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Annals of Biological Research, 2012, 3 (7):3765-3770
(http://scholarsresearchlibrary.com/archive.html)

Scholars Research Library
ISSN 0976-1233
CODEN (USA): ABRNBW

Relationship between Motor Proficiency and Anthropometric Measure in Six to Twelve Years-Old Children

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Abstract
This study aimed at evaluating motor proficiency and anthropometric parameters in children aged 6-12 years and their interrelationships. One hundred fifty-two children underwent standard anthropometry (BMI, waist circumference, waist-to-hip ratio, and sum of five skinfolds) and Bruininks –Oseretsky test. Data were stratified by age (6-7, 8-9, 10-12 years) and sex (M/F), and the Spearman correlation coefficient was used to evaluate the correlation between BMI and the other anthropometric measurements in each class as well as the correlation between anthropometric parameters and motor proficiency tests. The effect of age, sex, and individual anthropometric measurement on subtests was evaluated by ANOVA. BMI positively correlated with waist circumference and subcutaneous fat, and negatively correlated with body density. Motor proficiency was not significantly affected by sum of five skinfolds, waist, waist to hip ratio and body density while BMI associated with subtest 1 and subtest 4. The result shows that the BMI plays important roles in motor proficiency.

Introduction

The importance of movement is often overlooked because it is such a natural part of human life. It is, however, crucial for a child's physical, cognitive and social development. In addition, experiences support learning and development of fundamental movement skills. The foundations of those skills are laid in early childhood and essential to encourage a physically active life-style.

Physical growth in children is measured by changes in body size and/or composition as well as physical profile. Physical activity is considered as a key factor for a healthy physical and mental development of children (Denker & Andersen, 2008; Ortega et al., 2008); currently, the increasing prevalence of overweight in children make children at risk of developing several chronic diseases later in life, also because children who are not physically active are unlikely to become so in adulthood. In the last years, several national and international organizations have recommended that children take part in 60 min physical activities each day in organized form, both inside and outside school (Biddle, 1998; US 2005).

Motor proficiency involves two separate and distinct components: motor abilities and motor skills. Motor abilities are typically defined as underlying capabilities which are relatively stable and not easily improved upon through practice (Schmidt&Lee, 2005). Although abilities can be shaped during growth and development, they are also considered to have a genetic basis. On the other hand, generally consist of a few abilities. It has been suggested that motor skills are epically likely to changed and develop during preadolescence and may define a critical learning phase for such skills. Motor skills are also referred to as foundation movement skills or childhood movement skills.

Both components of motor proficiency consist of gross motor skills and fine motor skills. Most researches were focused on motor skill in relation to motor proficiency because intervention programs are not likely to change motor abilities, but may have significant effects on the development and maintenance of motor skills.

Simultaneous assessment of anthropometric parameters and motor Proficiency will provide more accurate information on the developmental process of children; however, it is not well known whether a relationship actually exists between motor Proficiency and anthropometric parameters in children or between different motor Proficiency evaluation tests.

The assessment process continues with identification of an appropriate f ram e of reference for treatment and the selection of specific evaluation procedure s that will yield the information needed as the basis f or clinical decision making. An administration of specific tests, clinical observations, structure d interviews, standardized tests, performance checklist, and activities and tasks are then used to evaluate specific performance abilities' and deficits [1]. Motor performance testing by physical therapists in rehabilitation programs is a major source of evaluation and efficacy data. Performance-base assessments or children and adult s are used to guide initial treatment planning and to provide a detailed analysis of motor component s that are relate d to successful rehabilitation outcome [2, 3]. The description of a performance profile for children with mild motor problem s is a helpful assessment guideline, especially in these times of expected greater efficiency and account ability [4, 5]. Many standardized tests of motor performance are available to physical therapists for specific pediatric (e. g. Bruininks - Oseretsky test of motor proficiency) or adult (e. g. Fugl -Meyer) populations; however, none have been shown to be applicable for motor assessment across the life span [2].

Bruininks - Oseretsk y test of motor proficiency was developed to provide educators, clinicians, and researchers with useful information to assist them in assessing the motor skill s of individual students, in developing and evaluating motor training programs, and in assessing serious motor dysfunction s and developmental handicaps in children [6]. These children may be diagnosed as having developmental coordination disorder(DCD), sensory integrative problems, or clumsy child syndrome [7].

This test is an individually administered test that assesses the motor functioning of children from 4 -14 years of age . The complete battery-eight subtests comprising 46 separate items-provides a comprehensive index of motor proficiency as well as separate measures of both gross and fine motor skills . The short form 14 items from the complete battery provide s a brie f survey of genera l motor proficiency. Test equipment is designed to be appealing to young children and adolescents, to provide uniform testing conditions, and to facilitate administration and scoring.

