Correlation between direct and indirect $\dot{V}O_{2max}$ measurements in indoor soccer players

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ABSTRACT

The importance of the morphofunctional qualities to greater efficiency in sports has increased the interest on the improvement on the physical fitness levels of athletes. However, not many studies on the physiological variables of indoor soccer are available in the world scientific literature. Thus, the objective of this work was to verify the existence of correlation between the direct and indirect $\dot{V}O_{2max}$ measurement tests in indoor soccer players. Thirteen indoor soccer players with age of 18.6 ± 1.9 years, height of 177.1 ± 3.5 cm, weight of 68.5 ± 9.5 kg and body mass index (BMI) of 21.7 ± 2.3 kg/m^2 were analyzed. For the direct $\dot{V}O_{2max}$ measurement, the computerized ergospirometric system was used (*VO-2000*, Aerosport, Medgraphics, St. Paul, Minnesota) and for the indirect $\dot{V}O_{2max}$ measurement, the 3,200 m field test was performed. The statistical analysis was elaborated through the t-Student test for paired samples and through the Pearson correlation coefficient. The $\dot{V}O_{2max}$ values obtained in the direct measurement test presented no significant differences in relation to the indirect measurement (62.8 ± 10.1 vs. 58.5 ± 8.5 ml/kg/min, respectively). When the $\dot{V}O_{2max}$ values obtained in both tests were correlated, a strong correlation (r = 0.72) was observed. In short, the indirect measurement tests presented good acceptance among indoor soccer players due to the high correlation with the direct measurement tests, the low cost and the attainment of important information that will be helpful in the training prescription and follow-up.

Key words: Aerobic capacity. $\dot{V}O_{2max}$ prediction tests.

INTRODUCTION

The importance of the morphofunctional qualities to greater efficiency in sports has increased the interest on the improvement on the physical fitness levels of athletes. However, not many studies on the physiological variables of indoor soccer are available in the world scientific literature.

Just like field soccer, the indoor soccer is also a sportive modality characterized by varied-extension and random-periodicity intermittent efforts. The current indoor soccer requires high-intensity and short-duration efforts, what distinguishes this sportive modality from other high-level ones[1,2]. The agility of the events and actions during an indoor soccer game requires the athlete to be prepared to react as fast and effective as possible to the most different stimuli[3].

The specific work on the energy supply aerobic system aims at increasing the individual cardiovascular resistance, what is extremely important in the physical preparation of indoor soccer players. The determination of this parameter is based on the calculation of the maximum oxygen intake ($\dot{V}O_{2max}$) that, for professional soccer players, ranges from 55 to 65 ml/kg/min[4]. The development of the aerobic capacity is one of the factors that determine the performance of these athletes during a game.

With regard to the $\dot{V}O_{2max}$ measurement, there are two methods that present advantages and disadvantages: the direct and indirect methods. The direct $\dot{V}O_{2max}$ measurement is performed by submitting the individual to an ergometric test with progressive loads and analyzing the exhaled oxygen and carbon dioxide fractions during effort as well as the pulmonary ventilation. This measurement provides a more reliable result; however, this method presents high cost in relation to the indirect measurement and requires sophisticated equipments and qualified labour to conduct the tests; longer time spent with each appraised, and also requires higher motivation from the individual, once it is generally performed in laboratory environment[5]. With regard to the indirect $\dot{V}O_{2max}$ measurement, the so-called field tests may be used, where the calculation of this variable is performed through equations based on preestablished time or distance. In this case, several individuals may be evaluated with low cost at once, and the test conditions, in some cases, are the closest from situations of practice and specificity of the sportive modality. However, its accuracy is many times questioned, once many of these equations are specific for predetermined groups (ex.: white sedentary men, black athlete women, etc)[6].

Considering the different metabolic systems and energetic demands required in the indoor soccer and the lack of data on the physiology of this sport, the objective of the present study was to correlate direct and indirect $\dot{V}O_{2max}$ measurements in indoor soccer players.

MATERIAL AND METHODS

Sample

Thirteen male indoor soccer players with age of 18.6 ± 1.9 years, height of 177.1 ± 3.5 cm, weight of 68.5 ± 9.5 kg and body mass index (BMI) of 21.7 ± 2.3 kg/m^2 participated in the present study. After being informed of the objectives of the study and of its possible benefits and risks, the subjects signed a consent term (resolution 196/96 of the National Health Council), previously approved by the Agamenon Magalhães Hospital Ethics Committee.

