Journal of Exercise Physiologyonline

February 2015
Volume 18 Number 1

Official Research Journal of the American Society of Exercise Physiologists

ISSN 1097-9751

JEPonline

Cross Validation of Different Equations to Predict Aerobic Fitness by the Shuttle Run 20 Meters Test in Brazilian Students

Carlos Ernesto[1,3], Francisco Martins da Silva[2], Lilian Alves Pereira[3], Gislane Ferreira de Melo[1,4]

[1]Professor MSc. Curso Educação Física Universidade Católica de Brasília, Brazil; [2]Professor Dr. Universidade Federal da Paraíba, João Pessoa, Brazil; [3]Laboratório de Avaliação Física e Treinamento – LAFIT, Universidade Católica de Brasília, Brazil; [4]Professora Dra. Programa Pós Graduação em Educação Física Universidade Católica de Brasília, Brazil

ABSTRACT

Ernesto C, Silva FM, Pereira LA, Melo GF. Cross Validation of Different Equations to Predict Aerobic Fitness by the Shuttle Run 20 Meters Test in Brazilian Students. **JEPonline** 2015;18(1):46-55. Indirect cardiorespiratory fitness (CF) tests have been proposed as a feasible alternative to predicting aerobic fitness. Regardless of feasible use of Shuttle Run 20 meters test (SR20m Test) in Brazilian schools, to date no study has investigated the validity of the main equations in predicting the VO_2 max by SR20m in Brazilian schoolchildren. Ninety Brazilian students 13 to 17 yrs of age (38% male, 62% female) participated in this study. All subjects performed an Incremental Treadmill Test with gas analysis (TT) to determine VO_2 max and the SR20m Test on different days. VO_2 max obtained from the TT was compared to the VO_2 max predicted by SR20m using 3 different equations (Léger, Kuipers, and Barnett). The findings indicate that for the males only, the equation by Léger was different compared to TT (P=0.023) with a strong correlation between TT and all the equations (Léger = 0.76; Kuipers = 0.75; Barnett = 0.76). For the females, only the equation proposed by Léger did not differ from VO_2 max obtained TT (P=0.181). Moderate correlations were observed for Léger, Kuipers, and Barnett (0.53; 0.54; 0.66, respectively). Therefore, we recommend the use of Kuipers and Barnett equations for males and Léger's equation for females to predict VO_2 max in Brazilian school children.

Key Words: VO_2 max, Shuttle Run 20m, Brazilian, School Children

INTRODUCTION

Cardiorespiratory fitness (CF) is an important physiological variable that is used to define physical fitness. It is also a variable that is strongly associated with decreasing the risks factors (RF) for developing cardiovascular diseases (CVD) (15). Unfortunately, several of these RF are present if not already diagnosed in young children (3). To avoid clinical problems with aging, it is important that these RF are addressed soon as possible. Low aerobic fitness among children is high (14).

Given the importance of CF, there are various assessment methods such as ergoespirometry that is considered the gold standard for measuring maximal oxygen uptake (VO_2 max). However, the downside of using high tech equipment is that it is expensive and time consuming. Also, to use the equipment correctly, the operator must be highly qualified. This is especially the case when it is used to evaluate the aerobic fitness of a large sample such as schools. This point brings into consideration the infeasibility of this method.

In order to solve the difficulties mentioned, indirect CF tests have been proposed. For example, the run and/or walk 12 min test (7) and the run and/or walk 9 min test (1) are tests used to evaluate CF. The "run and/or walk 9 min test" is most commonly used and recommended for Brazilian school children (4,13). However, there is one major problem, that is, the tests require access to a running track. Few public Brazilian schools have a track or a space sufficiently large enough to perform a CF test. Another problem has to do with the difficulties of school children in keeping the rhythm during the test.

Given these two major problems, a feasible alternative to testing for CF in Brazilian schools must be considered. Thus, in light of this brief analysis of ergoespirometry and the 12 and 9 min tests, it is more than reasonable to consider the Shuttle Run 20 Meters Test (SR20m) (19). It is more practical for Brazilian schools due to the fact that neither a running track nor a big place to execute the SR20m is needed. Also, a large number of students can be evaluated at same time, and the SR20m has as its main characteristic the use of prediction equations for different populations (2,19,20) based on the final speed.

