aerobic fitness reported lower TL values compared with their less fit counterparts, despite undergoing similar external TL (MILANEZ *et al.*, 2011). Therefore, since the pre-season is the first training period after the transition period (off-season), the aerobic capacity of the players may affect the perceived TL.

Pre-season training period usually focuses in improve the physical fitness in players following the off-season, consequently, this period for team sport athletes involves very high training loads with several physical capacities being developed in concomitance (JEONG *et al.*, 2011). Thus, the ability to repeat sprint, aerobic capacity, and lower-limb muscle power (neuromuscular adaptation) have been identified as paramount qualities for improvement during the pre-season in most team sports (BUCHHEIT *et al.*, 2013;

CASTAGNA *et al.*, 2013; OLIVEIRA *et al.*, 2013). Moreover, team sports players could experience important changes in body composition after pre-season (ARGUS *et al.*, 2010). Thus, the training program to the pre-season proposed on the present study could reduce significantly the fat mass and improve the lean mass and bone mineral content, however, the anaerobic and aerobic parameters was not change significantly. Furthermore, the peak force and force impulse during the maximal voluntary isometric contraction was significantly reduced post the 3 weeks of training. In contrast, during a 4-week pre-season training program for professional futsal players did not significantly change in body mass, fat mass percentage, lean body mass, aerobic and anaerobic parameters with mean weekly load higher than the present study (SOARES-CALDEIRA *et al.*, 2014). Nevertheless, 4-week pre-season with high intensity of resistance training and anaerobic and aerobic conditioning (mean intensity of 7.4 a.u.) could reduce the fat mass and increase the strength of the professional rugby player (ARGUS *et al.*, 2010).

In addition, it has been suggested that several parameters of immunity are affected by heavy exercise in field sports (BARBERO-ALVAREZ *et al.*, 2008). Therefore, there is a consensus in literature about the decrease in CBC induced by the endurance training (SCHUMACHER *et al.*, 2002). Moreover, the hematological parameters may be based on the characteristics of the specific modalities such endurance or strength training (SCHUMACHER *et al.*, 2002). However, sports team like futsal and soccer evolving different categories of training that cannot be classified only as endurance or strength training (SILVA *et al.*, 2008). Hence, on the present study the leukocytes and MCHC increased significantly ($p < 0.05$) and the Basophils reduce ($p < 0.05$), whereas the others parameters from the CBC did not change. The volume plasma expansion that result from an increment in the aldosterone production accompanied by osmotically active plasma proteins, a decrement in urodilatin activity, and sensibility of central baroreceptors situated in the medulla oblongata may be the responsible for part of the adaptations on the hematological parameters (SCHUMACHER *et al.*, 2002).

On the other hands, a season of soccer training may cause biochemical disturbances that may lead athletes to situations of higher risk of muscle damage, thus causing a decrease in performance (HEISTERBERG *et al.*, 2013; MEISTER *et al.*, 2013). On the present study the C protein reactive, lactate-acid dehydrogenase (LDH) and creatinine reduced significantly ($p < 0.05$) while, the creatine kinase (CK) increase ($p < 0.05$). Moreover, the percentage change of the LDH was positively correlation with the mean intensity of the training period ($r=0.77$; $p<0.05$). As opposed to our findings, during a 3-week preseason with professional soccer players the CK reduced significantly (429 ± 70 to 233 ± 60 $IU.L^{-1}$), however, the LDH did not change (PROIA *et al.*, 2012). The behavior of CK blood concentration depend on type, intensity, and duration of exercise (BRANCACCIO *et al.*, 2007), and studies reported that CK blood concentration increases after an intensified training period and return to pre training levels after one or two weeks of reduced TLs (FREITAS *et al.*, 2014). Moreover, CK, testosterone, and cortisol measures have been indicated as potential markers to be used for monitoring imbalances caused by training-induced fatigue (MOREIRA *et al.*, 2011; FREITAS *et al.*, 2014) and could be used to analyze the responses generated by specific training plans (MILOSKI *et al.*, 2016). However, testosterone and cortisol were not sensitive to the TL during the pre-season on the present study. Similar our finds MILOSKI *et al.* (2016) did not demonstrate alterations in testosterone concentration during the training season. An important fact on this study is the pre assessment happened exactly after the transition period (off-season), and the control on the routing of the players before the assessment was not possible. Because this, the biomarkers (c protein, LDH and specially CK) presents higher values than the normal range on the pre assessment.

