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original article

Aerobic power and jumps predict performance in intermittent running test in young indoor soccer players

Potencia aeróbia e saltos predizem desempenho de corrida intermitente em jovens jogadores de futsal

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Abstract – Indoor soccer is an intermittent modality, which requires high-intensity efforts of different demands such as aerobic and muscle power. Thus, the search for improvement of these requirements from mutual relations may be a relevant tool for the sport. This study attempted to correlate and calculate predictive equations for different physical fitness variables in intermittent effort protocols. Eighteen indoor soccer players (15 ± 1.3 years, 75.4 ± 20.2 kg, 167 ± 0.8 cm) were assessed for their ability to repeat sprints (from the Forward-Backward test), maximal aerobic power (MAP with the Yo-Yo Intermittent Recovery Test) and power of the lower limbs (triple horizontal jump, THJ). Pearson's test was used for correlations and the stepwise method for linear regressions. In addition to different significant correlation, considering performance at THJ and MAP, determination values of 44% to 64% for the capacity of repeating sprints were observed. In this context, THJ and MAP can predict the time spent in different series of repeated efforts ($p \leq 0{,}02$) and minimum, average and maximum power ($p < 0.05$). It was concluded that MAP and performance in THJ can determine and even predict the ability to repeat sprints.

Key words: Physical Education and Training; Physical Fitness; Young people; Prediction.

Resumo – *O futsal é uma modalidade intermitente, na qual se exige esforços de alta intensidade de diferentes demandas, como potência aeróbia e potência muscular. Dessa forma, a busca pelo aprimoramento dessas exigências a partir de relações entre si pode ser ferramenta relevante para o esporte. Buscou-se correlacionar e calcular equações preditivas para diferentes variáveis de aptidão física em protocolos de esforços intermitentes. Dezoito jogadores de futsal (15 ± 1,3 anos, 75,4 ± 20,2 kg, 167 ± 0,8 cm) foram avaliados quanto à capacidade de repetir corridas (a partir do Forward-Backward test), potência aeróbia máxima (PAM, com o Yo-Yo Intermitent Recovery Test) e potência de membros inferiores (salto horizontal triplo, SHT). O teste de Pearson foi utilizado para as correlações e o método stepwise para as regressões lineares. Além de diferentes correlações significantes, considerando o desempenho no SHT e de PAM, foram observados valores de determinação de 44% a 64% na capacidade de repetir corridas. Neste contexto, a PAM e SHT podem predizer o tempo em diferentes séries de esforços repetidos ($p \leq 0{,}02$) e potências mínima, média e máxima ($p<0{,}05$). Concluiu-se PAM e desempenho no SHT podem determinar e, inclusive, predizer a capacidade de repetir corridas.*

Palavras-chave: *Aptidão Física; Educação Física e Treinamento; Jovens; Predição.*

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INTRODUCTION

Indoor soccer is characterized as an intermittent sport due to the occurrence of high intensity efforts alternating with recovery periods with moderate- or mild-intensity activities, and the first type is crucial to the performance and competitive success in the sport modality[1]. It is noteworthy that the sport has nationwide reach, with over 300,000 records among adolescents and adults[2], so that there is need for professionals and qualified training practices for development to achieve optimal results.

Team sports show high-intensity short sprints that occur in a linear manner or with direction change lasting between 4 and 7 seconds, of which about 2 seconds are all-out, i.e. efforts at the highest possible intensity[3]. In addition, the effort: pause ratio (E: P) is 1: 6 and reaches 1:14, which suggests the occurrence of repetition of these actions, that is, the need to repeat them throughout the match. Although such data are scarce in indoor soccer, the distance traveled during matches is around 121 meters per minute, with 5% of the match time dedicated to high-intensity short sprints, 12% represent high-intensity sprints, totaling an average of approximately 79 seconds on high-intensity short sprints during a professional indoor soccer match[4].

Thus, improvements in the ability to resist fatigue in team sports such as indoor soccer may be associated with higher availability of oxygen and, in parallel, higher maximum aerobic power values[5]. Moreover, creatine phosphate resynthesis and the intracellular removal of inorganic phosphate are oxygen-dependent, suggesting that high levels of aerobic fitness can improve the ability to resist fatigue in this type of effort[6]. Furthermore, it is suggested that muscle power has an important contribution to the efficiency of the repetition of motor actions of indoor soccer such as sprints, decelerations and direction changes[7], since it is possible to store and use elastic energy as a result of repetition of concentric and eccentric movements required by indoor soccer, which is explained by the stretch -shortening cycle[8].