Experimental procedure

Direct $\dot{V}O_{2max}$ measurement

The experiments were conducted between 2:00 pm and 5:00 pm with room temperature kept between 22 and 24ºC, barometric pressure of 760 mmHg and air relative humidity of 55%. In the day before the test, the participants were asked to remain at least 24 h without performing any type of exhausting exercise.

Initially, with the individual on the treadmill (*Inbramed Millennium*, model ATL, Porto Alegre, RS, Brazil), the blood pressure (BP) was measured using the auscultatory method as well as the heart

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rate (HR), through electrodes (*Micromed*) placed at the manubrium, right and left iliac crest (derivation CM_5). The electrodes were connected to an electromyography equipment (*Micromed*®) and the HR values were visualized through the *Elite* software (Micromed Biotechnology, Brasilia, Brazil).

Later, the individual was connected to a metabolic gas analyzer (*VO-2000*, Aerosport, Medgraphics, St. Paul, Minnesota) through which the gas samples were collected and measured each 10 seconds during the test. The participants were submitted to ramp protocol with initial velocity of 5.0 km/h (0% of inclination), progressive increments, final velocity of 17 km/h (5% de inclination) and duration equal to 10 minutes or until voluntary exhaustion.

The criteria considered for the $\dot{V}O_{2max}$ calculation were at least two from those mentioned below:

- ✓ Establishment of a flat on the oxygen intake curve in relation to the load;
- ✓ Gas exchange ratio ≥ 1.0;
- ✓ Physical exhaustion.

Indirect $\dot{V}O_{2max}$ measurement

For the indirect $\dot{V}O_{2max}$ measurement, the 3,200 m field test was used through the formula:

$$\dot{V}O_{2max}\ (ml.kg.min) = 118.4\text{-}4.774\ (T)^{(7)},$$

where: T = time in minutes and decimal fraction of 3,200 m.

The test was performed in a 1,000 m track between 4:00 pm and 5:00 pm at different days and with minimum interval of two days and maximum interval of five days after treadmill test. In the day before tests, the athletes were oriented not to perform exhaustive physical activities, not to drink alcoholic beverages and not to smoke.

The volunteers were divided into groups of five individuals and the time obtained during the circuit was recorded through chronometer.

Statistical analysis

In order to verify the presence of correlation between direct and indirect $\dot{V}O_{2max}$ measurement tests of indoor soccer athletes, the Pearson (r) correlation coefficient was used, and to check the presence of significant differences between the $\dot{V}O_{2max}$ average values in the direct and indirect measurements, the Student's *t* test for paired samples was used. The results were expressed as average ± standard deviation (A ± SD). The value $p < 0.05$ was considered as statistical significance level.

RESULTS

Figure 1 shows a strong correlation (r = 0.72) between $\dot{V}O_{2max}$ values obtained in the direct and indirect measurement tests of indoor soccer athletes.

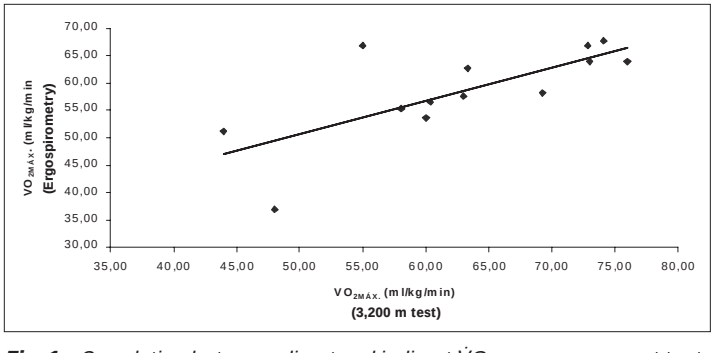

***Fig. 1** – Correlation between direct and indirect $\dot{V}O_{2max}$ measurement tests in indoor soccer players. N = 13; $p < 0.05$; r = 0.72*

In figure 2, no significant differences were found between $\dot{V}O_{2max}$ values in the direct and indirect measurements.

