Original article

Anthropometric profile and physical performance characteristic of the Brazilian amputee football (soccer) team

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Abstract—Amputee football is a variation of conventional soccer in which athletes with lower limb amputation and one athelete with upper limb amputation (the goalkeeper) participate. The objective of this study was to investigate the anthropometric and physical characteristics of amputee football athletes and to verify differences between heart rate peak (HRpeak) and equations for predicting maximum heart rate (HRmax). Twelve amputee soccer players from the Brazilian team participated in this study. The body mass, height and body composition were measured. The physical tests used were: the 20 m running test, the T-square test and the Yo Yo intermitent recovery test – level 1 (YYIRT1). The percentage of fat was significantly different between midfielders and defenders. No significant differences were found between positions in the physical tests. The HRpeak was significantly lower than all of HRmax prediction equations tested. We conclude that the indicators of physical performance did not differ significantly between the different tactics roles of players, and that, after intermittent maximum effort, the cardiac response was lower when compared with the investigated HRmax prediction equations.

Keywords: adapted physical activity, amputation, persons with disability

Resumo—"Perfil antropométrico e características físicas da equipe brasileira de futebol para amputados." O futebol de amputados é uma variação do futebol convencional, onde participam atletas amputados de membros inferiores e membros superiores (goleiro). O objetivo do estudo foi investigar as características físicas e antropométricas de atletas de futebol para amputados e verificar se existem diferenças entre a frequência cardíaca de pico (FCpico) e equações de predição da frequência cardíaca máxima (FCmax). Doze jogadores de futebol para amputados da seleção brasileira participaram do estudo. Foi mensurada a massa corporal, estatura e composição corporal. Os testes físicos utilizados foram: corrida de 20 m, teste do quadrado e o *Yo Yo intermitent recovery test – level 1* (YYIRT1). O percentual de gordura foi significativamente diferente entre os meio-campistas e defensores. Não foram encontradas diferenças significativas entre as posições nos testes físicos. A FCpico foi significativamente menor do que todas as equações de predição da FCmax testadas. Conclui-se que os indicadores de desempenho físico não diferenciaram significativamente entre as diferentes funções táticas dos jogadores, e que a resposta cardíaca após esforço máximo intermitente é menor quando comparada com as equações de predição da FCmax investigadas.

Palavras-chaves: atividade física adaptada, amputação, pessoas com deficiência

Resumen—"Perfil antropométrico y características físicas del equipo brasileño de fútbol para amputados." El fútbol de amputados es una variante del fútbol convencional, en el cual participan atletas amputados de miembros inferiores y miembros superiores (portero). El objetivo del estudio fue investigar las características físicas y antropométricas de atletas de fútbol para amputados y verificar si hay diferencias entre frecuencia cardíaca pico (FCpico) y ecuaciones de predicción de frecuencia cardíaca máxima (FCmax). Doce jugadores de fútbol para amputados del equipo oficial brasileño participaron del estudio. Fue mensurada la masa corporal, estatura y composición corporal. Los testes físicos utilizados fueron: carrera de 20 m, test del cuadrado y *Yo Yo intermitent recovery test – level 1* (YYIRT1). El porcentual de grasa fue significativamente diferente entre los mediocampistas

y defensores. No fueron identificadas diferencias significativas entre las posiciones en los testes físicos. FCpico fue significativamente menor que todas las ecuaciones de predicción de FCmax evaluadas. Concluí-se que los indicadores de desempeño físico no diferenciaron significativamente entre las diferentes funciones tácticas de los jugadores y que la respuesta cardíaca tras el esfuerzo máximo intermitente es menor si comparadas con las ecuaciones de predicción de FCmax investigados.

Palabras claves: actividad física adaptada, amputación, persona con discapacidad

Introduction

Amputation is defined as the absence of a limb or part of the body; usually the lower or upper limb or both. Amputation of a limb can cause some problems as compensatory movements, change of the center of gravity, decrease ability for walking, jogging or running, higher energy expenditure, elevated heart rate and lower oxygen consumption (Li, Armstrong, & Cipriani, 2001; Velzen Van et al., 2006; Krause et al., 2007; Mohanty, Lenka, Equebal, & Kumar, 2012). Participation in sports or regular physical activity provides positive effects on the well-being of people with amputation, mainly because improves balance, muscle strength, physical fitness and quality of life (Pitetti & Manske, 2004; Hanrahan, 2007; Yazicioglu, Taskaynatan, Guzelkucuk, & Tugcu, 2007; Bragaru, Dekker, Geertzen, & Dijkstra, 2011; Aytar, Pekyavas, Ergun, & Karatas, 2012).