The strongly correlation between percentage change of AT with monotony and strain ($r= -0.90$ and $r=-0.90$ respectively; $p < 0.01$) were founded. Since high scores of monotony and strain are a result of low TL variability and high intensity, which in turn has been suggested to be related to the onset of overtraining, when combined with high TL (FOSTER, 1998), seems the monotony affect negatively the aerobic fitness on the present study. The overall and mean TL of the pre-season showed a negative correlation with percentage change of the maximal heart rate on the lactate minimum test (r=-0.76; p <0.01) and a positive correlation MCH (r=0.71; p <0.05). This results indicate the distribution of the training load during the pre-season to futsal players may modulate the body composition, hematologic, biochemical and hormonal, however, it was not able to improve aerobic and anaerobic parameters and reduce the peak force on the MVC.

Study B. Six weeks of training during the competitive period (last phase on the season) in professional futsal players could increase the bone mineral content, enhance the anaerobic and aerobic parameters, and reduce the basophils, monocytes, LDH and creatinine parameters.

The last phase on the competitive period is on the most important period on the season, since, in this period happen the playoffs matches and can decide the success of the program training during the season. Therefore, during this period the coaches having the expectation of the players reach the best physical performance. Based this, the accumulated TL on this was 1699.8 ± 198.5 a.u. This results was similar with the results of JEONG *et al.* (2011) for futsal players (1703 ± 173 a.u.). Others studies with Brazilian futsal players reported accumulated training load higher than the present study with a range between 2900-3000 a.u. (MOREIRA *et al.*, 2013; MILOSKI *et al.*, 2016). The fact the present study monitors a competitive period with official match approximately each 3 days, may led to reduce the training volume during the period. A limitation on the present study was not take in consideration the TL of the official matches during the competitive period, because the researchers realized the rating of perceived exertion of athletes was directly affected by the condition of winning or losing in the matches, distorting the real perception of intensity of the match. Moreover, the behavior of the TL during the competitive period on this present study showed a significantly reduction of the load on the last three weeks.

MOREIRA *et al.* (2013) reported a similar reduction on the TL during the last two weeks aimed at providing a taper (50% decrease in training volume) and increased player recovery. The magnitude of the reduction on the present study was similar to reported by (MOREIRA *et al.*, 2013) for futsal players and reported in professional soccer league during the competitive season (IMPELLIZZERI *et al.*, 2004).

Ideally, the main physical capacities determining performance in a given sport are substantially improved over the preseason, and thereafter maintained or even further improved during the competitive season (OLIVEIRA *et al.*, 2013). The anaerobic threshold (AT) and maximal velocity reached on the lactate minimum test on the Futsal_circut increase after 6-week competitive period. Furthermore, the percentage of the intensity on the AT in relation to the maximal velocity on the test had a significantly reduction (87.9±30.1 to 64.0±24.5). Since, the AT can be defining by the highest exercise intensity which is an equilibrium between lactate transport into the blood and lactate removal from the blood (BILLAT *et al.*, 2002), and through the close relationship of the intensity index, this result may to the endurance performance. Moreover, PEDRO *et al.* (2013) showed the intensity associated with VO_{2max} and anaerobic threshold during the assessment of aerobic fitness of futsal players should be efficient to discriminate the competitive level of futsal Brazilian players. The results of the aerobic parameters (AT: 64-87% of maximal intensity on the test; 93-95% maximal intensity on the test) were similar with reported by BARONI e LEAL (2010) to Brazilian futsal players, however, in an assessment through laboratory tests. In addition, these percentages are similar with observed during a match (90% of HR max), once, during 83% of match players perform high-intensity exercise (above 85% of HR max) (BARBERO-ALVAREZ *et al.*, 2008).

Since the match have a high intensity, to improve the anaerobic fitness is a good strategy to improve the performance on the match, and the present study showed a significantly increase on the peak and mean power and velocity during the RAST. Corroborating with this results, (OLIVEIRA *et al.*, 2013) related an increase on the repeated-sprint ability during the competitive period.

Neuromuscular parameters did not change after 6-week training on the present study. However, development of players' neuromuscular abilities seems to be important for improving performance during the most intense and decisive game actions and a correlation between power-speed abilities (and changes in them) and training loads were related by (BARBIERI *et al.*, 2016b; NAKAMURA, PEREIRA, RABELO, RAMIREZ-CAMPILLO*, et al.*, 2016). Therefore, the training model proposed by the coaches on the present study was not able to enhance the neuromuscular parameters.

Since the blood parameters are important markers of the training adaptation and has strongly correlation with the TL (COUTTS *et al.*, 2007; MOREIRA *et al.*, 2011; MILOSKI *et al.*, 2016), the basophils and monocytes reduced after 6-week competitive period on the present study. This results are similar to reported to soccer players (SILVA *et al.*, 2008) and related to endurance training (SCHUMACHER *et al.*, 2002). The mechanisms to explain this regulation was explained on the discussion section of the study A.