From indications that physical capabilities determinants of competitive success in indoor soccer such as repetition of high-intensity efforts, muscle strength and aerobic fitness, have affinity for each other[9], the attempt to optimize physical training considering such variables becomes relevant[10]. Thus, a better understanding of the relationship between variables may produce a significant impact with regard to the training methods performed due to the possibility of improving the practices developed. Therefore, the aim of this study was to quantify the correlation of physical fitness variables among young indoor soccer players and verify the prediction that muscle and maximum aerobic power has on the ability to repeat short sprints with direction changes.

METHODOLOGICAL PROCEDURES

Types of study and subjects involved

This is a cross-sectional observational predictive study[11] conducted in the city of Pelotas / RS, with the participation of young indoor soccer players of U-15 and U-17 categories. The following were the dependent variables: times of high-intensity short sprints, maximum, average and minimum power (absolute and relative, respectively, in W and W / kg), derived from the test that assessed the ability to repeat high-intensity short sprints. Independent variables were maximum aerobic power and performance (better measure and average of three attempts) in the triple horizontal jump test.

Young male individuals aged 14-17 years involved in this study should have at least two years of practice of indoor soccer and have weekly frequency of two to three sessions continuously in the last three months. Thus, the group was composed of 18 players, who were enrolled in the state level championship in the year of the study.

DESIGN

The project was approved by the local ethics committee (protocol 005/2012), and participants and their guardians signed the informed consent form. Procedures were performed in the same place of matches and training sessions under the supervision of coaches, physical trainers and teachers. With appropriate clothing and footwear for the practice of indoor soccer, players were evaluated on two different days, always in the afternoon (from 3:00 pm to 6:00 pm) and with three days of rest in between. During the week of collection, participants were asked not to perform intense exercise for the 24 hours prior to assessments and not to change their daily routines, including food.

On the first day of evaluations, the aims of the study were presented to subjects, who were also provided of clarification on the testing procedures. Additionally, anamnesis and instrument that assesses sexual maturation of young people from their secondary characteristics were also used[12]. Then, height and body weight were measured (stadiometer with accuracy of 0.1 cm and Filizola® scales with accuracy of 0.01 kg). Subsequently, warm-up protocol was initiated, which was composed of efforts with moderate to severe intensity - trot, dynamic stretches for lower limbs, vertical and horizontal jumps, high-intensity short sprints - with total duration of 10 minutes . After this initial part of activities, players were organized to perform the Forward-Backward of the Triple Horizontal Jump.

On the second day, subjects performed the same warm-up protocol and then performed familiarization with the Yo-Yo Intermittent Recovery Test protocol. Subsequently, the maximal aerobic power was measured. Coaches, all with degree in Physical Education, could follow evaluations at all times.

Procedures of Data Collection and Registration

Tests occurred in the indoor soccer court where players were used to perform their activities, with wooden floor of 30m x 15m in length and width, respectively. There was day division to conduct procedures with the Forward-Backward testing of the triple horizontal jump applied on the first day and the Yo-Yo Intermittent Recovery Test on the second day, with an interval of 72 hours between them. Data were recorded on custom evaluation forms and protocols used to evaluate the athletes were:

a) Forward-Backward test to measure the ability of participants to repeat high-intensity short sprints, which quantifies the time spent to run 35 meters at full speed, performed with linear displacements containing direction changes of 180 º at the highest possible intensity with distances of 9m, 3m, 6m, 3m, 9m and 5m, which are marked with cones (Figure 1). This course was performed six times at intervals of ten seconds between series[13]. During the test, the time was registered with the aid of photocells and a notebook (Multi-SprintFull Kit, HIDROFIT®, Belo Horizonte).