Amputee football is a variation of conventional soccer, where athletes are subdivided in classes: A2/A4 (lower limbs amputee) and A6/A8 (upper limbs amputee) (Wilson, Riley, & Reilly, 2005). A2/A4 classes athletes play in the field and A6/A8 classes can play only as a goalkeeper (Wilson et al., 2005). The goalkeeper has the two legs, but one of the upper limbs is amputated. Thus, goalkeeper is not allowed out side the goal area, because they possess normal mechanics for the locomotion. The outfield players (A2/A4 classes) use Canadian crutches for locomotion (Wilson et al., 2005; Frère, 2007), which allows functional locomotion (Li et al., 2001), with upper body weight transferance (Krause et al., 2007). For the amputee soccer players, these crutches are adjustable and bilaterally held (Yazicioglu et al., 2007). They enable functional activity such as going up and down stars (Krause et al., 2007), performing sport activities, running and maintaing balanced while kicking (Yazicioglu et al., 2007).

This sport can be played in natural or synthetic grass with minimum of 60 x 30 m and maximum of 70 x 55 m. Seven players and one goalkeeper form one team. A match is subdivided into two 25-min intervals, with 10-min recovery interval in between (Wilson et al., 2005; Yazicioglu, 2007). Amputee soccer involves explosive activity such as jumps, kicking, changes of direction, high-speed sprints, and controlling the ball while dodging opponents (Göktepe, 2007; Aytar et al., 2012).

In a tactical function, a player positions himself in the field to perform a defensive or ofensive action while, at the same time, is subjected to metabolic processes with subsequent adaptations (Mohr, Krustrup, & Bangsbo, 2003; Reilly, 2005; Bloomfield, Polman, & O'Donoghue, 2007). Physiological responses, such as determination of maximal oxygen uptake (VO_{2max}), have been utilized to measure and prescribe the intensity of training soccer sessions. Since direct determination of VO_{2max} is expensive, inaccessible and nonspecific to the sport (soccer), another test has been recommended: the *Yo-Yo Intermittent Recovery Test Level 1* (YYIRT1). YYIRT1 is accessible, movement sport-specific (acceleration, slowdown and change of direction) and has good validity with the physical performance required in a match (Stølen, Chamari, Castagna, & Wisløff, 2005; Bangsbo, Iaia, & Krustrup, 2008).

The relative intensity in energy expenditure in a match seems to be similar to both, elite and amateur games. However, absolute intensity of the movements (e.g., sprint velocity, frequency and distances covered during a match) is superior to those of an elite soccer team. Studies that investigated the intensity of exertion during soccer matches utilize percentage of maximum heart rate (HRmax) as an alternative to VO_{2max} direct determination (hazardous to perform in live games). In one entire match, the average value is ~ 85% HRmax. It represents ~ 75% of VO_{2max} (Stølen et al., 2005). Although this HRmax value is estimate using the equation "220 - age" (Robergs & Landwehr, 2002), responses of amputee soccer players are unknown.

Additionally, although soccer is considerable the most popular sport in Brazil and around the world, by contrast, little is known about amputee soccer. Recent systematic review (Bragaru et al., 2011) showed that studies with amputee soccer are scare, signaling the need for more research about the characteristics of this sport, especially with regard the physiological and anthropometric parameters of these athletes.

Thus, the purposes of the current study are: a) to describe anthropometric and physical characteristics of amputee soccer players; b) to compare these results taking into comsideration the players' tactical function; c) to verify if there are differences between HR after maximum test (HRpeak) and the employment of six equations for prediction of HRmax.