For biochemical parameters, LDH had a significantly reduction after 6-week on the competitive period, however, the others biochemical and hormonal parameters had no significantly percentage change, in especially creatine kinase. Since LDH and creatine kinase are indirect markers of muscle damage (MEISTER *et al.*, 2013), it was expected a reduction of this parameters simultaneously. (LEAL DE QUEIROZ THOMAZ DE AQUINO *et al.*, 2016) with young soccer players, found positive changes across the periodization training (e.g., reducing the activities of the biochemical markers of muscle damage) with a simultaneous improvement in physical performance. Moreover, high training loads with insufficient recovery periods has been suggested the cause to reduce the strength performance and physiological function in team sport players, such as soccer (KRAEMER *et al.*, 2004). Consequently, the reduction on the TL during the last two weeks aimed at providing a taper, could improve the anaerobic and aerobic capacity, however, without a significantly impact to reduce the hematologic, biochemical and hormonal parameters.

Based on the negatives correlations of the strain training on the competitive period with the percentage change of c protein reactive and maximal velocity reached on the lactate minimum test (r=-0.96 and -0.71 respectively), indicate the high TL during this period may affect the inflammatory marker and reduce the aerobic power.

General. A limitation of this study was the absence of a control group., however, the design of the experimental protocol and the training program hinders the formation of 2 groups or comparison with other teams. Moreover, to our knowledge, are few studies to show an overview of internal training load, body composition, neuromuscular, hematologic, biochemical, hormonal, anaerobic and aerobic parameters during the season, in special during the playoffs. It is important to highlight the methods applied to assess the parameters in this study show a great reproducibility and reliability with the good standard.

Other important point on the present study is the application of the lactate minimum test on the Futsal_Circuit (BARBIERI et al. 2016a), since, the test can be performing on the area of training and match (court), and takes into consideration the technical demands and his index reflects mean values during the match. Others studies applied non-specific protocols for the modality, such as laboratory measurements fitness (Alvarez et al. 2009; Lima et al. 2005), indirect measurements (BARBIERI *et al.*, 2012; BARBIERI *et al.*, 2016b) and/or protocols specific to soccer (KRUSTRUP *et al.*, 2006; DITTRICH *et al.*, 2011). In addition, it is important to highlight the training program on the pre-season and competitive period were able to improve de bone mineral content, since, Low levels of bone mineral content (BMD) during earlier stages of life may contribute to the development of osteoporosis later on in life (RIZZOLI *et al.*, 2010). Therefore, this fact can lead a protection of bony problems of athletes during their career.

Based on the results, the distribution of the training load during the 3-week pre-season with high TL parameters can improve significantly the body composition and result in a high stress metabolic, however, this model seems not be good to lead an increase in the aerobic capacity, important key for the competitive season, since the high TL strain showed a strong correlation with the low percentage change on the anaerobic threshold. On the other hands, the distribution of the training load during the 6-week competitive period cannot change the body composition parameters, however, this model was able to enhance the anaerobic and aerobic capacity, important key for the success during the playoffs. In addition, the taper may not be efficient to reduce all metabolic stress markers, in special the creatine kinase. Moreover, independent of the training period or the magnitude of the training load, a training program with high strain and monotony may affect the physical adaptation and increase the metabolic stress.

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6. CONCLUSÕES

1º Trabalho:

Um teste para avaliar a capacidade aeróbia adaptado a partir do circuito proposto por HOFF *et al.* (2002) é valido em comparação com a máxima fase estável de lactato?

Conclusão:

O específico teste proposto para jogadores de futsal se mostrou ser reprodutível, confiável e valido para avaliar a capacidade aeróbia de jogadores de futsal. Além disso, a frequência cardíaca parece ser um bom indicador de controle de intensidade para o treinamento nesse circuito.

2º Trabalho

O teste de campo proposto para o futsal que possui movimentos e específicos como condução de bola e constante mudanças de direção (trabalho 1) apresenta uma melhor correlação com a demanda física em jogos simulados e oficiais quando comparados aos testes laboratoriais?

Conclusão:

Ambos os protocolos de campo e laboratório apresentarem fortes correlações com a demanda física exigida durante o jogo. No entanto, uma vez que para o teste de campo as intensidades associadas com o limiar anaeróbio e VO_2max apresentaram fortes correlações com a demanda técnica do jogo, enquanto que, para o teste de laboratório o VO_2max foi a variável quem mais se associou mais com o jogo, o teste de campo parece ser mais específico e associado com a demanda física do jogo.