Among the most commonly used equations that stand out are the original equations by Léger (Leg) and Barnett (Bar), which were recommended in a recent study by Ruiz et al. (26) regarding Europeans school children, and the equation by Kuipers (Kui) (18). Yet, regardless of feasibility of using the SR20m Test in Brazilian schools and the importance of identifying RF for CVD as soon as possible, to date there are no study that have investigated the validity of the equations in predicting the VO_2 max in Brazilian school children.

METHODS

Subjects

The study consisted of 90 Brazilian students aged 13 to 17 yrs (38% males and 62% females). The subjects were invited to participate in the study on behalf of the public and private schools in the Federal District areas. The characteristics of the subjects are presented in Table 1.

The present study has a comparative characteristic and concordance approach to assess the validity of the reference test to VO_2 max (Ergospirometry) and the prediction equations proposed by Léger et al. (20), Kuipers (18), and Barnett (2) using the Shuttle Run 20 Meters Test.

Table 1. Descriptive Data of the Subjects.

Variables	Male (n=32)	Female (n=45)
Age (yrs)	15.41 ± 1.48	15.23 ± 1.83
SBP (mmHg)	116.55 ± 17.96	109.96 ± 14.87
DBP (mmHg)	75.27 ± 10.60	70.47 ± 13.47
Weight (kg)	59.99 ± 8.52	55.39 ± 9.86
Height (cm)	171.23 ± 7.76	161.82 ± 5.81
BMI ($kg \cdot m^{-2}$)	20.42 ± 2.27	21.13 ± 3.25
BF (%)	15.99 ± 7.16	25.93 ± 9.61

The results are expressed as Mean ± Standard Deviation (±SD).

Procedures

Each guardian for the volunteers was informed of the procedures required for participation in the study, which is also true for the risks and benefits that may occur from participation. An informed consent term was given that addressed the above information in accordance with Resolution 466/12 of the National Health Board regarding human research. Before data collection, the present study was submitted to the Ethics Committee on Human Research of the Catholic University of Brasília (UCB). After clinical evaluation by a cardiologist, the volunteers underwent a maximal treadmill stress test with gas analysis as well as the SR20m test on different days separated by at least 48 hrs and no more than 14 days between each test.

Anthropometric

Body mass (BM) was determined using a digital scale (Toledo). Height was determined using a stadiometer (Country Inc Technology, Gays Mills, WI - Model 37034). Both measurements were used to determine the subjects' body mass index (BMI). Body composition was calculated by skinfolds (Lange, Santa Cruz, California, USA). The thickness values for triceps and calf were collected for subsequent calculation of the percentage of fat (Slaughter et al., 1988) via specific software (Galileu, Micromed, Brazil).

Cardiorespiratory Fitness

Treadmill Test

All subjects underwent an incremental test on the treadmill (Super ATL Imbramed, Brazil) while connected to a breath by breath gas analyzer (Cortex Biophysik - Metalyzer 3B, Leipzig, Germany) to determine maximal oxygen uptake (VO_2 max). During the test, all subjects were monitored via digital electrocardiogram (ELITE Micromed, Brazil) by a cardiologist. Prior to the VO_2 max testing, the gas analyzer was calibrated in accordance with manufacturer's recommendations.

The ramp protocol was applied (22) throughout the evaluation process. The criteria proposed by Whipp et al. (31) were used to determine VO_2 max. If there were issues with the collection process, the highest VO_2 was used (which is also known as VO_2 peak). All tests were conducted at *Laboratório de Avaliação Física e Treinamento* (LAFIT) at the Catholic University of Brasília (UCB).

Shuttle Run 20 Meters

All subjects performed the SR20m Test as previously described by Leger et al, 1988. For calculation of VO_2 max by SR20m (in ml·kg^{-1}·min^{-1}), three equations were used (as shown in Table 2).

