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PREDICTION EQUATION FOR SHUTTLE RUN DISTANCE USING 20 METRE SHUTTLE RUN TEST IN HEALTHY, INDIAN CHILDREN AGED 7 TO 19 YEARS.

Pediatrics

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ABSTRACT

Objectives: To frame individualized gender – specific prediction equations for shuttle run distance using 20 metre shuttle run test in healthy, Indian children aged between 7 to 19 years and to correlate shuttle run distance with age, height, weight & body mass index.

Methods: 494 subjects between the age group of 7 to 19 years were recruited in this study. Demographic details like age, gender, height, weight and body mass index were noted. 20 metre shuttle run test was performed and shuttle run distance was calculated for all participants.

Results: Shuttle run distance significantly correlated with age (r =0.303), height (r =0.357), weight (r =0.294), and body mass index (r =0.126). The gender specific reference equation generated forboys is -367.724 + (27.225 x Age) + (487.457 x Height) – (3.213 x Weight) and for girls is 153.689 +(10.306 x Age) +(118.113 x Height) – (1.421 x Weight).

Conclusion: The established prediction equation can be used as a reference to evaluate exercise capacity for children and adolescents and to improve the applicability of the 20 metre shuttle run test in clinical practice.

KEYWORDS

20 Metre Shuttle Run Test, Indian Population, Reference Values, Children

INTRODUCTION:

Physical activity is defined as any bodily movement produced by skeletal muscles that requires energy expenditure. Physical inactivity has been identified as the fourth leading risk factor for global mortality.Strong evidence shows that physical inactivity increases the risk of many adverse health conditions, including the world's major non-communicable diseases like coronary heart disease (CHD), type 2 diabetes, and breast and colon cancers, and shortens life expectancy.[1] Physical inactivity is estimated to be the main cause for approximately 21–25% of breast and colon cancers, 27% of diabetes and approximately 30% of ischaemic heart disease burden according to the recent WHO statement. Because much of the world's population is inactive, this presents a major public health problem. Systematic reviews and primary studies of physical activity and health have indicated that children and adolescents who engaged in increased levels of physical activities had better physical and mental health and psychosocial well-being than those in an inactive lifestyle.[2,3] The adverse consequences resulted from sedentary behaviour include an increased risk of obesity, cardiovascular disease and all-cause mortality, and a range of impaired psychological health. Sedentary behaviour also contributes to a delay of cognitive development and a decrease in academic achievement of children and youth.[4]Hence, there is an urgent need for early detection and for the initiation of lifestyle changes in children and adolescents.

Cardiorespiratory fitness is a direct indicator of an individual's physiological status and reflects the overall capacity of the cardiovascular and respiratory systems. Assessment of cardiorespiratory fitness is important for the promotion of physical activity for a healthy lifestyle right from the paediatric age group. Exercise testing is a non -invasive procedure and an important clinical tool that provides diagnostic and prognostic information and evaluates an individual's capacity for dynamic exercise.The current gold standard for the evaluation of cardiorespiratory fitness is through cardiopulmonary exercise testing.

Walk/ run tests have been widely used in clinical practice to evaluate exercise capacity. These tests do not require any expensive equipments and are easy to perform.[5,6,7,8] The 6-min walk test (6MWT) has been widely used and accepted as a simple, cost-effective means of clinicallyassessing the functional status of patients with cardiopulmonary diseases and other disorders. It is a self – paced walking test which is objective, reliable, valid, and sensitive tool that provides a reproducible measurement of functional capacity. However, the major disadvantages of this test are that it allows the individual to set the speed of walking and is affected by a variety of factors unrelated to cardiopulmonary status such as age, gender, height, and weight.[9] The multi – stage 20 metre shuttle run test (20 m SRT) eliminates these disadvantages as it diminishes the operator's control. This test is usually conducted indoors, thereby reducing challenges related to outdoor testing. Also, test results are not influenced by the ability of the participant to choose an adequate running pace, which sometimes reduces the validity of distance-running tests. Furthermore, participants are more motivated by audio signals to keep the running pace. Finally, the 20 m SRT is submaximal for much of its duration, so that maximal effort and motivation are only required in the last part of the test.[10]

20 m SRT is the most widely used field test for estimating cardiorespiratory fitness. It was designed to determine the maximal aerobic power of school children and healthy adults.[11] This test consists of running between two lines 20 metre apart at a progressively increasing speed every minute paced by pre – recorded audio signals. 20 metre SRT has been extensively used in situations when it is unfeasible to use direct measurements and because its results are highly correlated with laboratory measurements. It correlates more strongly with maximal oxygen uptake than the traditional six-minute walk test. It also presents a strong evidence of criterion – related validity.[12,13]

Matsuzaka et al (2004) established prediction equations for use with 20 m SRT in Japanese population for children, adolescents and young adults.[14] However, predictive distances derived from non - Indian population would not apply for Indian populationdue to variations in demographic, anthropometric, lifestyle, racial, environmental and socio – economic status among different ethnicities. No valid reference equations have been derived for predicting shuttle run distance in the Indian paediatric population till date. In the present study, we assessed shuttle run distance (SRD) in a population-based sample of Indian healthy paediatric subjects aged 7 - 19 years and established gender specific reference equations to predict SRD. The secondary objective was to correlate SRD with age and anthropometric characteristics.