Method

Participants

Twelve players from the Brazilian Amputee Soccer Team (29.3 ± 8.6 years old and 10.2 ± 5.1 years' experience in the sport) voluntered for this study. The following criteria were considered to include the athletes at the moment the study was conducted: (a) 18 years of age or older; (b) to have at

least five years of experience as an amputee soccer player; (c) to be the a member of the Brazilian Amputee Soccer Team; (d) to be familiarized with the tests.

The players were classified into the following groups: forwards (n = 4), midfielders (n = 4) and defenders (n = 4). All athletes were lower limb amputees (right = 42%, n = 5 and left = 58%, n = 7) and used Canadian crutches for locomotion. The goalkeepers were excluded from this study because their morphological characteristics (place of amputation) and motor skills were distinct from the other players (both legs intact).

The study was conducted in agreement with the Declaration of Helsinki (1964 and versions 1975, 1983 and 1989). Before the research began, the volunteers signed an informed consent form.

Design and study protocol

This research was conducted during the pre-season of the Amputee World Champion Soccer. The tests were administered in a random order, with at least 24h of recovery between the two testing sessions and five min between the two first tests on day one. Before the appliation of the tests, all athletes carried out a standardized warm-up session for a period of ~ 10 min (low intensity running and stretching exercise). All tests were performed in the official field with natural grass.

Anthropometry and body composition

Body mass was measured using an electronic scale platform (Filizola®), with 0.1 kg precision and height obtained with a stadiometer with 0.1 cm accuracy. Skinfolds were measured in the right side of the body, with three repetitions in each site. A mean value at the following anatomic sites was computed: triceps (TR), subscapular (SB), suprailiac (SI) and abdomen (AB). A single trained examiner recorded measurements using a caliper scientific (Sanny®). The relative body fat (% BF) was estimated using the following formula: % G= (TR+SI+SB+AB) x 0,153 + 5,783 (Faulkner, 1968).

Physical performance tests

The running 20 m test (T20) was employed to assess movement speed (Figure 2). This test requires a maximal sprint covering 20 m (limited by two cones) as fast as possible. A stopwatch was used to measure time. The stopwatch was triggered at the initiation of the athlete's movement and stopped when passing the 20 m marker. To calculate mean speed we utilized the equation:

$$Vm = \text{distance/time in m/s}$$

Agility was determined by the T-square test (Tsquare) that consists in a squared area limitedf by four cones with 4 m inside. There, the athlete moved as fas as he could while forming an "X" displacement (Figure 2). Three attempts were performed with 3 min rest in between. The best time was recorded. The results were express in seconds (s).

The YYIRT1 was employed to measure aerobic power (Bangsbo et al., 2008). The YYIRT1 consisted of a 20-m shuttle run performed at increasing velocities, with 10 seconds of active recovery between runs until exhaustion. YYIRT1 performance was considered as the total distance covered by the subject when they drop out. The test was considered complete when the participant failed twice to reach the front line within the time limit (objective evaluation), or when the participant felt unable to complete another run at the imposed speed (subjective evaluation).

The HRmax was recorded immediately after YYIRT1 (Polar® F5), and compared with six equations used to predict HRmax as commonly utilized in literature: HRmax = 220 - age (FC220), the most popular; 205,8 - 0,685 x age (Inbar et al., 1994) (INB) used with healthy people (Robergs & Landwehr, 2002); 207 - 0,7 x age (Tanaka, Monahan, & Seals, 2001) (TNK_At) used with active people; 206 - 0,7 x age (Tanaka et al., 2001) (TNK_End) used with endurance athletes; 202,8 - 0,533 x age - 0,00006 x (age 4/1000) (Londeree & Moeschberger, 1982) used with high school athletes and 200 - age, used with amputee youngsters (Short & Winnick, 1999).

Statistical analyses

The data were analyzed using SPSS software (version 17.0; SPSS, Inc., Chicago, IL). The normality of the data was

