

Relationship Between Fundamental Movement Skills and Body Mass Index in 7-To-8 Year-Old Children

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Abstract: Purpose of this study was to investigate the relationships between fundamental movement skills (FMS) and body mass index (BMI) of the 7-to-8 year-old children. We used randomized study design to answer the study questions. Eight Fundamental Movement Skills (FMS) of 200 children were assessed; four locomotor skills (run, gallop, hop, horizontal jump) and four object control skills (striking a stationary ball, catch, kick, overhand throw) using the Test of Gross Motor Development-2 (TGMD-2). BMI was calculated from the height (m) and weight (kg) [$\text{weight}/\text{height}^2$] for each participant. Raw scores of the participants' fundamental movement skills were correlated with BMI in all subjects. Similarly, significant negative correlations were found between the raw scores of the locomotor skills subtest and BMI; whereas correlations were not found between strike, catch, kick and BMI. The hypothesis of a perceptual-motor deficit in obese children is rather speculative and must therefore be addressed further.

Key words: Fundamental movement skills % Locomotor skills % Object control skills % Body mass index % Body Composition

INTRODUCTION

Preschool and school years are critical to a child's development and mastery of fundamental movement skills (FMS). The acquisition of FMS are developmentally sequenced and are contingent upon multiple internal and external factors (biological, psychological, social, motivational, cognitive, etc.) and the process of acquisition occurring through a range of active play experiences and structured programs [1]. These skills allow children to interact and explore their environment [2]. Furthermore, research among school aged children [3] shows that mastery of FMS is correlated with higher levels of physical activity and there is emerging evidence among preschoolers that FMS and in particular locomotor skills are also positively associated with physical activity. Basic descriptive epidemiological information on FMS among preschool aged children (i.e. 2-5 years) is limited [4].

Studies among primary school aged children indicate low levels of FMS mastery [5, 6] and given that children with low FMS competence are less likely to participate in

and enjoy many physical activities compared with their skilled peers, it appears prudent to examine FMS in preschool aged children [7]. Socio-demographic differences in FMS have been noted in school aged children, albeit inconsistently. There is some evidence which suggests socioeconomic status was positively associated with FMS among boys and children from non-English-speaking backgrounds had lower levels of FMS mastery [8].

Childhood obesity is a growing epidemic. Prevalence levels of overweight and obesity are dramatically increasing among children worldwide [9]. The global prevalence of childhood overweight for 2010 is already estimated at 46% in the Americas and at 38% in the European region [10]. This increase is alarming because obesity related health risks and psychosocial consequences are no longer only seen in adults. Several adverse health outcomes (e.g. hypertension, high cholesterol, type II diabetes, the development of cardiovascular disease, orthopedic abnormalities, sleep apnea) are already associated with childhood obesity too [11-13]. In the long term, obese children are more likely to

become obese adults, exposed to an increased comorbidity and mortality risk [14]. Physical fitness of overweight and obese children has extensively been documented.

Numerous studies already established a negative relationship between excessive body mass and performances on both endurance and weight-bearing tasks, whereas flexibility does not seem to differ significantly between overweight or obese children and normal-weight peers [15-17]. With respect to the relationship between movement coordination and childhood overweight, findings are somewhat contradictory. Using a single test item (lateral jumping) it was concluded that overweight and obese children show whole body coordination deficits¹⁶. However, it was shown that test battery consists of four interdependent factors, seems to evaluate children's general dynamic coordination. In contrast, fully completed the European physical fitness test battery demonstrated that limb coordination in itself is not really impaired [15].

Such inconsistent findings may be due to the tests being used and can be partially explained by the amount of body mass involved in the action. Although overweight and obese individuals do not produce lower scores on all fitness components, it is clear that they have inferior performances on physical tests requiring propulsion or lifting of the body mass [18].