Table 2. Equations to Estimated VO_2 Max by 20 M Shuttle Run Test.

Study	Equation
Léger et al. (1988)	VO_2 max = 31.025 + 3.238*S – 3.248*A + 0.1536*S*A Where: S = Final Speed (km·h^{-1}) A = Age (yrs) (S=8 + 0.5 *last stage completed)
Barnett et al. (1993)	VO_2 max = 24.2-(5.0*G)-(0.8*A)+(3.4*S) Where: G= Gender (Male = 0; Female = 1) A = Age S = Final Speed (km·h^{-1})
Kuipers (1985)	For adjusting the final speed: S+((ns/ts)*0.5) Where: S= speed of the last stage completed; ns = number of shuttle of stage that volunteer completed; ts = number of total shuttle from the uncompleted stage.

Statistical Analyses

Descriptive statistics were used with average and standard deviation (± SD) for characterization of sample. Data normality was investigated using the Kolmogorov-Smirnov (KS test). The *t*-test for repeated measures was used to detect differences between the treadmill test with gas analysis (TT) compared to the prediction equations (Léger, Barnett, and Kuipers). Concordance analysis was investigated using the technique of Bland Altman. For statistical significance, $P \leq 0.05$ was used.

RESULTS

The main findings of the present study are two fold. First, the data demonstrated that the equation proposed by Léger (20) was different compared from the gas analysis derived during the TT in male Brazilian school children (P=0.023). Second, as demonstrated in Table 3, a strong correlation was found for TT and the three equations (Léger = 0.76, Kuipers = 0.75, and Barnett = 0.76).

Table 3. Male Performance from Treadmill Incremental Test (TT) and SR20m Test (n=32).

Condition	VO_2 max (ml·kg^{-1}·min^{-1})	*t*	P	VC (%)	R	R^2	SEE (ml·kg^{-1}·min^{-1})
TT	50.75 ± 7.83	-	-	-			
Léger	*48.54 ± 4.69	2.396	.023	9.7	0.76**	0.58	4.10
Kuipers	49.94 ± 4.47	.861	.396	8.9	0.75**	0.56	4.06
Barnett	52.19 ± 3.57	-1.451	.157	6.8	0.76**	0.58	3.42

*P<0.05 compared to TT (Gas analysis). ** P<0.01 Significant correlation.

On the other hand, in regards to the female subjects, only the equation proposed by Léger (20) did not differ from VO_2 max obtained from TT (P=0.181), while the equation proposed by Barnett (3) and the adjustment for velocity proposed by Kuipers (18) were statistically different from the VO_2 max reached by TT (P=0.001). Moderate correlations were observed for all equations (0.53, 0.54, and 0.66 for Léger, Kuipers, and Barnett, respectively) (Table 4).

Table 4. Female Performance from Treadmill Incremental Test (TT) and SR20m Test (n=45).

	VO_2 max (ml·kg^{-1}·min^{-1})	*t*	P	VC (%)	R	R^2	SEE (ml·kg^{-1}·min^{-1})
TT	39.36 ± 4.85	-	-	-			
Léger	40.34 ± 5.10	-1.358	.181	12.6	0.53**	0.28	2.43
Kuipers	*41.90 ± 4.96	-3.625	.001	11.8	0.54**	0.29	4.76
Barnett	*41.69 ± 3.58	-4.272	.001	8.6	0.66**	0.44	3.42

*P<0.05 compared to TT (Gas analysis). ** P<0.01 Significant correlation.

The Bland Altman plot showns greater agreement for measured VO_2 max, which was estimated by the Kuipers equation (18) in males (Figure 1b) and the Léger equation in females (Figure 2a).

