ANALYSIS OF THE CORRELATION BETWEEN POLAR FITNESS TEST® PROTOCOL AND ERGOSPIROMETRY

EXERCISE AND SPORTS SCIENCES

ORIGINAL ARTICLE

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ABSTRACT

Introduction: The importance of maximal oxygen consumption ($\dot{V}O_{2max}$) measurement is justified by its international acceptance as the best physiological parameter to assess the functional capacity of the cardiorespiratory system in both athletes and non-athletes who physically train in order to achieve better health. Objective: To determine the agreement between the Polar Fitness Test® protocols to estimate of $\dot{V}O_{2max}$ and the maximal exercise test with direct gas measurement. Methods: Seventeen active males (22.5 ± 2 years) participated in the study. At rest, the Polar Fitness Test® protocol by direct gas collection under maximum effort on treadmill and the Bruce protocol were applied. Results: Significant difference in the $\dot{V}O_{2max}$ estimation was observed between methods. The Polar Fitness Test® protocol underestimated $\dot{V}O_{2max}$ a mean of 15% ($CI_{95\%}$: 24;-53%) when compared to the direct protocol. The values obtained by the Polar Fitness Test® did not correlate well with direct measurement in ergospirometer (r = 0.1). Conclusion: The Polar Fitness Test® protocol is not valid to estimate $\dot{V}O_{2max}$ in physically active young men.

Keywords: efficiency, oxygen consumption, ergospirometer, estimation, heart rate.

INTRODUCTION

The importance of the oxygen maximum consumption ($\dot{V}O_{2max}$) measurement is justified by its international acceptance as the best physiological parameter for evaluation of the functional capacity of the cardiorespiratory system both in athletes[1,2] and in non-athletes who physically train with the goal to obtain better health[3]. Moreover, it has also been used as basis for the prescription of physical exercises in individuals with non-transmissible chronic diseases such as diabetes[4].

Aerobic power can be determined in experimental laboratories through pricy ergometers (treadmills, bicycles, etc) and with direct measurement in spirometers, during exercise[5]. However, in practice, simple evaluations as the ones performed on benches, tracks or moving treadmills are also efficient, of low cost and of great viability and practicality in their application[6-8]. The indirect estimations represent a useful instrument available both to the coach and athlete, especially for being based on observations collected in real environment, with all the influence factors being present, rather than in closed laboratory conditions[9]. However, appropriate measurement devices, reliable and valid, are necessary[10]. Moreover, it is known that the maximum aerobic power varies according to the body weight, physical activity habits, age and sex[5,11].

The protocol called Polar *Fitness Test*® proposes the prediction of the $\dot{V}O_{2max}$ testing the individual at rest and is based on the use of the HR variability (HRV). The HRV is the variation which occurs between successive heart beats in sinus rhythm. Since the frequency meter used in the Polar *Fitness Test*® is able to record the HRV signals, which are obtained from the record of the RR intervals, it is possible to estimate the $\dot{V}O_{2max}$. Such estimation occurs due to the traditional physiological effect of the aerobic physical training, which is the highest stimulation of the parasympathetic nervous system at rest. Consequently, there is also increase of the autonomic modulation and of the HRV[(12)].

Thus, this protocol (Polar *Fitness Test*®) enables the application of the $\dot{V}O_{2max}$ test in some situations in which there are not standardized instruments for this purpose and/or in individuals not apt to perform maximal or submaximal tests. It is evident that it would be useful in some occasions.

Therefore, the Polar *Fitness Test*® protocol estimates the $\dot{V}O_{2max}$ value from a "artificial neural web", having as entrance variables: age, sex, height, weight, level of physical activity and HRV[13].

Data collection through the Polar *Fitness Test*®, besides being a portable, rapid and cheap method for measurement of the $\dot{V}O_{2max}$, can encourage future research. However, comparisons between the direct method with gas analysis and the protocol under consideration which validated it have not been systematically studied. Thus, this study had the aim to verify the concordance between the Polar *Fitness Test*® protocol for estimation of the $\dot{V}O_{2max}$ and the maximum exertion test with direct gas analysis, in male, active individuals aged between 19 and 27 years.

MATERIAL AND METHODS

This research was approved by the Ethics in Research in Humans Committee of the Federal University of Juiz de Fora (UFJF) under the document number 171/2008. Additionally, all participants were informed about the aims and potential risks involved in this study and signed the Free and Clarified Consent Form.