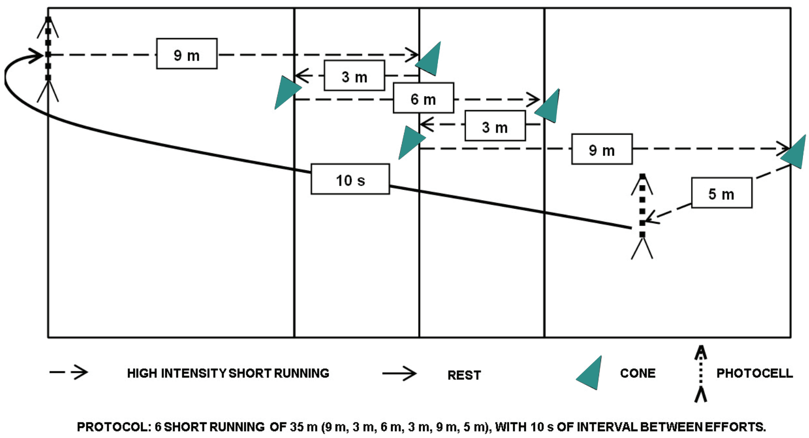

Figure 1. Forward-Backward test used to evaluate the ability to perform high-intensity short sprints.

b) Yo-Yo Intermittent Recovery Test (Level 1), to estimate maximal aerobic power[14], which can be used because it is a good measure of cardiorespiratory adjustments and sensitive to training in indoor soccer[15,16]. The player runs the longest possible time in a round trip scheme in space of 20 meters with intervals of ten seconds returning to the starting point[14]. Participants should perform the displacement at speed imposed by beeps, with lines marked on the floor, and the athlete's arrival must match the beep. The interval between beeps reduces each minute, forcing the player to slightly increase the speed (0.5 km / h per round). The review ends when asked by the athlete or when he is no longer able to follow the pace imposed by the test after two errors per stage[14]. The Yo-Yo Intermittent Recovery Test Level 1 has high reproducibility, showing intraclass correlation coefficient of 0.71[17]. With the known distance and the withdrawal stage, the maximal aerobic power is calculated with the formula: $VO_2max\ (mL{\bullet}min^{-1}{\bullet}kg^{-1}) = distance\ (m) \times 0.0084 + 36.4$.

c) Triple horizontal jump, used to assess the power of the lower limbs. The test has high reproducibility (r = 0.96) to assess athletes [18] and involves three jumps in sequence, and the second and third jumps should be applied as soon as the athletes touches his feet on the floor. The distance obtained was measured using measure tape, which was placed on the line of the tip of the athlete's foot at the starting position up to the greatest distance reached by the heel. Two consecutive attempts were performed, and the longest distance reached was considered as valid[18].

Data analysis

Data were analyzed using SPSS 16.0 software. The presentation of results was made with tables using mean and standard deviation (SD). Comparisons between age groups were made with the Student test or nonparametric equivalent (Mann-Whitney test), according to data normality, verified by the Shapiro-Wilk test. For differences between proportions, the chi-square test (χ^2) was used. Correlations were performed with the Pearson test. For multiple linear regressions and for the R^2 calculation, the stepwise procedure was used, which keeps in the predictive model only independent variables that show statistically significant correlation with the respective dependent variable[19]. The standard errors of estimates (SEE) and respective percentage in relation to the dependent variable were presented. Equations with % SEE equal to or less than 15% of the predicted value were assumed as valid. However, it is noteworthy that no reference values in literature were found to identify cutoff points as for the percentage to be accepted for % SEE. The significance level adopted was 5%.

RESULTS

The descriptive and physical test results are shown in Table 1. In relation to the sexual maturation characteristics, it was found that players of the child group were at stage four of maturation and those of the juvenile group, only two were at stage four, the others were at stage five.

Table 1. Descriptive values of physical fitness intermittent tests

	Mean	sd
Power of lower limbs		
Triple horizontal jump – Best (m)	6.72	0.68
Triple horizontal jump – Mean* (m)	6.47	0.61
Forward-Backward Test		
Sprint 1 (s)	11.70	0.56
Sprint 2 (s)	12.06	0.65
Sprint 3 (s)	12.51	0.66
Sprint 4 (s)	12.79	0.59
Sprint 5 (s)	12.98	0.59
Sprint 6 (s)	13.00	0.79
Absolute maximum power (w)	51.02	12.57
Relative maximum power (w/Kg)	0.77	0.11
Absolute maximum power (w)	42.08	9.25
Relative maximum power (w/Kg)	0.64	0.08
Absolute maximum power (w)	34.85	7.54
Relative maximum power (w/Kg)	0.53	0.08
Maximum Aerobic Power ($mL \cdot Kg^{-1} \cdot min^{-1}$)	46.7	2.8

* Average of three attempts

Table 2 shows the significant correlations between the different variables, and height was correlated with the triple jump performance and production of absolute power (maximum, average and minimum) in the Forward-Backward test. The best sequence of jumps is positively correlated with average and minimum power, and the sequence of jumps with age and maximum, minimum and average power in the Forward-Backward test. Maximum aerobic power was correlated with the running time in the 2, 3, 5 and 6 sprints, together with the mean relative power.