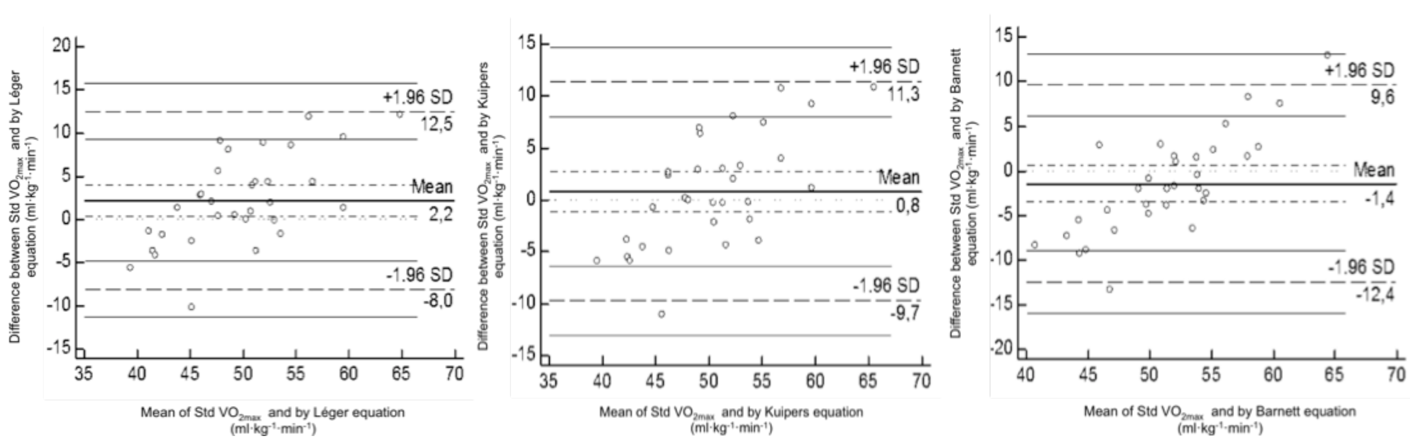

Figure 1. (a) Bland Altman plot between VO_2 max (ml·kg^{-1}·min^{-1}) in male, from: (a) TT and Léger equation; (b) TT and Kuipers equation; and (c) TT and Barnett equation. The upper and lower dotted lines represent the upper and lower 95% limits of agreement.

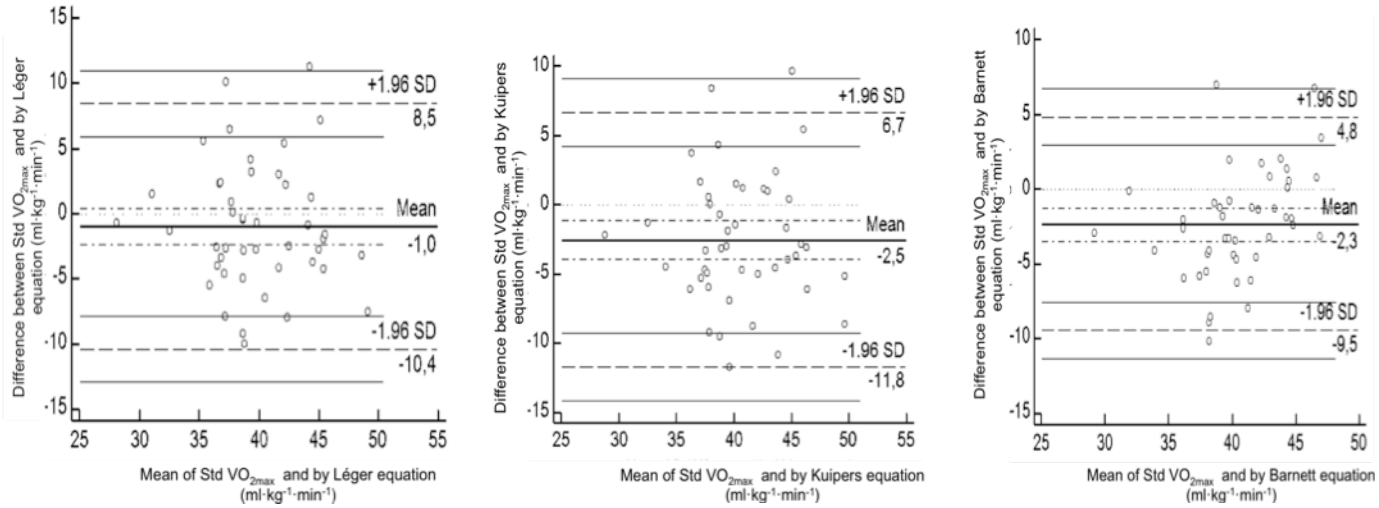

Figure 2. (a) Bland Altman plot between VO_2 max (ml·kg^{-1}·min^{-1}) in female, from: (a) TT and Léger equation; (b) TT and Kuipers equation; and (c) TT and Barnett equation. The upper and lower dotted lines represent the upper and lower 95% limits of agreement.