Each of the eight subtests in the Bruininks –Oseretsky test is designed to assess an important aspect of motor development. Four of the subtests measure gross motor skills, three measure fine motor skills, and one measures both gross and fine motor skills. The differentiated measurement of gross and fine motor skill s make s it possible to obtain meaningful comparison s of performance in two areas.

Results of the Bruininks-Oseretsky test will be useful to educators, clinicians, and researcher s in evaluating children f or a variety of purposes:

1. *Making decisions about educational placement:* Acceleration or early entrance might be inadvisable for a student whose level of motor development is low in relation to other students of the same age. Decisions about the most appropriate physical education program for handicapped students and the program adjustments necessary for them can be made with greater insight after giving the test. In addition, the test results will aid teachers in determining the type of corrective motor training by physically awkward students.
2. *Assessing gross and fine motor skills:* The subtests that asses s gross motor skill s will be especially helpful to physical educators and physical therapists; the subtest s that asses s fine motor skill s will be of considerable value to occupational therapists.
3. *Developing and evaluating motor training programs:* The test result s will be useful to educators in identifying students who will benefit from remedial programs designed to improve physical fitness, fine motor skills, and movement patterns.
4. *Screening f or special purposes:* This test is useful to the early intervention of physical, mental, social and emotional problems in children.
5. *Assisting clinicians and researchers:* The Bruininks-Oseretsky test should be useful to investigate the unexplored aspects of motor development; the structure of motor abilities in early childhood and the change s in this structure with age : the relationship between motor development and demographic characteristics such as age, sex, geographic region and physical development ; the role of motor proficiency in childhood socialization processes ; and the transfer of motor training to other areas of motor, social, and academic learning [6].

The aim of this investigation is to evaluate the possible relationships between selected anthropometric parameters and motor proficiency, as well as the perceptual motor themselves in 6-12-year-old children.

Material and Method

Participants

A total of 221 children were selected to this study but 69 were excluded from analysis because they did not complete anthropometric measurements, leaving 152 subjects for the final analysis (103 boys and 49 girls). All children and their parents were thoroughly informed about the purposes and contents of the study, and written informed consent was obtained from one parent. The study protocol is in accordance with the declaration of Helsinki. Measurement sessions were taken over three consecutive years in June/July. When a subject underwent more than one measurement session, the first eligible one was considered.

Anthropometry

All measurements were taken by one operator (CM) using conventional criteria and measuring procedures (Lohman et al., 1988). Weight was assessed to the nearest 0.1 kg using a certified electronic scale (Tanita electronic scale BWB-800 MA (Wunder SA.BI. Srl). Height to the nearest 0.01 m was measured using a Harpenden portable stadiometer (Holtain Ltd., Crymych, and Pembs. UK). The body mass index (BMI) was calculated as kg/m^2. Girth was taken at the waist and the hip using fiberglass tape; the waist-to-hip (W/H) ratio was calculated. To define overweight and obesity, the cut-offs proposed by Cole et al. (2000), were used.

Skin fold measurement

The triceps, sub scapular, chest, abdominal, and front thigh skin fold thicknesses were measured by one operator (CM) using a Harpenden caliper (Gima, Modena, Italy) according to standard procedures (Norton & Olds, 1996). Two measurements were taken at each site, and the average of the two readings was considered. If the two measures differed by more than 2 mm, a third measurement was taken, and the two closest were then averaged and recorded as the final value. The equation proposed by Poplawska et al. (2006), was used to estimate body density.

Assessment of motor proficiency

In this study, Bruininks -Oseretsky tests of motor proficiency – short form were used to assess the gross motor skills and fine motor skills. These tests are running speed and agility (subtest 1/item 1), balance /walking forward heel-to-toe on walking line (subtest 2/ item 1 & 6) , bilateral coordination /tapping-foot and finger on same side synchronized (subtest 3/item 1 & 6) , strength/standing broad jump(subtest 4/item 1) ,upper limbs coordinator (subtest 5/item 3 & 5), response speed (subtest 6/ item 1) , visual motor control /cutting out a circle with preferred hand (subtest 7/ item 3,5 & 8) , upper-limb speed and dexterity /placing pennies in two boxes with both hands (subtest 8/ item 2) . All children (n=152) were evaluated for subtests 1 to 8.

