RBPFEX
Revista Brasileira de Prescrição e Fisiologia do Exercício

PREDICTION EQUATIONS FOR DISTANCE WALKED IN THE INCREMENTAL SHUTTLE WALKING TEST AND THE MODIFIED SHUTTLE TEST IN CHILDREN AND ADOLESCENTS

Bruno Alvarenga Soares[1], Fernanda Cordoba Lanza[1]

ABSTRACT

Objectives: To provide a review of studies on prediction equations for the distance walked in the Incremental Shuttle Walking Test (ISWT) and Modified Shuttle Test (MST) in healthy children and adolescents and the methodology used. Materials and methods: Literature review carried out in the databases MEDLINE (US National Library of Medicine), SciELO (Scientific Electronic Library Online), EMBASE, CINAHL (Cumulative Index to Nursing and Allied Health Literature), Scopus, PEDro (Physiotherapy Evidence Database) and The Cochrane Library with period of publication of studies from January 2000 to May 2024. Terms used: shuttle test, reference values, normative values, reference equation, healthy children, healthy adolescents, distance. Searching in gray literature was allowed. Results: There are few studies that proposed reference values or prediction equations for the distance walked in the ISWT or MST in healthy children and adolescents. The predictor variables used in the equations in all studies were sex, age, and BMI. In all studies, boys had a greater distance walked than girls. The r^2 values described were between 0.48 and 0.54, and all equations were performed in single centers with a sample ranging from 108 to 180 participants. Conclusion: There are equations available for ISWT and its modified version, however R2 values are relatively low, and the sample is not very representative of the population.

Key words: ISWT. Walking. Children. Adolescents.

RESUMO

Equações de previsão para a distância percorrida no teste de marcha incremental shuttle e no teste shuttle modificado em crianças e adolescentes

Objetivo: Realizar revisão narrativa sobre equações de predição para a distância percorrida no Incremental Shuttle Walking Test (ISWT) e Modified Shuttle Test (MST) em crianças e adolescentes saudáveis e da metodologia utilizada para realização do teste. Materiais e métodos: Revisão narrativa da literatura realizada nos bancos de dados MEDLINE (US National Library of Medicine), SciELO (Scientific Eletronic Library Online), EMBASE, CINAHL (Cumulative Index to Nursing and Allied Health Literature), Scopus, PEDro (Physiotherapy Evidence Database) and The Cochrane Library, com período de publicação dos estudos de janeiro de 2000 a maio de 2024. Termos utilizados: shuttle test, reference values, normative values, reference equation, healthy children, healthy adolescents, distance. Foi permitido busca na literatura cinza. Resultados: Três estudos propuseram valores de referência ou equações de predição para a distância percorrida no ISWT ou MST em crianças e adolescentes saudáveis. As variáveis preditoras utilizadas nas equações em todos os estudos foram sexo, idade e IMC. Em todos os estudos, meninos apresentaram distância percorrida maior que as meninas. Os valores de r^2 descritos foram entre 0,48 a 0,54, e todas equações realizadas em centro único com amostra variando entre 108 a 180 participantes. Conclusão: Existem equações disponíveis para ISWT e sua versão modificada, entretanto valores de R2 são relativamente baixos e a amostra com pouca representatividade da população.

Palavras-chave: ISWT. Caminhada. Crianças. Adolescentes.

1 - Programa de Pós-Graduação em Ciências da Reabilitação, Universidade Federal de Minas Gerais, Belo Horizonte, Minas Gerais, Brasil.

E-mail dos autores:
brunoalvarengasoares@outlook.com
lanzafe@gmail.com

Corresponding author:
Name: Bruno Alvarenga Soares
brunoalvarengasoares@outlook.com

RBPFEX
Revista Brasileira de Prescrição e Fisiologia do Exercício

INTRODUCTION

The Incremental Shuttle Walking Test (ISWT) is a highly widespread field test due to its practical application and lower costs compared to the Cardiopulmonary Exercise Test (CPET)(Spruit et al., 2013), being widely used in the evaluation of the functional capacity in different health conditions(Singh et al., 1992).