MATERIAL AND METHODS:

Ethical clearance was sought from the Institutional Ethical Committee of Terna Physiotherapy College, Navi Mumbai, India for this cross – sectional study. Informed consent was obtained from all selected participants along with parental assent from their parents/ legal guardians. 494 healthy subjects with equal number of boys and girls (247 each) between the age group of 7 to 19 years were selected from various urban schools and colleges after obtaining the necessary consent from the respective school Principals.

Each participant was scrutinized using the Physical Activity Readiness Questionnaire – plus (PAR-Q+). PAR – Q+ is a modified version of Physical Activity Readiness Questionnaire (PAR – Q) which is a self - screening tool used for evaluating readiness for participation in

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exercise testing. Although the original PAR-Q is used extensively worldwide, barriers in this physical activity participation clearance process have been identified by physicians, physical activity participants, fitness professionals, and various organizations. For instance, the PAR-Q is purposely conservative, leading to many false positive results and causing considerable unnecessary medical referrals. Also, the age restrictions of the PAR-Q (i.e. 15 to 69 years) create an unnecessary barrier to physical activity participation for children and elderly people; and there is often inconsistent or improper use of the clearance forms.[15] Subjects with low risk profiles as per American College of Sports Medicine (ACSM) guidelines, who answered "no" to all questions in PAR-Q+ were included in the study. Subjects suffering from any musculoskeletal condition of the lower extremitieswhich could hamperrunning, any cardiovascular/pulmonary/neurological disorder, active infections and those involved in any formal, regular physical training were excluded from the study.

All participants were instructed to wear loose, comfortable clothing, wear shoes appropriate for walking, consume a light meal 2 hours prior to testing, and avoid vigorous exercise within 2 hours of beginning the test. Demographic and anthropometric details such as age, gender, height, weight, and body mass index (BMI) were recorded. Measurements were made with a calibrated weighing machine and with a fixed wall inch tape. BMI was calculated by the standard formula [body mass (kg)/ body height (m)^2].

Test procedure:

The 20 m SRT was administered according to the protocol by Léger and colleagues.[11] Tests were held in a hall with a nonslippery surface. The participants ran back and forth between two lines 20 metre apart at 8.5 km/hr with the speed increasing by 0.5 km/hr per minute. Subjects were instructed to run in a straight line, to pivot on completing a shuttle, and to pace themselves in accordance with the audio signals. The test was terminated when the participant failed to reach the end lines concurrent with the audio signals on two consecutive occasionsor when the participant reached exhaustion.Shuttle run distance (SRD)was calculated as total number of shuttles x 20.

Statistical analysis:

Statistical analysis was performed using the Statistical Package for Social Sciences (SPSS) 20.0Descriptive statistics were used to present central tendency and spread of data. Data were reported as mean ± standard deviation (SD) or as median (interquartile range). Data was checked for normality using the Shapiro – Wilk test. The data showed a parametric distribution.Boys and girls were compared using independent t test. Pearson correlation coefficient was used between the independent variables (age, height, weight and BMI) and the dependent variable (SRD) to evaluate the correlations between them and to select independent variables for deriving the prediction equation. Stepwise multiple regression analysis was used for developing the prediction equation.

RESULTS:

Of the 494 subjects evaluated,there were equal number of boys and girls (247 each). The characteristics of the 494 subjects are summarized in [Table 1].

Table -1: Characteristics of the subjects (expressed as Mean ± SD)

Parameters	Boys (n=247)	Girls (n=247)	Z-Test	P-value	Significant at 5% level
Age (years)	13.00±3.75	13.00±3.75	0.000	1.000	No
Height (metres)	1.49±0.20	1.43±0.16	3.713	<0.001	Yes
Weight (kg)	42.68±17.35	36.68±13.44	4.290	<0.001	Yes
BMI (kg/m2)	18.44±4.37	17.35±3.90	2.928	0.004	Yes
Shuttle Run Distance(metres)	576.52±345.42	404.70±206.69	6.691	<0.001	Yes

Height and weight showed a statistically significant difference between boys and girls ($p < 0.001$) with a greater value in boys. BMI also showed a greater value in boys than girls ($p = 0.004$). As expected, boys covered a greater distance in the 20 metre shuttle run test than girls ($p < 0.001$)

Bivariate analysis showed that SRD correlated significantly with age, height, weight ($p<0.00$) and BMI ($p < 0.005$) as shown in [Table 2].