Subtest 1/ Item 1

Running speed and agility measures running speed during a shuttle run. Tennis or crepe-soled shoes were requiring d for the study. The subtest was administered in a large area that is free of obstacles and hazards and that has a non-slipper y surface. Running course was prepared. The subjects run to the end line, pick up the block, and run back across the start /finish line. The subject is timed between the first and last crossing of the timing line. If the subject stumbles or falls, fails to pick up the block, or drops the block before crossing the timing line , the trial is started .

Subtest 2/ Item 1 & 6

Balance / walking forward heel-to-toe on walking line assess performance balance by requiring the subject to maintain balance while the subject walking forward on the walking line heel-to-toe. The subject must make six consecutive steps correctly to achieve a maximum score. if the subject doesn't achieve a maximum score on the first trial , a second trial is administered . The number of correct and incorrect steps was recorded.

Subtest 3/item 1 & 6

Bilateral coordination /tapping-foot and finger on same side synchronized assess sequential and simultaneous coordination of the upper limbs with the lower limbs. The subject simultaneously tapped the foot and index finger on one side of the body and then simultaneously tapped the foot and index finger on the opposite side. The subject was given 90 second s to complete 10 consecutive foot /finger taps correctly. The score was recorded as a pass or a fail.

Subtest 4/ item 1

Strength/standing broad jump assesses arm and shoulder strength, abdominal strength, and leg strength. In this subtest, the subject jumped forward as far as possible, starting from a bent-knee position. The distance of each jump was recorded.

Subtest 5/ item 3 & 5)

Upper limbs coordinator is the ability of the receiving ball with hands and throwing the ball with preferred hand to the destination.

Subtest 6/item 1

Response speed measures the ability to respond quickly to a moving visual stimulus. In this subtest, the subject placed the preferred hand at on the wall, next to the response speed stick. A physical therapist holds the stick vertically against the wall and then drops s the stick. The subject used the thumb of the preferred hand to stop the stick as it drops. The response speed stick number that is at or just above the tape strip when the stick is stopped is the trial score. The pointscore is derive d from the trial score. During seven test trials, the response speed stick number was recorded. In this subtest, the median (middle) score is the point score.

Subtest7/ Item 3, 5& 8

Visual motor control, cutting out a circle with preferred hand measure s the ability to coordinate precise hand and visual movements. With the preferred hand, the subject cut out a heavy circle embedded within six concentric circles. The number of error s made was recorded.

Subtest 8/Item 2

Upper-limb speed and dexterity/placing pennies in the box with hands measures hand and finger dexterity, hand speed, and arm speed. The subject simultaneously picks up a penny with each hand and places the pennies in the box. The subject was given a maxi-mum of 50 second s to place seven pair s of pennies intothe box correctly. The time taken to complete the task was recorded.

Statistical analysis

Children were stratified by age (6-7, 8-9, 10-12 years) and sex (M/F).

Difference in the proportion of overweight/obesity between genders was evaluated by Fisher's exact test. Significance of differences between genders in anthropometric parameters and motor fitness tests was evaluated by ANOVA for quantitative variables, taking into account also age class. BMI, sum of five skin folds, waist and 30m dash velocity were log-transformed to cope with the assumptions of normality and/or homoscedasticity.

The BMI was assumed to be the gold standard among anthropometric measurements. Spearman rank-order correlation coefficient (Spearman's rho) was used to evaluate the correlation between BMI and different anthropometric measurements (waist, waist-to-hip ratio, body density, sum of five skin folds) in each sex- age-specific group. Spearman's rho was also used to evaluate the correlation between the anthropometric measurements (BMI and sum of five skin folds), and between anthropometric measurements and motor proficiency tests in either sex or in each sex- age-specific group. Analysis of variance was used to study the effect of age, sex, and anthropometric measurement (either BMI or sum of five skin folds) all items.

Results:

The main characteristics of the study population are presented in Table 1 as a function of sex and age. Overall, the prevalence of overweight-obesity was 17% (18/103) among males and 26% (12/47) among females; of these, 1 boy (1%) and 3 girls (6%) were obese. Girls had thicker skin folds than boys, the difference being significant in the younger age group, while BMI did not differ between genders.

Table1. Characteristics of the study population as a function of sex and age. Data are reported as median for quantitative variables (BMI, sum of five skin folds, absolute frequencies (percentages) for categorical variables (overweight and obesity).