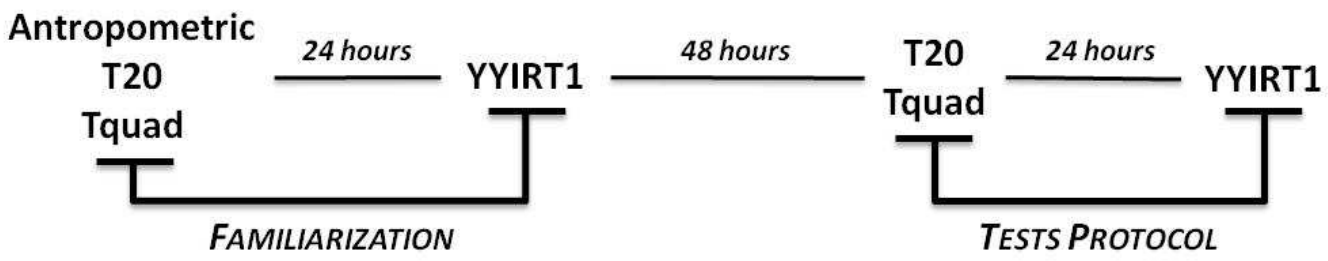

Figure 1. Study design.

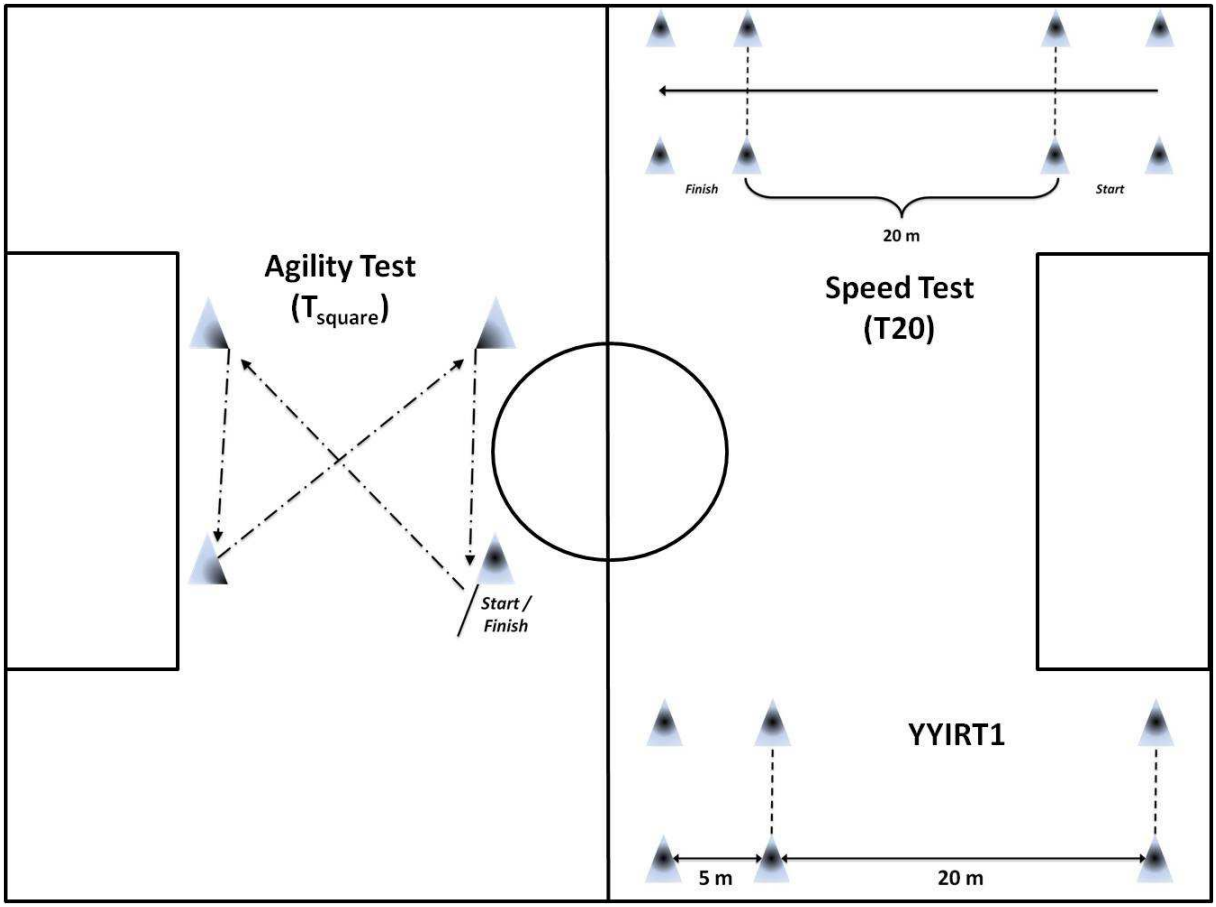

Figure 2. Schematic representation of the test site.