Table – 2: Correlation of shuttle run distance with age, height, weight and BMI score

Parameter	Correlation	Age (years)	Height (metres)	Weight (kg)	BMI (kg/m2)
SRD (metres)	r	.303	.357	.294	.126
	p value	< 0.001	< 0.001	< 0.001	0.005

In the multiple linear regression analysis, age and anthropometric traits were selected as predictors of SRD. The anthropometric traits and age jointly explain 18% of the total variance in SRD in boys (coefficient of determination $R2 = 0.18$) and 3% in girls (coefficient of determination $R2 = 0.03$)

The individual equations for both the genders yielded are shown in [Table 3].

Table -3: Prediction equations for healthy Indian children (7 – 19 years)

Gender	Reference Equation	Coefficient of Determinants (R^2)	Standard Error of the Estimate
Boys	-367.724 + [27.225 x age (years)] + [487.457 x height (cm)] – [3.213 x weight (kg)]	0.185	313.84
Girls	153.689+[10.306 x age (years)] + [118.113 x height (cm)] – [1.421 x weight (kg)]	0.038	205.54

DISCUSSION:

The present study is the first large study to investigate potential demographic and anthropometric determinants to shuttle run distance in healthy Indian children and to propose a predictive equation.Equations derived from other non – Indian populations commonly overestimated shuttle run distance in relation to the values obtained for Indian subjects – due to differences in race and ethnicity.[16] Reference equations would permit a more appropriate functional evaluation of Indian children. Since we adhered to the guidelines given by Leger et al for performing 20 m SRT[11], we believe that our derived equations would predict shuttle run distance precisely in accordance with the predicted equations derived from non – Indian population. These results can be used as a baseline for long-term physical fitness surveillance among school - going population.

Data from this study show the well-documented differences between sexes and the typical changes in aerobic test performance associated with growth and maturation in youth according to Beunen G, Malina RM (1988).[17] Age, height, weight, and BMI significantly influenced shuttle run distance in the present study. Boys covered a greater shuttle run distance than girls as expected. This could be attributed to a greater muscle mass, higher muscle strength in boys as compared to girls which is in agreement with the previous trials.[16,17] The positive influence of increasing age in children with shuttle run distance might be explained by the biological maturation occurring as the child grows leading to a greater muscle mass and strength.

Leg length influences upright balance and speed. Taller children demonstrated a greater shuttle run distance owing to a greater stride length. Dintiman et al (1997) concluded that individuals with longer legs demonstrated faster running time and distance. Weight showed a positive correlation with shuttle run distance in this study. However, a study by Lohman et al (2006) demonstrated an inverse relationship between physical activity and weight. But the correlations were very low ($r = -0.15$) and differences in body weight between active and inactive children tend to be very small.Body mass index is an important predictor of shuttle run distance. It declines during early childhood reaching its lowest point by ages 5 to 6 years and then increases through adolescence. The present study showed a positive correlation between body mass index and shuttle run distance. Physical activity &body mass index, however,were inversely correlated in children and adolescents in a study by Lohman et al (2006) though the correlations were modest.

In the present study, gender – specific reference equation for predicting shuttle run distance demonstrated a squared correlation coefficient of 0.18 which is in agreement to values reported from previous studies (ranging from 0.20 to 0.80).[18,19] This equation could serve as a benchmark for predicting fitness in Indian paediatric population using 20 metre SRT. It could also be used by physical educators in schools and colleges for evaluating physical fitness which would help in planning exercise prescription in children and adolescents.

Our study has a few potential limitations. Data was collected only from the urban paediatric population. Major proportion of Indian population resides in rural area with differing culture, lifestyle and socio – economic status. This can lead to a difference in physical education and physical activity pattern between urban and rural schools. Therefore, the reference equation derived in this study cannot be generalized for the entire Indian population. To overcome this limitation, a large – scale study including the rural paediatric population should be undertaken. The degree of agreement between predicted equation derived for Indian paediatric population in this study and for western population was not assessed. Since there exists variations in demographic, anthropometric, lifestyle, racial, environmental and socio – economic status among different ethnicities, it would be interesting to analyse this degree of agreement between the Indian and western predicted equations.

CONCLUSION:

Our study resulted in gender specific reference equations for the prediction of shuttle run distance in healthy Indian paediatric subjects. Shuttle run distance was affected by age, height, weight and body mass index. We conclude that generation of these prediction equations will facilitate the assessment of exercise capacity in healthy Indian children and adolescents. Reference values & prediction equation generated in this study could be used to improve the interpretability of the 20 m SRT and its applicability in clinical practice.

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