	Males 6-7 yrs (n=33)	Females 6-7 yrs (n=12)	Males 8-9 yrs (n=33)	Females 8-9 yrs (n=20)	Males 10-11 yrs (n=37)	Females 10-11 yrs (n=17)	P value
BMI(kg/m^2)	16.0	16.6	16.4	16.5	17.7	18.5	0.089
Sum of skinflods (mm)	38.6	62.9	41.2	49.9	53.3	63.8	<0.001
Waist	55.0	57.0	57.5	56.3	62.0	62.5	0.541
Overweight Children	4	3	6	3	7	3	0.158
Obese children	1	2	0	1	0	0	

When the children were classified according to sex, the results in eight subtests were as in table2.

Table 2 The means of subtests in both gender.

Test	Gender	X	SD	P
Subtest 1	Girls	4.56	2.11	0.92 > 0.05
	Boys	6.34	2.42	
Subtest 2	Girls	2.05	0.74	0.17 > 0.05
	Boys	2.06	0.79	
Subtest 3	Girls	0.84	0.37	0.06 > 0.05
	Boys	0.91	0.30	
Subtest 4	Girls	96.73	22.81	0.24 > 0.05
	Boys	114.88	25.90	
Subtest 5	Girls	3.67	2.54	0.06>0.05
	Boys	3.98	1.99	
Subtest 6	Girls	7.87	4.04	* 0.02 < 0.05
	Boys	8.36	3.26	
Subtest 7	Girls	3.58	2.62	* 0.04< 0.05
	Boys	3.01	1.95	
Subtest 8	Girls	10.42	2.68	0.20 > 0.05
	Boys	9.50	2.16	

On the other hand there were significant positive correlation between the subtests and some anthropometric measures (Table3). There were significant correlations between subtest 1 and BMI and subtests 2 and waist to hip ratio. Moreover there was a significant correlation between subtest 4 and BMI. There was not significant correlation between the anthropometric measure and others subtests.

Table 3: correlations between anthropometric measures and subtests

Test	BMI(kg/m^2)	Sum of skinflods (mm)	Waist	Waist-to-hip ratio	Body Density
Subtest 1	0.53 *	- 0.33	0.19	0.22	0.27
Subtest 2	0.46	0.36	0.17	0.56 *	0.33
Subtest 3	0.13	0.21	0.25	0.21	0.18
Subtest 4	0.53 *	- 0.36	- 0.34	0.12	0.43
Subtest 5	0.14	0.28	0.30	0.24	0.22
Subtest 6	0.36	0.33	0.23	0.17	0.24
Subtest 7	0.22	- 0.19	- 0.33	0.28	0.32
Subtest 8	0.27	0.23	- 0.36	- 0.22	0.35

* $\alpha < 0.05$

Discussion:

The most common assessments of the level of motor development focus on running, jumping and throwing [8]. In this study, gross and fine motor skills of Bruininks-Oseretsky test of motor proficiency's subtests were also selected. It was known that the preschool child (2±6 years) spends a considerable portion of each day engaged in gross and fine motor activities. During the preschool years, the gross motor developmental milestones that are most frequently recorded are relate d to the addition of locomotors skill s and the refinement of the throwing pattern [8].

In late childhood, the general fundamental movement skills are refined to specific movement skills. As the skills are applied to sport performances, more emphasis is placed on form, accuracy and adaptability. Movement s becomes more fluid and automatic [8].

In the fourth year, the child develops s the balance to stand on one foot f or 8 second s and to walk on tiptoe with control. During the sixth year, the child can balance on the preferred foot for 8 or more seconds and one the non-preferred foot f or 5 or more seconds. The child is developing a rhythmic to movements.

During the previous 4 year s (2±6 years), the child has mastered all the fundamental gross motor skills. The remainder of gross motor development is refinements of those skills.

Muscular strength increases linearly with age from early childhood until adolescence. In girls, the linear relationship of strength and age continues through to the age of 15 years. Boys are stronger than girls at all ages. Boys demonstrate a marked acceleration of strength development between the age s of 13 and 20years [4].

The analysis of variance is used to compare the age group s (group s 1±4) used. The result s showed that there was a statistically significant difference in running speed and agility, balance /walking heel-to-toe on walking line, upper limb speed and dexterity /placing pennies in box with hands, strength /standing broad jumps subtests. When the gross motor skill tests were examined; the score s of running speed and agility and strength /standing broad jump subtest s were higher in older ages, because of the increase in muscle strength.

The positive correlation between BMI and subtests 4 and subtests 1 indicates that BMI play important roles in motor proficiency.

Conclusion:

The usefulness of the Bruininks-Oseretsky test of motor proficiency was used to investigate the relation between the subtests and anthropometric measures in six to twelve year-old children. Children were classified in 4 groups according to their ages.

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