In order to participate in the study, the individuals should meet the following inclusion/exclusion criteria: male sex, nonsmoker, not to have cardiovascular diseases and other diseases which could hamper participation in the maximal physical tests and who used any kind of medication at the time of the study. Moreover, the level of physical activity should be classified above 2 according to table 1[14].

Out of the 29 volunteers, 17 met the criteria described and hence were selected. The sample characterization is illustrated in table 2.

The individuals were initially submitted to anamnesis and anthropometric measurement. After that, they remained at supine position (rest) for five minutes and the Polar *Fitness Test*® (Polar® frequency meter, model RS800) protocol was applied, which uses age, sex, stature, body mass and level of physical activity by self-evaluation (table 1).

The maximal exertion test on treadmill (KT-10200 ATL, Inbramed®), following the Bruce protocol[11,15], using a gas analyzer (Teem 100/Inbrasport®), was performed in the Laboratory of Motor Evaluation of the Physical Education College of the UFJF.

Table 1. Classification of the level of activity, according to the Polar Fitness Test®[14].

Level	Weekly physical activity
1 Low	< 30min
2 Medium	30 to60min
3 High	60 to 180min
4 Maximum	> 180min

Table 2. General characteristics of the participants.

	Mean	SD	Minimum	Maximum
Age	22.4	2.0	19	27
Weight	71.7	10.0	49.1	93.7
Height	177.7	8.4	158.8	189.6
%F	8.6	3.9	3.5	16.7
HR_{Re}	60.5	7.9	45	78

We can mention the time of duration of the stage, constant in three minutes, the work velocity ranging between 1.7 and 6.0MPH (2.73 to 9.65km/h) and constant increase of inclination in 2% (1.8°)[11,15] as the most important characteristics of the protocol. It is also an exertion test with a realistic estimation of the maximal aerobic power[16]. In order to confirm the test as maximal, a secondary criterion was used, namely respiratory exchange (R) above one (1.0)[17].

At the end of the maximal exertion test, the following values were recorded: HR_{max} and $\dot{V}O_{2max}$ peak (the highest oxygen uptake value measured during the test[17]).

STATISTICAL ANALYSIS

In order to analyze the concurrent validity of the prediction method in comparison to the direct method for estimation of the $\dot{V}O_{2max}$, the means were compared with the paired Student's *t* test (95% of significance), Pearson linear correlation and determination correlation (R^2) were also used. Concordance between measurements was determined with the use of correlation and intraclass coefficients. Additionally, the mean difference (MD) and the estimation standard error (ESE) between the techniques and the dispersion analysis of the residuals were analyzed.

RESULTS

Table 3 presents the results of the concurrent validity of the prediction method (Polar *Fitness Test*®) in comparison to the direct method to estimate the $\dot{V}O_{2max}$. Significant difference has been found ($p < 0.01$) between means, where MD = −7.0ml/kg/min. The correlation between the methods was of r = 0.09 (p = 0.742). The R^2 indicates that less than 1% of the predicted $\dot{V}O_{2max}$ was explained by the direct $\dot{V}O_{2max}$.

Low concordance level was observed in the estimations, being 0.06 ($CI_{95\%}$: −0.23 to 0.43) and 0.06 ($CI_{95\%}$: −0.27 to 0.37) for the intraclass correlation and concordance coefficients, respectively.

Figure 1 indicates that the mean error between the direct and prediction methods was of 14.8% ± 19.7% and $CI_{95\%}$ of 23.9%; −53.4% (concordance threshold).

Table 3. Concurrent validity analysis of the prediction method for the estimation of $\dot{V}O_{2max}$ (mL.kg.min^{-1}).

Methods	Mean	SD	r	R^2	MD
VO_{2max} Direct	52.1	6.4	0.09	0.008	−7.0*
VO_{2max} Polar[1]	45.1	7.5			

MD = mean difference; r = correlation coefficient; r^2 determination coefficient; [1]VO_{2max} obtained by the *Polar Fitness Test*® *$p < 0.01$ (Paired Student's *t* test).