Wong and Cheung conducted a study and provided normative information on gross motor skills performance of the Hong Kong Chinese children. A total number of 1251 children aged from 3 to 10 years participated in the Test of Gross Motor Development-Second Edition (TGMD-2). Their results indicated that the 630 children aged from 3 to 5 years performed best in run, jump and leap in the locomotor subtest (run, gallop, leap, hop, horizontal jump and slide). For the object control subtest (striking a stationary ball, dribbling, kick, catch, overhead throw and underhand roll), kick, dribbling and striking a stationary ball received the highest score. They also found that boys did better in object control skills while boys and girls did almost the same on locomotor skills. Results also indicated that there are significant negative correlations between body mass index (BMI) and locomotor subtest (run, gallop, leap, hop, horizontal jump) [19].

In a cross sectional study a total of 1377 K1 to K3 children aged from 3 years to 6 years participated in a self-designed test to assess children's performance. In the gross motor test, seven items were selected such as

overhand and underhand throw. The result reflected that boys were superior to girls on throwing task while girls performed better than boys on static balance [20].

The same findings were shown by an earlier study that aimed to investigate the age and sex differences in motor performance of pre-school Nigerian children. A list of motor tests items were administered to 341 young Nigerian children aged 3 to 5 years such as running, catching, tennis ball throw and etc. The result showed that boys consistently performed better than the girls in four of the six motor tests: catching, standing long jump, tennis ball throw and speed run. Also, the inverse correlation is founded between fundamental movement skills and BMI in this study [21].

Morris *et al.* (1982) examined the relationship of BMI and fundamental skills movements of 3-6 year olds on seven motor performance tests. BMI was found to be related more to performance than was gender on balance, scramble, catching, speed run, standing long jump, tennis ball throw for distance and softball throw for distance tests [22].

Loovis *et al.* have shown that body proportions were correlated with the fundamental movement skills of individuals. On the other hand, Kinnunen *et al.* indicated that through 60 free throws performed by 15 girls from Michigan and 18 girls from Puerto Rico (mean age 10), the inverse correlations between fundamental skills movement (run, gallop, Hop and Horizontal jump) and BMI were low [23]. Loovis and Butterfield examined the relationship between hand length and catching performance by 257 children in grade K2 (142 boys and 115 girls). The performance was determined by the number of successful catches (0-5) and the result reflected that hand length contributed significantly to catching accuracy and catching form [24].

Raudsepp and Jurimae stated that throwing results were significantly correlated with several somatic dimensions like femur width and height. In this study, 203 boys of 7 to 10 years old were being assessed on overhand throwing, body fatness and other anthropometric measurements [25].

Graf *et al.* (2004) evaluated the effect of BMI on the whole body gross motor development for 668 six years old children. Children were tested on a body gross motor development test and 6-minute run. Researchers found that overweight or obesity is associated with a poorer body gross motor development and endurance performance while the normal BMI children 31 had better result [26].

According to the wide variety of the results, the aim of this study was to examine the relationship between fundamental movement skills and BMI in 7- to 8 -Year-old children. Therefore, the purpose of this study was to investigate both gross and fine motor skills in overweight and obese children compared with normal-weight peers. To achieve this objective, children's motor skill competence was tested by means of a movement assessment battery covering the whole spectrum of motor skill.

MATERIALS AND METHODS

Experimental Design and Participants: The study took place in elementary schools in a middle class that were boys 7_8 years old. 200 children participated in study and Parents of the children were informed about the study. They read and signed an informed consent document prepared and approved by the Board for Protection of Human Rights affiliated to the University of Mohaghegh Ardabili.

The test was taken on the 4th, March, 2011 (Tuesday) and 6th, March, 2011 (Thursday), from 11AM to 3PM. At the beginning of the two testing days, the examiner explained the testing procedures to the participants in details. Eight FMS were assessed; four locomotor skills (run, gallop, hop, horizontal jump) and four object control skills (striking a stationary ball, catch, kick, overhand throw) using the Test of Gross Motor Development-2 (TGMD-2). The TGMD-2 was operated with the following sequences: run, gallop, hop, horizontal jump, striking a stationary ball, catch, kick, overhand throw and underhand roll. The participants queued behind the black line and performed the skill within 15 m space, which was marked with green and white tapes. A black line was also marked to provide guidance to the child. The examiner preceded the assessment with an accurate demonstration and verbal description of the skill, i.e. run. Then, a practice trial was provided for the child who queued at the front, to assure the child understands what to do. One additional demonstration was provided when the child did not appear to understand the task. After that, two test trials were given to the subjects and the raw skill score was given for each item ranged from 0-2. When the first subject was done, the second one at the queue started the test with the practice trial, an additional demonstration when he did not appear to understand and two test trials. The procedures were repeated until the last participant