Field tests such as ISWT and MST allow assessment of functional capacity, an important component of health related to physical fitness. Functional capacity provides parameters for the prescription and development of exercise programs, information on reduced exercise tolerance, morbidity, and mortality prognosis(Nici et al., 2006; Palange et al., 2006).

This test was created with the aim of accessing the exercise capacity of adults with chronic obstructive pulmonary disease. The ISWT is a 12-level test in which the subject is allowed to walk on flat ground repeatedly covering 10 meters marked by two cones.

Walking speed is dictated by a sound signal that indicates speed to walk the distance between the cones. During the test, the sound signals become closer each minute, causing the subject to walk at an ever-increasing speed.

The initial speed is 0.5 m/s and will increase by 0.17 m/s every minute, with a maximum duration of 12 minutes. The test is limited by symptoms or when the patient does not follow the sound signal and cannot go around the cones twice consecutively(Singh et al., 1992).

The modified version has been applied in other populations such as the pediatric one, as certain populations reach a plateau with the original test not representing the true functional capacity of the individual(Bradley et al., 2000; Gomes et al., 2018; Lanza et al., 2015; Probst et al., 2012).

In the Modified Shuttle Test (MST), the subject is allowed to run, and the test has a longer duration (15 levels lasting up to 15 minutes)(Bradley et al., 1999). Its reliability and reproducibility have been evaluated in children and adolescents (Selvadurai et al., 2003; Verschuren, Bosma, Takken, 2011).

The MST is considered a maximum effort test in the pediatric population. Its reliability and reproducibility were evaluated in children and adolescents, showing that this test can be reliably applied in this population, being a valid and reproducible form as an alternative to the gold standard test, the CPET (Gomes et al., 2018; Lanza et al., 2015).

Studies that facilitate the investigation of exercise capacity are necessary because they help in the prevention of several health conditions (Dourado, Guerra, 2013; Jürgensen et al., 2015), as well being able to be used as a predictor of some conditions in children in the case of MST(Tsopanoglou et al., 2014).

This study aims to provide a review of studies on reference values and prediction equations for the distance walked on the ISWT and the MST in healthy children and adolescents and the methodology applied.

MATERIALS AND METHODS

This is a narrative review of the literature carried out in the databases MEDLINE (US National Library of Medicine), SciELO (Scientific Electronic Library Online), EMBASE, CINAHL (Cumulative Index to Nursing and Allied Health Literature), Scopus, PEDro (Physiotherapy Evidence Database) and The Cochrane Library with the publication period of the studies from January 2000 to May 2024. A combination of the terms used was performed: shuttle test, reference values, normative values, reference equation, healthy children, healthy adolescents, distance. Gray literature search was allowed.

Studies were considered eligible if: the purpose of the study was to establish reference values or reference equations for the distance walked in the ISWT or MST; the sample consisted of people aged 18 years or less; articles describing the applied methodology; no language restriction; complete articles published in journals.

Studies were excluded if: participants had musculoskeletal, neurological, cardiovascular, or respiratory diseases limiting walking ability; the study population was limited to obese participants; participants required a device or human assistance to walk.

After reading the titles and abstracts, duplicate studies or studies that did not meet the inclusion criteria were excluded. The remaining studies were selected for full reading. An active search of article reference lists was performed to identify potentially relevant studies.

The following data were extracted from the selected articles: author and year of publication; sample size and characteristics; criteria for inclusion and exclusion of subjects;

maximum distance walked; variables correlated with the distance walked; proposed prediction equations; protocol and standardization of the tests performed.

RESULTS

Selected studies

The search and extraction results are shown in Figure 1. Initially, a total of 11 articles were identified. After removing duplicates and reading titles and abstracts, five studies were excluded.

After reading the articles completely, four studies were excluded (two for not dealing with the ISWT or MST and two for not having a sample of children and adolescents).

A study was inserted after searching the gray literature(Vardhan et al., 2017). Three studies were included in this review (Lanza et al., 2015; Pinho et al., 2019; Vardhan et al., 2017).