analyzed by Shapiro-Wilk test. The intraclass correlation coefficient - ICC (two-way mixed effects model; type: absolute agreement) was used to verify the reproducibility of the measurements (familiarization and tests). A one-way analysis of variance was used to compare the anthropometric and physical variables between field positions. The differences between the HR values and the values from the prediction equations were calculated using an analysis of variance (repeated measures ANOVA) with post hoc Bonferroni test. Statistical significance was accepted at $p < 0.05$. The results are shown in mean, standard deviation (SD), minimum, maximum and confidence interval (CI).

Results

Table 1 presents the ICC for the test-retest (familiarization x test) values of both conducted tests in this study. The ICC values were higher than 0.80, which is considered to be of high reliability.

Anthropometric profile

Table 2 presents the anthropometric characteristics of the athletes (body mass, height, body fat percentage and BMI). All anthropometric measurements were similar among the tactical functions, except midfielders that showed lower body fat percentage than defenders (F = 7.752; $p = 0.011$; 95% CI = -12.43 to -1.79).

Physical performance tests

Considering all players together (without discrimination of field positions), the values found were: T_{20} (4.85 ± 0.18 m/s), T_{square} (6.14 ± 0.47 s), distance covered (736.67 ± 311.11 m) and HRpeak (148 ± 16 bpm). No significant statistical

Table 1. Intraclass coeficient correlation for the test-retest (Familiarization x Test) in Brazilian amputee soccer players.

Variables	ICC	95% Confidence Interval		p
		Lower Bound	Upper Bound	
T20 (m/s)	0.872	0.567	0.963	0.001*
T_{square} (s)	0.990	0.954	0.997	0.001*
Distance covered (m)	0.996	0.939	0.999	0.001*

*$p<.05$

Table 2. Anthropometric characteristics of Brazilian amputee soccer players.

		$\bar{x}$	SD	95% Confidence Interval		Minimum	Maximum
				Lower Bound	Upper Bound		
Body Mass (kg)	Defenders	72.10	8.74	58.19	86.01	63.70	84.00
	Midfielders	60.58	15.59	35.77	85.38	45.00	81.00
	Forwards	66.38	15.74	41.33	91.42	43.80	78.70
	All groups	66.35	13.37	57.85	74.85	43.80	84.00
	F-ratio = 0.703		*P-value* = 0.520				
Height (m)	Defenders	1.74	0.03	1.70	1.78	1.70	1.76
	Midfielders	1.78	0.10	1.61	1.94	1.71	1.93
	Forwards	1.67	0.04	1.60	1.74	1.61	1.71
	All groups	1.73	0.08	1.68	1.78	1.61	1.93
	F-ratio = 2.715		*P-value* = 0.120				
BMI (kg/m^2)	Defenders	23.79	2.56	19.71	27.87	21.95	27.43
	Midfielders	18.96	3.15	13.95	23.97	15.39	21.75
	Forwards	23.63	4.76	16.06	31.20	16.90	27.88
	All groups	22.13	4.02	19.57	24.68	15.39	27.88
	F-ratio = 2.308		*P-value* = 0.155				
Body fat (%)	Defenders	19.10	2.58	14.99	23.20	16.65	22.31
	Midfielders	11.98**	1.24	10.01	13.95	10.22	13.13
	Forwards	16.11	3.40	10.70	21.52	11.14	18.64
	All groups	15.73	3.83	13.30	18.16	10.22	22.31
	F-ratio = 7.752		*P-value* = 0.011*				

*$p<.05$
** Statistical significant difference between Midfielders and Defenders (p = 0.011; 95% CI = -12.43 to -1.79)

differences were found between positions (Table 3).

HRpeak showed the lowest heart rate values (148±16 bpm) and highest values (191±9 bpm) for equation HR220. HRpeak observed in YYIRT1 was significantly lower (F= 55.438; p = 0.01; η^2 = 0.834) than all tested equations (Figure 3).