With respect to the determination values found in regression models, Table 3 presents the dependent variables using equations and independent values with respective R^2 and statistical significance values.

Table 2. Significant correlations among the different variables measured.

Variable 1	Variable 2	r	p
Best sequence of jumps	Mean value of the sequence of jumps	0.95	0.00
	Mean Absolute Power	0.57	0.01
	Mean Relative Power	0.54	0.02
	Mean Absolute Power	0.60	0.01
Mean value of the sequence of jumps	Mean Absolute Power	0.59	0.01
	Mean Absolute Power	0.71	0.001
	Mean Relative Power	0.57	0.01
	Mean Absolute Power	0.71	0.001
	Age	0.59	0.01
Maximal Aerobic Power	Forward-Backward – Sprint 2	-0.58	0.01
	Forward-Backward – Sprint 3	-0.57	0.01
	Forward-Backward – Sprint 5	-0.50	0.04
	Forward-Backward – Sprint 6	-0.68	0.001
	Mean Relative Power	0.57	0.01

r = correlation coefficient; p = significance value.

Table 3. Predictive equations and respective determination values according to the regression model.

Dependent V ariables	Independent Variables	R^2	SEE (%)	F	p-value
Forward-Backward – Sprint 2 (s)	19.7 - (0.11• Maximum Aerobic Power) - (0.48• Triple horizontal jump – Mean) - (0.11• Triple horizontal jump – Best)	0.44	0.5 (4)	3.6	0,040
Forward-Backward – Sprint 3 (s)	20.2 - (0.11• Maximum Aerobic Power) - (0.74• Triple horizontal jump – Mean) - (0.31• Triple horizontal jump – Best)	0.46	0.5 (4)	3.9	0,030
Forward-Backward – Sprint 5 (s)	17.9 - (0.03• Maximum Aerobic Power) + (0.13• Triple horizontal jump – Mean) - (0.62• Triple horizontal jump – Best)	0.41	0.5 (4)	3.2	0,050
Forward-Backward – Sprint 6 (s)	22.7 - (0.18• Maximum Aerobic Power) - (0.21• Triple horizontal jump – Mean) - (0.36• Triple horizontal jump – Best)	0.49	0.6 (5)	4.5	0,020
Mean Absolute Power (w)	-21.1 - (0.23• Maximum Aerobic Power) + (28.7• Triple horizontal jump – Mean) - (16.7• Triple horizontal jump – Best)	0.64	6.1 (14)	8.1	0,002
Mean Relative Power (w/Kg)	-0.3 + (0.01• Maximum Aerobic Power) + (0.05• Triple horizontal jump – Mean) + (0.06• Triple horizontal jump – Best)	0.52	0.06 (9)	4.9	0,010
Minimum Absolute Power (w)	-18.5 - (0.13• Maximum Aerobic Power) + (19.3• Triple horizontal jump – Mean) - (9.7• Triple horizontal jump – Best)	0.58	5.4 (15)	6.3	0,006

R^2 = Determination coefficient. SEE (%) = estimate standard error and % SEE in relation to predicted dependent variable. F = Value of the analysis of variance test.

DISCUSSION

The main aim of this study was to relate different physical fitness variables of indoor soccer players from two different basic categories and the most significant findings indicate that maximum aerobic power and performance in the triple horizontal jump exhibit determination scores from 45% to 60% of the capacity to perform high-intensity short sprints. The prediction values of dependent variables found in the study can be especially justified: i) by the Stretch-Shortening Cycle and; ii) in the relationship that aerobic power may have with the ability to repeat high-intensity short sprints, considering that this is a task with characteristic predominantly of aerobic source[3,8]. Although the Forward-Backward and YYIRT protocols include direction changes in 180°, it is unlikely that the necessary requirements for direction changes significantly contribute to the findings, given that at every effort made, the Forward-Backward test displays five changes and the YYIRT only one. In addition, the distance traveled so far up to the moment of direction exchange is variable and reasonably lower in tests. These two factors are related to the way force is applied at the time of direction change, which indicates relevant differences between protocols[20].