DISCUSSION

The practice of exercise physiology is centered on VO_2 max testing to prescribe exercise as the first line of treatment for the majority of medical problems society faces. Thus, it is commonly recognized that cardiorespiratory fitness data, along with lifestyle and genetic factors, are extremely helpful in educating the general public as to the importance of exercise, good food choices, and stress. Often, with the context of researchers, VO2 max assessments are used to predict coronary heart disease (17,28) and neurocognitive health in adults (10,30), children (21,25) and the elderly (6).

Yet, despite the accuracy of gas analysis, the limitation with respect to the cost of the technology and the accessibility begs for an alternative. One such alternative is the SR20m Test, which has been explored by many researchers as to its validity, reliability, and applicability in children, adolescents, adults. The test has also been evaluated by the Canadian school system as well as other areas around the world with different populations (8,12,23).

The finding of the present study support the recent work of Kim et al. (16) who evaluated the sensitivity of the equation proposed by Léger to predict VO_2 max in Korean subjects. According to Kim and colleagues, the Léger equation was unable to predict VO_2 max with precision. In fact, it overestimated the results. However, it is important to point out that the Kim et al. study focused on adults only. According to Léger et al. (20), when comparing the validity of the SR20m Test in predicting VO_2 max in children, they observed a lower validity compared to the same procedures in adults (which may be due to the greater possibility of variation in biological age).

Regardless of facilities in which the SR20m Test is implemented, it clearly not used that much in Brazil. There has been only one study by Duarte and Duarte (9). Contrary to their findings, the present study indicates that the Léger equation tends to underestimate the VO_2 max in Brazilian male school children. While it is possible that the age differences in the subjects between the present study and their study confounded the results, another methodological difference is that they use both gender in the same sample.

More recent studies (26,27) investigated the validity of different equations to predict VO_2 max by the SR20m Test in European children. The authors concluded that only few equations are able to do it precisely, thus recommending caution when using them. As a result, they proposed a multivariate equation for ages ranged 13 to 19 yrs, which is not pragmatic since it requires spreadsheets that must use speed, gender, age, weight, and height.

Another factor to consider is that Léger and Lambert (20) used a Douglas bag to measure VO_2 max, which is not as accurate as gas analyzers used in the more recent studies. Moreover, Flouris et al. (11) demonstrated that VO_2 max is higher during the SR20m Test compared to the incremental TT. This might be explained by the acceleration, deceleration, and change of direction at each 20 m during the SR20m Test. Furthermore, Flouris et al. (11) used the Bruce protocol (5) with the incremental TT, which demonstrated in a recent study of our group a lower metabolic demand (VO_2 max, HR max) compared to a Ramp protocol (24).

CONCLUSIONS

In accordance with our findings, we recommend that the prediction of VO_2 max of Brazilian school children should be determined via the Kuipers and Barnett equations for males and only the Léger equation for females. Also, to provide even better VO_2 max prediction, the equations should undergo mathematical adjustments.

ACKNOWLEDGMENTS

All technicians (Fernanda Rodrigues da Silva and Danielle Garcia de Araújo) and physician (Dr. Ronaldo Esch Benford) from Laboratório de Avaliação Física e Treinamento – LAFIT for help in collecting data.

Address for correspondence: Carlos Ernesto, MSc, Curso Educação Física da Universidade Católica de Brasília, EPTC, QS07, LT1 s/n. Bloco G Sala 120, Águas Claras, DF, Brazil, CEP 71966-700, Email: ernestobsb@gmail.com

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