3º Trabalho

Qual é a relação dos parâmetros neuromusculares, bioquímicos, hematológicos, hormonais e de performance aeróbia e anaeróbia com a distribuição da carga interna da pré-temporada e durante o período competitivo?

Conclusão:

Três semanas de pré-temporada com elevada carga interna melhorou significativamente a composição corporal, porém apresentou elevado dano muscular. No entanto, os estímulos utilizados não foram suficientes para melhorar a capacidade aeróbia, importante chave para a temporada competitiva, uma vez que, o alto strain apresentou uma forte correlação negativa com o delta percentual do limiar anaeróbio. Já a carga interna imposta durante do período competitivo foi capaz de melhorar a capacidade aeróbia e anaeróbia, importante para o desempenho nos jogos.

Além disso, independentemente do período de treino, distribuição de cargas com alta monotonia e strain parece não foram adequadas para induzir adaptações positivas ao longo da temporada para jogadores de futsal.

Pergunta Central:

Os parâmetros neuromusculares, hormonais, bioquímicos, hematológicos e performances aeróbia e anaeróbias monitoradas, por meio de protocolo específico, estão associadas com a distribuição da carga interna de treinamento ao longo da temporada competitiva no futsal?

Conclusão:

Os parâmetros monitorados ao longo da temporada foram modulados a partir das diferentes distribuições de carga nos diferentes períodos de treinamento (pré-temporada e período competitivo). Ainda, independente do período de treinamento, um treinamento com elevado índice de monotonia e Strain afetaram negativamente os marcadores de lesão muscular e estresse metabólico, e parece não ter sido uma estratégia adequada para melhora o desempenho físico.

Além disso, o teste específico para avaliação da capacidade aeróbia de atletas de futsal proposto se mostrou ser uma ferramenta sensível para monitorar o desempenho dos atletas ao longo da temporada competitiva, além de ser uma ferramenta atrativa para a prescrição de treinamento físico.

7. CONSIDERAÇÕES FINAIS

A partir dos resultados encontrados nos estudos apresentados na presente tese, podemos concluir que o teste de avaliação da capacidade aeróbia num circuito específico para o futsal que leva em conta a demanda técnica, se mostrou válido para a avaliação do desempenho físico, sendo altamente associado com a demanda física exigida no jogo, sensível para o monitoramento do desempenho ao longo da temporada e uma excelente ferramenta para a prescrição do treinamento baseado nas intensidades de limiar anaeróbio e/ou velocidade associada ao VO_2max. Ainda a inclusão da bola durante o teste é um fator que pode melhorar a motivação dos atletas durante a avaliação e/ou treinamento.

Além disso, a realização do teste proposto pode requerer uma grande habilidade técnica, porém, mais estudos precisam ser realizados para determinar esta exigência. Ainda, para estudos futuros, a medição do consumo de oxigênio durante o esforço no circuito para mensurar as exigências energéticas do protocolo proposto será de grande valia para um melhor entendimento para a aplicação prática.

Uma limitação do terceiro trabalho foi a ausência de um grupo controle. No entanto, o desenho do protocolo experimental e o programa de treinamento impede a formação de dois grupos ou a comparação com outras equipes. Além disso, em nosso conhecimento, são poucos os estudos que mostraram uma visão geral da relação da carga interna de treinamento sobre os parâmetros de composição corporal, neuromuscular, hematológicos, bioquímicos, hormonais, anaeróbio e aeróbios durante a temporada, em especial durante os playoffs. Ainda, é importante destacar que os métodos aplicados para avaliar os parâmetros deste estudo, são quase todos medidas diretas e apresentam uma grande reprodutibilidade e confiabilidade.

Além disso, é importante destacar que o programa de treinamento durante a pré-temporada e período competitivo foram capazes de aumentar o conteúdo mineral ósseo

(CMO), uma vez que, altos níveis de CMO podem levar a uma proteção de problemas ósseos dos atletas durante a sua carreira.

Ainda, independentemente do período de treinamento, distribuições de carga de treinamento com alta monotonia e strain parece não ser adequado para implementar efeitos positivos sobre o desempenho durante a temporada para os jogadores de futsal.

Portanto, entende-se que os dados da presente tese são inovadores pelo fato de fornecer informações a respeito de novos métodos de avaliação. Também fornece informações que contribuem para o entendimento da relação dose-resposta entre a distribuição de carga de treinamento e adaptação fisiológica de atletas de futsal.

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