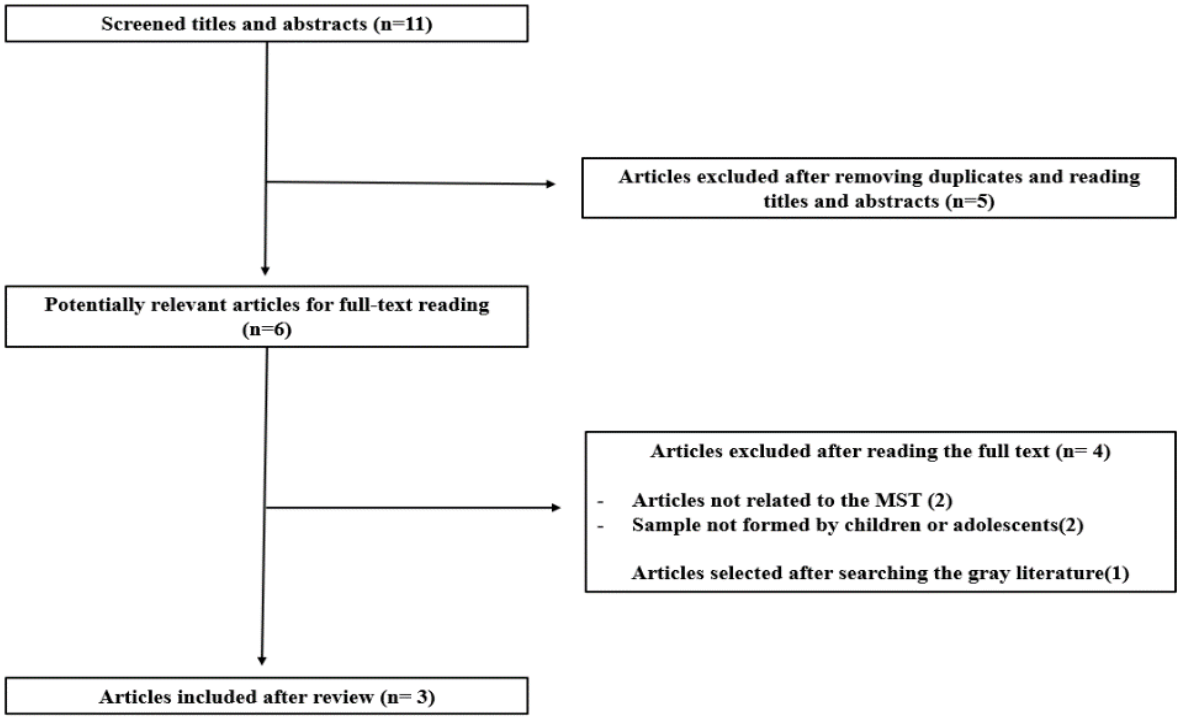

Figure 1 - Flowchart of the study search and extraction process.

Characteristics of the studies

Of the three included studies, all were written in English. All studies proposed reference equations for the distance walked in the ISWT or MST that included children and adolescents, totaling three equations. Only one study proposed normality values for the sample of children and adolescents in the study with stratification by age (Vardhan et al., 2017). The proposed equations were developed in three different countries: Brazil(Lanza et al., 2015), Portugal (Pinho et al., 2019) and India (Vardhan et al., 2017). All studies used a convenience sample. Only two studies presented sample calculation (Lanza et al., 2015; Pinho et al., 2019). (Table 1).

Table 1 - Identification and sample description of the studies that developed reference equations for the distance walked in the Incremental Shuttle Walking Test and Modified Shuttle Test.

Study	Country	Sample number	Sample selection	Sample calculation
Lanza et al. (2015)	Brazil	108	Convenience	Yes
Vardhan et al. (2017)	India	180	Convenience	No
Pinho et al. (2019)	Portugal	130	Convenience	Yes

Sample characteristic

All studies had a sample of both sexes. Age ranged from five to 18 years. One study did not present inclusion and exclusion criteria (Vardhan et al., 2017). The Brazilian and Portuguese studies reported that the sample was appropriate from public and private schools (Lanza et al., 2015; Pinho et al., 2019). The Indian study contradicts itself by saying that the study was carried out in several schools and in only one school (Vardhan et al. 2017) (Table 2).

Table 2 - Characteristics of the studies that developed reference equations for predicting the distance walked in the Incremental Shuttle Walking Test and Modified Shuttle Test.