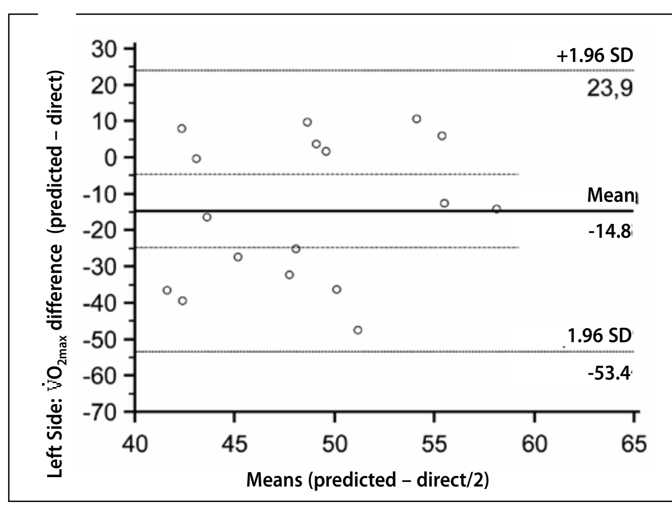

Figure 1. Analysis of the residual scores obtained by the prediction and direct methods. The continuous line represents the mean error and the traced line represents the mean error and the confidence interval (95%).

DISCUSSION

The aim of this investigation was to verify the concordance between the Polar *Fitness Test*® and direct maximal exertion tests in physically active men. Our results showed that there is no concordance between the two analyzed protocols.

The test considered gold standard for determination of the $\dot{V}O_{2max}$ involves direct gas exchange analysis[17] and this procedure was performed in this study, which provides high reliability to our results. Likewise, for comparison with the Polar *Fitness Test*® protocol all recommended guidelines have been followed[13,14]. Concerning the values found in our sample, the $\dot{V}O_{2max}$ values obtained by the direct method (52.1 ± 6.4mL.kg.min^{-1}) demonstrated that the participants can be really considered physically active[18], which is in agreement with our exclusion and inclusion criteria.

According to Kinnunen *et al.*[13], the result of the validation test of the frequency meter presented high correlation coefficient of 0.8 with maximal tests on treadmill. In the present study, the results demonstrated that there was significant difference between the VO_{2max} means in the methods proposed, direct and prediction by the Polar *Fitness Test*®. It is important to highlight that the errors in the $\dot{V}O_{2max}$ estimation by the direct and prediction methods (figure 1) suggest that the means in differences (14.8% ± 19.7%) are high and the $\dot{V}O_{2max}$ variations are extreme, since 95% of the sample presents error between 24% and –53% (variation of 77%), evidencing hence that the equation proposed by the Polar *Fitness Test*® is not suitable to estimate the $\dot{V}O_{2max}$. Low concordance was confirmed by the correlation and intraclass coefficients. Our results corroborate the findings by Kruel *et al.*[19], who found in 61 physical education students, healthy and non-athletes, aged between 18 and 24 years, high protocol reproducibility, but unfortunately not valid due to its questionable accuracy.

Errors measured by the Polar *Fitness Test*® may occur because one of the entrance variables (level of physical activity) is self-evaluating (1 to 4) triggering important differences in the $\dot{V}O_{2max}$ calculation. Although the Polar *Fitness Test*® protocol uses the fact established in the literature that the HRV is higher at rest in well-trained individuals when compared to sedentary ones[12,20] and therefore, there is correlation between higher $\dot{V}O_{2max}$ values and HRV at rest, our results showed that such association is not highly accurate. Thus, in situations in which the absolute $\dot{V}O_{2max}$ values need to be extremely exact, as in high performance athletes, the use of the Polar *Fitness Test*® seems inappropriate.

Nevertheless, a possible application of the Polar *Fitness Test*® protocol would be the viability of its use at rest conditions (injured individuals or with high risk to maximal tests), in case there is good agreement with the real values in the sample group to be applied. In addition to that, good reproducibility already demonstrated by Kruel *et al.*[19] would enable the identification of possible alterations in the $\dot{V}O_{2max}$ in situations in which maximal tests are not suggested, such as in the middle of the competition season of athletes, allowing hence better adjustment of the training load.

CONCLUSION

It can be concluded that the Polar *Fitness Test*® protocol does not present agreement with the maximal exertion test on treadmill, when using a homogeneous sample of active and young individuals and it tends to underestimate the $\dot{V}O_{2max}$ values. Studies with larger samples, non-homogeneous populations are necessary in order to have this $\dot{V}O_{2max}$ estimation protocol validated.

All authors have declared there is not any potential conflict of interests concerning this article.

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