The stretch-shortening cycle is a phenomenon explained by the storage of potential elastic energy as a result of the mechanical energy arising from the eccentric action of a muscle group, and this energy stock is used in rapid and subsequent concentric action[8]. At the transition moment from stretching to shortening, the cycle peak, it is possible that greater force is applied due to the isometric condition; furthermore, since the increase in force occurs during the eccentric phase of the movement, there is more time for the development of force, which is exemplified by the performance of jumps in counter movements with the aid the upper limb[21]. The peripheral mechanism that allows the occurrence of the stretch-shortening cycle is directly related to the ability of elasticity capacity of components of the muscle-tendon unit, that is, how much the structure of tendons and muscle components are able to undergo deformation and use the stored energy during a short-duration motor task[22].

Neural elements are related to the myotatic reflex (reflex stretching), performed by muscle spindles, and to the Golgi tendon reflex, performed by the Golgi tendon organs[22]. They are back fed, participate in the modification of muscle components due to movements, acting on the control of these changes in a counterbalanced way, and have variable activation intensities, and the intensity that indeed activates the muscle consists of a combination of these two neural elements[21]. This phenomenon is common to many team sports, which use intermittent efforts that include complex motor tasks, with reduced execution time and held at maximum intensities.

In relation to the relationship between aerobic fitness, characterized here by maximal aerobic power, and the ability to repeat high-intensity short sprints, the results have confirmed data from literature: short-duration and high-intensity exercises performed intermittently or with intervals have significant participation or predominance of the aerobic component[3,5,23]. Therefore, sports training addresses specificity and, therefore, team sports have their dynamic of activities in E: P, then, the contribution of energy systems should be applied considering this characteristic. However, in the early past and even today, this interpretation is not being properly observed by researchers and trainers working with MEC and other sports[24-26].

When assessing the energy contribution during short sprints, oxidative metabolism has little involvement[3,6]; however, as this motor gesture is repeated after recovery intervals, this energy system has high contribution, especially in the last stages[5,6,27]. Such evidence can be seen in Table 2, since after the first effort, four out of five sprints had an important participation of the aerobic metabolism, in addition to the mean and minimum powers, which are obtained after or including the first effort (usually, the best performance). Another aspect that reinforces the relationship between these variables is the fact that studies show results indicating that the increase in power and / or aerobic fitness is reflected in improved ability to repeat sprints[25,27,28]. It is noteworthy that the maximum aerobic power is an aerobic fitness component and therefore general changes in fitness (e.g., economy in the oxygen kinetics; VO_2max speed) may directly or indirectly reflect in VO_2max [3,5,28] and in the ability to repeat high-intensity short sprints[3,6,28].

The three protocols were used to measure power of young indoor soccer players of the basic categories through different motor tasks. According to the results, it was possible to identify when the ability to repeat high-intensity short sprints are adequate or unsatisfactory through performance in tasks involving jumping and motor actions that require significant participation of the aerobic component. Furthermore, a certain level of dependency between tasks could be verified, or during training, these activities are complementary and auxiliary, thus, tend not to compete.

The use of indirect protocols to measure physical fitness variables is a study limitation. However, the approach to the principle of specificity contributes to the understanding that the evaluation should occur from more specific protocols of efforts found in indoor soccer[15,16]. Thus, the use of field protocols is relevant to improve the understanding of features required by this practice and allows collecting information in environment more familiar for players, both for familiarization as for practice[14]. This allows the approach between practical reality and the field of scientific study. Another point is the absence of measures related to the level of specific skills of indoor soccer[29], which may represent the absence of parameters when characterizing and comparing the young people involved in this study[30]. In addition, the number of subjects present in this investigation can be considered low; however, the study selected athletes from basic categories in better conditions than other practitioners of the sport because the competitive and training level of players of this study is reference in the region.

CONCLUSION

The results of this study indicate moderate to strong correlations found among some of the intermittent effort variables measured in this study. In addition, important and significant determination values and respective predictive equations were obtained, showing that the muscle power of the lower limbs as measured by the triple horizontal jump and maximal aerobic power can influence the ability to repeat high-intensity short sprints.

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