Study	Sample	Inclusion Criteria	Exclusion Criteria
Lanza et al. (2015)	Both sexes. Age between 6-18 years. Selected from public and private schools.	Both sexes, ages 6-18 years, absence of chronic or acute diseases, normal lung function (FVC and FEV1 > 80% pred, FEV1/FVC > 80%).	Not understanding the test, premature delivery, practiced physical activity > 2x/week, parents did not sign a consent form.
Vardhan et al. (2017)	Both sexes. Age between 10-16 years. Study contradicts itself by saying that the study was carried out in several schools and in only one school.	Not reported	Not reported
Pinho et al. (2019)	Both sexes. Age between 5-17 years. Selected from public and private schools.	Age between 5-17 years, absence of chronic or acute diseases, understanding of the study, accepting to participate.	Significant neurological, cardiopulmonary or musculoskeletal impairment, or any other contraindication that may affect test performance.

FVC = forced vital capacity; FEV1: forced expiratory volume in one second; pred = predicted.

Protocol of the studies

Two studies used the modified protocol with up to 15 levels where running was allowed (Lanza et al., 2015; Pinho et al., 2019). One study used the protocol with 12 levels where running was not allowed (Vardhan et al., 2017).

The number of tests performed also varied. In one study, a third test was performed if there was a difference greater than 40 meters between the first two tests (Lanza et al., 2015). Another study performed only one test (Pinho et al., 2019) and the other one performed two tests (Vardhan et al., 2017). In both studies that performed more than one test, there was an interval of at least 30 minutes between tests.

Prediction variables for the distance walked in the tests

All studies used sex, age, and body mass index (BMI) as independent variables in their prediction equations for distance walked. Only two studies presented the coefficient of determination of the proposed equations (Lanza et al., 2015; Pinho et al., 2019) (Table 3).

RBPFEX
Revista Brasileira de Prescrição e Fisiologia do Exercício

Table 3 - Prediction equations for the distance walked in the Incremental Shuttle Test and Modified Shuttle Test for healthy children and adolescents. BMI = body mass index.

Study	Equation	Determination coefficient (R^2)
Lanza et al. (2015)	Distance = 845.559 + (sex * 193.265) + (age * 47.850) - (BMI * 26.179). Girls = 0 and boys = 1.	0.48
Vardhan et al. (2017)	Distance = - 28.930 + (40.784 * age) - (20,739 * sex) - (3,479 * BMI). Girls = 0 and boys = 1.	Not reported.
Pinho et al. (2019)	Distance = 342.06 + (283.07 * sex) + (83.61 * age) - (22.22 × BMI). Girls = 0 and boys = 1.	0.54

One study showed a significant correlation for all variables included in the proposed equation (gender, age, BMI)(Lanza et al., 2015). One study showed a significant correlation between the distance walked and age, with no significant correlation with BMI and did not present the value of the correlation between the distance walked and gender (Pinho et al., 2019). The other study did not present correlation values (Vardhan et al., 2017) (Table 4).

Table 4 - Correlations between the distance walked in the Incremental Shuttle Walking Test and Modifed Shuttle Test and the independent variables selected for the elaboration of the prediction equations.

Study	Sex	Age	BMI
Lanza et al. (2015)	r = 0.35; p < 0.0001	r = 0.37; p < 0.0001	r = - 0,30; p = 0,002
Vardhan et al. (2017)	Not reported r value, but it says there is a correlation; p = 0.56	r = 0.43; p < 0.001	r = 0.04; p = 0.58
Pinho et al. (2019)	Not reported	Not reported	Not reported

BMI = body mass index.

Regarding the gender variable, all studies report a significant difference between boys and girls in the distance walked. Boys had a greater distance walked than girls.

Statistics in the elaboration of the equations

In the Brazilian study, a multiple regression was performed in the stepwise mode. Interaction between variables was tested to avoid multicollinearity (Lanza et al., 2015).

The Portuguese study used multiple regression, but in enter mode. Multicollinearity, independence of errors, homoscedastic, unusual points and normality of residues were analyzed (Pinho et al., 2019).

The Indian study only claims to have performed an analysis with regression and correlation (Vardhan et al., 2017).