Discussion

The main findings of this study were: a) no significant differences were observed between anthropometric variables (except for body fat percentage, which was lower in midfielders) and physical tests performed (T20, Tsquare, YYIRT1) when compared to tactics functions for the amputees football players; b) HRpeak recorded at the end of the maximum intermittent test was significantly lower than all investigated equations for the prediction of HRmax.

Body composition is a difficult parameter to be measured because there is not specific protocol for this population. Furthermore, each disability generates individual consequences which can affect location of the body site for measurement. However, the determination of body composition is important to control individual training requirements for each athlete, and to maintain adequate levels of health (Short & Winnick, 2005). The results of body composition in this study were lower compared to recent investigations about this sport (Wilson et al., 2005; Gomes, Ribeiro, & Soares, 2006).

Wilson et al. (2005) founded body mass values (71.2± 13.2 kg) similar to seven athletes from the England Soccer Team for Amputee. Gomes et al. (2006) measured anthropometric profile and nutritional state in 15 athletes from the Brazilian Soccer Team for Amputees and reported values for body mass equal to: 67.2 ± 8.1 kg; height: 1.74.5 ± 4.5 m, and body fat: 14.4 ± 4.4 %. Some of these parameters were close to those found in the present study, i.e., body mass (66.35 ± 13.37 kg) and body fat (15.73 ± 3.83 %).

With regard to soccer, studies indicated (Reilly, Bangsbo, & Franks, 2000; McIntyre & Hall, 2005; Gomes et al., 2006) that midfielders athletes show lower body fat percentage compared with athletes of other positions. In the present investigation, midfielders showed lower values of body fat percentage when comapred to defenders. One explanation for this, is that midfielders also respond to great physical demands, which is observed when they cover the total field distance during a match (McIntyre & Hall, 2005; Bangsbo, Mohr, & Krustrup, 2006).

Studies investigating speed in football players demonstrated that the players typically sprint no further than 20-meters at a time (Little & Williams, 2005; Vescovi, Rupf, Brown, & Marques, 2012). Specifically in amputee football, we speculated that this also is the distance the athletes are able to cover, although they are also subjected to the mechanical stress from walking with Canadians crutches and the dimensions of the field.

Generally the distance used to evaluate agility is ~ 16 m and includes changes in directions every 4 meters. However, because different agility tests are commonly utilized, it is difficult to compare the results in the current literature. Moreover, at the present moment there is no clear and unified definition about agility (Svensson & Drust, 2005; Vescovi et al., 2012).

When comparing speed and agility between players of different field positions, we found no significant differences in the results. Our findings corroborate with those reported by Dunbar and Treasure (2005). They emphasize that speed, power and agility of lower limbs are not significantly different between the English Premier League soccer players of different field positions and levels of play.

Various studies have examined the performance of athletes in the Yo-Yo IR test (Krustrup et al., 2003; Bangsbo et al., 2008; Kloyiam, Breen, Jakeman, Conway, & Hutzler, 2011). Our results showed that the amputee soccer athletes performed distances that ranged from 200 -to 1.140 m (736,67 ± 311,11 m) in the YYIRT1. These results are lower when compared to those of professionals (Krustrup et al., 2003), amateurs (Castagna, Impellizzeri, Chamari, Carlomagno, & Rampinini, 2006) and international athletes with cerebral palsy from 7-a-side soccer (Kloyiam et al., 2011). This result

Table 3. Physical characteristics of Brazilian amputee soccer players.

				95% Confidence Interval			
		$\bar{x}$	SD	Lower Bound	Upper Bound	Minimum	Maximum
T20 (m/s)	Defenders	4.85	0.17	4.57	5.13	4.70	5.10
	Midfielders	4.85	0.06	4.76	4.94	4.80	4.90
	Forwards	4.85	0.30	4.37	5.33	4.70	5.30
	All groups	4.85	0.18	4.73	4.97	4.70	5.30
	F-ratio = 0.001	*P-value* = 1.000					
T_{square} (s)	Defenders	6.20	0.43	5.52	6.88	5.68	6.72
	Midfielders	5.82	0.63	4.82	6.82	4.98	6.36
	Forwards	6.40	0.15	6.15	6.64	6.17	6.50
	All groups	6.14	0.47	5.84	6.44	4.98	6.72
	F-ratio = 1.731	*P-value* = 0.231					
Distance covered (m)	Defenders	495.00	271.97	62.24	927.76	200.00	820.00
	Midfielders	880.00	212.29	542.20	1217.80	580.00	1080.00
	Forwards	835.00	343.07	289.09	1380.91	360.00	1140.00
	All groups	736.67	311.11	539.00	934.33	200.00	1140.00
	F-ratio = 2.246	*P-value* = 0.162					
HRpeak (bpm)	Defenders	142	19	113	172	120	160
	Midfielders	155	21	122	188	129	180
	Forwards	145	8	132	158	134	152
	All groups	148	16	137	158	120	180
	F-ratio = 0.665	*P-value* = 0.538					