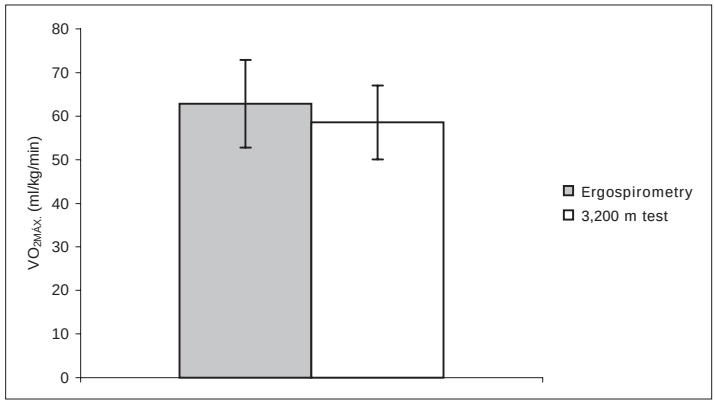

***Fig. 2** – Comparison between direct and indirect $\dot{V}O_{2max}$ measurement tests in indoor soccer players. N = 13*

DISCUSSION

The physical conditioning of indoor soccer players, as in other sportive modalities, is one of the factors that influences the performance and the results reached in competitions. According to Ekblom[8], although the aerobic resistance is not a determinant element, it strongly influences the performance and the team's competitive level. Some researchers believe that, the higher the team's cardiovascular capacity, the better the competitive performance will be[8,11]; however, there are controversies with this regard. Faina *et al.*[12] reported higher $\dot{V}O_{2max}$ values in Italian amateur soccer players when compared to professional ones. It is important emphasizing that when a $\dot{V}O_{2max}$ value above 70 ml/kg/min is obtained, the velocity reached by the player may be impaired. This may be explained by the fact that with high $\dot{V}O_{2max}$ levels, the individual works and develops preferentially fibers type I (slow fibers) that act under aerobic metabolism[14].

According to our results, the values of the indirect $\dot{V}O_{2max}$ measurement for indoor soccer athletes were of 58.5 ± 8.5 ml/kg/min. These data are similar to those found by Souza[9], studying field soccer players of the same age range. Despite the fact that these modalities are performed in distinct environments, the metabolic requirements are similar, what justifies these findings. With regard to the direct $\dot{V}O_{2max}$ measurement, values of 62.8 ± 10.1 ml/kg/min were found in the present study and were similar to those reported by Jones and Helmes[10], who studied soccer players with ages ranging from 14 to 18 years and verified that the $\dot{V}O_{2max}$ value ranged from 55.1 to 61.1 ml/kg/min.

When both tests were correlated to predict $\dot{V}O_{2max}$ (figure 1), a strong correlation was verified (r = 0.72), suggesting that the use of 3,200 m field test may be valid to determine the maximum oxygen intake in indoor soccer players. When both types of measurement were compared, no significant differences were observed in the $\dot{V}O_{2max}$ measurements obtained in the 3,200 m test compared to the ergospirometry (figure 2). When evaluating the field test and laboratory procedures to determine the aerobic performance in soccer players, Bangsbo and Lindquist[14] reported strong correlation indexes between field and laboratory tests for these athletes. Grant *et al.*[15] compared the $\dot{V}O_{2max}$ results obtained through the shuttle run progressive multi-stages Cooper test and through the submaximal cycle ergometer direct measurement test in healthy men, and verified higher accuracy in values provided by the Cooper test. The field tests showed to be more reliable in relation to the submaximal laboratory test, fact that may be attributed to the familiarity and motivation of individuals in places where field tests were usually performed, once, despite not being athletes, all participants performed regular physical exercises. The similarity of the test with the activity the athlete practices should be considered in the evaluation moment, once this fact may influence the results

obtained. However, a laboratory test correctly conducted and with the control of the variables involved will also provide reliable results. In this case, the loads will be increasingly administrated with accuracy in order to reach the maximum oxygen intake[16].

The main limitation of this study was the lack of an indirect $\dot{V}O_{2max}$ measurement field test specific for indoor soccer that would reproduce the sport's specificity with higher accuracy. Thus, differences that, by chance, have not been detected, when the results obtained in the 3,200 m test were compared with results obtained through ergospirometry, could become evident.

CONCLUSION

The use of physiological variables has obtained prominence with regard to the improvement and development of the performance of athletes among the most different types of sport modalities, although we have concluded that the factors that determine the sportive performance are complex and involve a series of biochemical, physiological, genetic, anatomical-morphological and psychological factors.

According to results of the present work, we have concluded that the indirect $\dot{V}O_{2max}$ measurement tests present strong correlation with the direct measurement tests. Thus, one concludes that the use of 3,200 m field tests may allow the determination of the aerobic capacity of these athletes.

Furthermore, the indirect measurement is easy to be applied and presents low cost in relation to the direct one, providing the collection of practical data that consider the biological individuality of the players, improving performance and increasing the team's competitive level.

All the authors declared there is not any potential conflict of interests regarding this article.

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