Control variables

In the Brazilian and Portuguese studies, spirometry was performed to ensure that the study subjects had normal lung function(Lanza et al., 2015; Pinho et al., 2019). The Portuguese study also applied a questionnaire to check the level of physical activity (the Physical Activity Index). The Physical Activity Index consists of 5 questions and the answers are scored on a Likert scale of 1 to 4 points. The final score ranges from 5 to 20 points, and can be divided into 4 categories: sedentary, little active, moderate active and vigorously active (Mota, Esculcas, 2002). Also, the Portuguese study evaluated quadriceps muscle strength with a dynamometer (Pinho et al., 2019).

Reference values for the distance walked

The Indian study was the only study that presented reference values for the distance walked. The reference values were stratified by age ranging from ten to 16 years old, not showing values for 15-year-old subjects. The number of subjects at each age was not uniform, ranging from 10 to 56 subjects per group. Still, it is worth noting that the sample calculation was not presented (Vardhan et al., 2017). The other studies bring only the values found for boys and girls without other stratifications (Lanza et al., 2015; Pinho et al., 2019).

RBPFEX
Revista Brasileira de Prescrição e Fisiologia do Exercício

DISCUSSION

This study described a review of studies on reference values and prediction equations for distance walked on the ISWT and its modified version in healthy children and adolescents and the methodology used, providing a basis for planning future studies.

The independent variables sex, age and BMI were used in the formation of all equations presented in this review. Only the Brazilian study presented all the values of the correlation coefficient of the independent variables that formed the prediction equation for the distance walked. The higher the correlation coefficient, the better the variables can fit in the regression model (better the power of prediction/accuracy)(Portney, Watkins, 2009).

The square of the correlation coefficient (coefficient of determination or R^2) represents a percentage of the total variance that an independent variable has over a dependent variable (how many percent that variable explains another variable)(Portney, Watkins, 2009). The R^2 in the two studies that presented such data ranged from 0.48 to 0.54 (Lanza et al., 2015; Pinho et al., 2019). The Indian study did not present the R^2 (Vardhan et al., 2017), which makes it impossible to determine how much the proposed equation explains the distance walked in the test.

Both studies that evaluated the distance walked by children and adolescents using the MST showed significant differences between boys and girls. The study that carried out the ISWT only reports differences between the sexes but does not present statistics. Several factors can explain the difference between boys and girls. Menarche is related to body composition, chemical exposure, and insulin resistance in girls (Anderson, Must, 2005; Buttke, Sircar, Martin, 2012; Slyper, 2006).

The growth period happens earlier in girls and boys have a longer growth time (Aksglaede et al., 2008; Kelly et al., 2014).

The difference between fat-free mass, lean mass and percentage of body fat is more noticeable in adolescence, with girls having a higher percentage of body fat than boys and boys having a greater amount of fat-free mass (Rogol, 2009).

Healthy girls show a decrease in bone mass around the age of 16 (Theintz et al., 1992). Before age 14, boys and girls differ little in their performance on a variety of motor tasks, including running speed. With puberty, much greater differences occur in neuromuscular responses and explosive activities mainly because there is a plateau in girls' performance (Eisenmann, Malina, 2003).

About cardiorespiratory performance, improvements in maximal oxygen consumption (VO_2 peak) increase linearly from seven years old to peak growth velocity, and then plateau in girls but not in boys (Kim, Nattiv, 2016).

The study population must be well described, as the predictions will only be adequate for that population. Such values cannot be generalized to the population that escapes the sample (Portney, Watkins, 2009).

Knowing that there are anthropometric differences between children and adolescents and between boys and girls and between age groups (Rogol, 2009), the elaboration of separate specific equations for children and adolescents and for boys and girls can be an interesting strategy. This option allows for a greater reduction in variance and thus more reliable values for the sample.

Only the Indian study brought reference values for the study sample, but it has some methodological biases (not presenting sample calculation, small and inconsistent sample between groups, restriction of the sample from ten to 16 years old, not presenting inclusion or exclusion criteria, not presenting statistic process)(Vardhan et al., 2017). The results found in the study should be viewed with great caution.

As limitations, this study only found three studies. All studies have a single center sample, which hinders the extrapolation of data to other regions, even more so in continental-sized countries such as Brazil and India, which are countries that are demographically larger than Portugal.