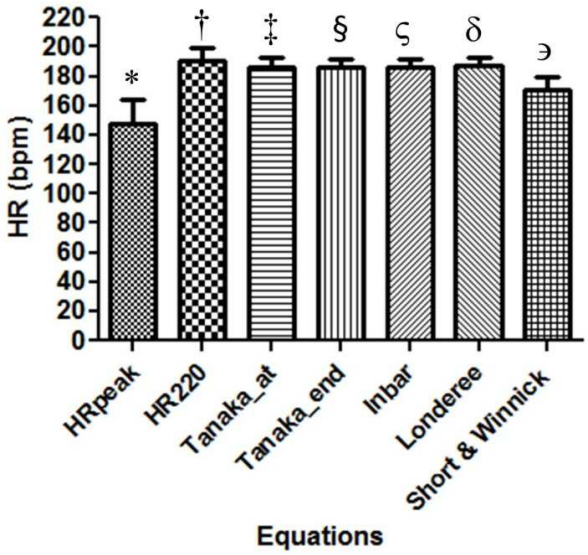

Figure 3: Heart rate values ($\bar{\chi}$ ±SD) obtained during YYIRT1 (HRpeak) and equations for predicting HRmax. *Significant difference between HRpeak and others equations; † HR220 and others equations; ‡ TNK-At and others equations; § TNK-End and others equations; ς INB and others equations; δ Londeree and others equations; ɜ Short and Winnick and others equations.

was expected, since the mechanics of running presented by these athletes while walking with crutches leads to limitations whne comaored to soccer players without disability. Moreover, energy expenditure during walking with crutches is approximately twice as high when compared to the normal gait (Mohanty et al., 2012), therefore, resulting in fatigue and decreased distance in the test.

It has been demonstrated that soccer players of different playing positions had obvious differences in the Yo-Yo test performance. Krustrup et al. (2003) demonstrated that the distance covered by midfielders was 13% further than defenders. In the present study, no significant statistical differences were found for the distance covered between players of different field positions. However, there was a tendency for midfielders to exhibit higher values of distance than other players of different positions. The explanation for this result is that the dimensions of the field in amputee soccer requires a link between defense and attack, demanding more time for running and other displacements.

The HR measure at the end of YYIRT1 provided information about the parameter behavior in amputee soccer players while performing maximal exertion. Interestingly, HRpeak values were lower (p <0.05) than all values from the formulas for predicting HRmax, including the specific formula for amputees. To our knowledge, it was the first study that compared HRpeak after an intermittent test with different equations for predicting HRmax.

Although it was not the goal of this study, probably the mechanisms that explain this lower HRpeak may be related to lower muscle mass found for this group (Glaser, Janssen, Suryaprasad, Gupta, & Mathews, 2004; Korkmaz, 2007), and to muscle fatigue of the upper limbs responsible for handling the crutches. Nevertheless, our findings (HRpeak lower than estimated) suggest that the values of equations should not be used to determine HRmax in amputee soccer players.

We conclude that the indicators of physical performance (speed, agility, distance and HR at the end of maximum intermittent test) did not differ significantly between the different tactical field function of the players; and the absolute cardiac response (HR) after intermittent effort was lower than the investigated HRmax prediction equations. Considering the novelty of our results, we believe that this information will help coaches, athletic trainers and other sport professionals from multidisciplinary teams working with amputee soccer athletes, better understand and interpret physical assessments and, consequently, develop more suitable training programs.

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