As a perspective, new studies could present reference values and prediction equations for the distance walked in the ISWT or MST of healthy children and adolescents stratified by age and sex, and additionally multicenter studies that consider the different demographic characteristics of the country.

CONCLUSION

There are few studies that have proposed reference values or prediction equations for the distance walked in the ISWT or MST in healthy children and adolescents.

The predictive variables used in the equations in all studies were sex, age, and BMI. In all studies, boys had a greater distance walked than girls. There are equations available for ISWT and its modified version, however R2 values are relatively low, and the sample is not very representative of the population.

Conflict of interests

The authors declare there is no conflict of interests.

Auhors' contributions

All authors contributed to every step of this article.

REFERENCES

1-Anderson, S.E.; Must, A. Interpreting the Continued Decline in the Average Age at Menarche: Results from Two Nationally Representative Surveys of U.S. Girls Studied 10 Years Apart. The Journal of Pediatrics. Vol. 147. Num. 6. 2005. p. 753-760.

2-Aksglaede, L.; Olsen, L.W.; Sørensen, T.I.A.; Juul, A. Forty Years Trends in Timing of Pubertal Growth Spurt in 157,000 Danish School Children. PLoS ONE. Vol. 3. Num. 7. 2008. p. e2728.

3-Bradley, J.; Howard, J.; Wallace, E.; Elborn, S. Validity of a modified shuttle test in adult cystic fibrosis. Thorax. Vol. 54. Num. 5. 1999. p. 437-439.

4-Buttke, D.E.; Sircar, K.; Martin, C. Exposures to Endocrine-Disrupting Chemicals and Age of Menarche in Adolescent Girls in NHANES (2003–2008). Environmental Health Perspectives. Vol. 120. Num. 11. 2012. p. 1613-1618.

5-Dourado, V.Z.; Guerra, R.L.F. Reliability and validity of heart rate variability threshold assessment during an incremental shuttle-walk test in middle-aged and older adults. Brazilian Journal of Medical and Biological Research. Vol. 46. Num. 2. 2013. p. 194-199.

6-Eisenmann, J.; Malina, R. Age- and sex-associated variation in neuromuscular capacities of adolescent distance runners. Journal of Sports Sciences. Vol. 21. Num. 7. 2003. p. 551-557.

7-Gomes, A.L.; Mendonça, V.A.; Silva, T.S.; Pires, C.K.V; Lima, L.P.; Silva, A.M. Cardiorespiratory and metabolic responses and reference equation validation to predict peak oxygen uptake for the incremental shuttle waking test in adolescent boys. PLoS One. Vol. 13. Num. 12. 2018. p. e0208826.

8-Jürgensen, S.P.; Trimer, R.; Dourado, V.Z.; Thommazo-Luporini, L.Di; Bonjorno-Junior, J.C.; Oliveira, C.R.; Arena, R.; Mendes, R.G.; Borghi-Silva, A. Shuttle walking test in obese women: test-retest reliability and concurrent validity with peak oxygen uptake. Clinical Physiology and Functional Imaging. Vol. 35. Num. 2. 2015. p. 120-126.

9-Kelly, A.; Winer, K.K.; Kalkwarf, H.; Oberfield, S. E.; Lappe, J.; Gilsanz, V.; Zemel, B.S. Age-Based Reference Ranges for Annual Height Velocity in US Children. The Journal of Clinical Endocrinology & Metabolism. Vol. 99. Num. 6. 2014. p. 2104-2112.

10-Kim, B.Y.; Nattiv, A. Health Considerations in Female Runners. Physical Medicine and Rehabilitation Clinics of North America. Vol. 27. Num. 1. 2016. p. 151-178.

11-Lanza, F.D.C.; Zagatto, E.D.P.; Silva, J.C.; Selman, J.P.R.; Imperatori, T.B.G.; Zanatta, D.J.M.; Carvalho, L.N.; Reimberg, M.M.; Dal Corso, S. Reference Equation for the Incremental Shuttle Walk Test in Children and Adolescents. Journal of Pediatrics. Vol. 167. Num. 5. 2015. p. 1057-1061.

12-Mota, J.; Esculcas, C. Leisure-time physical activity behavior: Structured and unstructured choices according to sex, age, and level of physical activity. International Journal of Behavioral Medicine. Vol. 9. Num. 2. 2002. p. 111-121.

13-Nici, L.; Donner, C.; Wouters, E.; Zuwallack, R.; Ambrosino, N.; Bourbeau, J.; ... & Troosters, T. American Thoracic Society/European Respiratory Society statement on pulmonary rehabilitation. American journal of respiratory and critical care medicine. Vol. 173. Num. 12. 2006. p. 1390-413.

14-Palange, P.; Ward, S.A.; Carlsen, K.-H.; Casaburi, R.; Gallagher, C.G.; Gosselink, R.; O'donnell, D.E.; Puente-Maestu, L.; Schols, A. M.; Singh, S.; Whipp, B.J. Recommendations on the use of exercise testing in clinical practice. European Respiratory Journal. Vol. 29. Num. 1. 2006. p. 185-209.

15-Pinho, T.; Jácome, C.; Pinto, J.; Marques, A. Reference equation for the incremental shuttle walk test in Portuguese children and adolescents. Pulmonology. Vol. 25. Num. 4. 2019. p. 208-214.

16-Portney, L.G.; Watkins, M.P. Foundations of clinical research: applications to practice. 2009.

17-Probst, V.S.; Hernandes, N.A.; Teixeira, D.C.; Felcar, J.M.; Mesquita, R.B.; Gonalves, C.G.; Hayashi, D.; Singh, S.; Pitta, F. Reference values for the incremental shuttle walking test. Respiratory Medicine. Vol. 106. Num. 2. 2012. p. 243-248.

18-Rogol, A.D. Sex steroids, growth hormone, leptin and the pubertal growth spurt. Endocrine Development. Vol. 17. 2009. p. 77-85.

19-Singh, S.J.; Morgan, M.D.L.; Scott, S.; Walters, D.; Hardman, A.E. Development of a shuttle walking test of disability in patients with chronic airways obstruction. Thorax. Vol. 47. Num. 12. 1992. p. 1019-1024.

20-Slyper, A.H. The pubertal timing controversy in the USA, and a review of possible causative factors for the advance in timing of onset of puberty. Clinical Endocrinology. Vol. 65. Num. 1. 2006. p. 1-8.

21-Spruit, M.A.; Singh, S.J.; Garvey, C.; ZuWallack, R.; Nici, L.; Rochester, C.; Wouters, E.F. An Official American Thoracic Society/European Respiratory Society Statement: Key Concepts and Advances in Pulmonary Rehabilitation. American Journal of Respiratory and Critical Care Medicine. Vol. 188. Num. 8. 2013. p. e13-e64.

22-Selvadurai, H.C.; Cooper, P.J.; Meyers, N.; Blimkie, C.J.; Smith, L.; Mellis, C.M.; Asperen, P.P. Van. Validation of shuttle tests in children with cystic fibrosis. Pediatric Pulmonology. Vol. 35. Num. 2. 2003. p. 133-138.

23-Theintz, G.; Buchs, B.; Rizzoli, R.; Slosman, D.; Clavien, H.; Sizonenko, P.C.; Bonjour, J.P. Longitudinal monitoring of bone mass accumulation in healthy adolescents: evidence for a marked reduction after 16 years of age at the levels of lumbar spine and femoral neck in female subjects. The Journal of Clinical Endocrinology & Metabolism. Vol. 75. Num. 4. 1992. p. 1060-1065.

24-Tsopanoglou, S.P.; Davidson, J.; Goulart, A.L.; Moraes Barros, M.C.; Santos, A.M.N. Functional capacity during exercise in very-low-birth-weight premature children. Pediatric Pulmonology. Vol. 49. Num. 1. 2014. p. 91-98.

25-Vardhan, V.; Palekar, T.; Dhuke, P.; Baxi, G. Normative values of incremental shuttle walk test in children and adolescents: an observational study. International Journal of pharma and Bio Sciences. Vol. 8. Num. 4. 2017.

26-Verschuren, O.; Bosma, L.; Takken, T. Reliability of a shuttle run test for children with cerebral palsy who are classified at Gross Motor Function Classification System level III. Developmental Medicine & Child Neurology. Vol. 53. Num. 5. 2011. p. 470-472.

Received for publication in 29/08/2024
Accepted in 14/09/2024