was completed. The test was then followed by the second skill task, i.e. gallop and the process were same as before. However, the sequence of the queue was alternate so that one child did not always go first or last. In order to assure the consistency of the data, one examiner demonstrated the skill while another examiner observed and scored all participants' performance. Scores for each child were calculated by totaling the correctly performed criteria for two trials for each skill (i.e. if a skill comprises three performance criteria the score range is 0-6). The maximum sub-test scores for locomotor and object control skills were 38 and 32, respectively, with a minimum of 0. The sum of both sub-tests yielded the total gross motor skill score (total FMS).

FMS Assessments

Run: In the 15 m of running space and 2.5 m of stopping distance the child ran as fast as he can from the green line to the white line when the examiner said "Go". For the second trial, the child ran from the white line back to the green line and then waited at the end of the queue. The performance criteria for run were as follows: arms move in opposition to legs, elbows bent; brief period where both feet are off the ground; narrow foot placement landing on heel or toe (i.e. not flat footed); and nonsupport leg bent approximately 90 degrees.

Gallop: In the 7.5 m distance, from the green line, the child galloped to the middle between the green and white line and repeated a second trial by galloping back to the green line. The performance criteria for gallop were as follows: arms bent and lifted to waist level at 45 takeoff; a step forward with the lead foot followed by a step with the trailing foot to a position adjacent to or behind the lead foot; brief period when both feet are off the floor; maintains a rhythmic pattern for four consecutive gallops.

HOP: In the 4.5 m the child was hopped three times on his preferred foot and then three times on the other foot towards the white line. The second trial repeated by hopping back to the green line. The performance criteria for hop were as follows: nonsupport leg swings forward in pendular fashion to produce force; foot of nonsupport leg remains behind body; arms flexed and swing forward to produce force; takes off and lands three consecutive times on preferred foot; takes off and lands three consecutive times on non-preferred foot.

Horizontal Jump: In the 3 m the child started behind the green line and jump as far as he can. The second trial repeat from the green line again. The performance criteria for horizontal jump were as follows: preparatory movement includes flexion of both knees with arms extended behind body; arms extend forcefully forward and upward reaching full extension above the head; take off and land on both feet simultaneously; arms are thrust downward during landing.

Striking Stationary Ball: A plastic bat, a batting tee and two 10 cm lightweight balls were needed in this test. The batting tee was adjusted to the child's waist level. In the performing area, the child was told to hold the bat with both hand and hit the ball hard. For time saving, a second trial was done by using another ball. The performance criteria for striking a stationary ball were as follows: dominant hand grips bat above non-dominant hand; non-preferred side of body faces the imaginary tosser with feet parallel; hip and shoulder rotation during swing; transfers body weight to front foot; bat contacts ball.

Object Control Subtests

Catch: The 20- to 25-cm playground ball replaced the 10 cm plastic ball as mentioned by Ulrich (2000). The child and the tosser stood 4.5 m away of each other and the latter tossed the ball underhand directly to the child with a slight arc aiming for his chest. The child had to catch the ball with both hands for two times. The performance criteria for catch were as follows: preparation phase where hands are in front of the body and elbows are flexed; arms extend while reaching for the ball as it arrives; ball is caught by hands only.

Kick: Two 20- to 25-cm playground balls, a bean bag and 9 m of clear space were needed for this test. The ball was placed on the top of the bean bag between the green and white line, i.e. 3 m away from the green line. The child waited behind the green line and then ran up and kicked the ball hard. A second trial was repeated by using another ball. The performance criteria for kick were as follows: rapid continuous approach to the ball; an elongated stride or leap immediately prior to ball contact; non-kicking foot placed even with or slightly in back of the ball; kicks ball with instep of preferred foot (shoelaces) or toe.

Overhand Throw: Two tennis balls and 6 m of clear space were required in this test. The child was told to stand behind the green line and threw the ball hard. A second trial was done by using another ball. The performance criteria for overhand throw were as follows: windup is initiated with downward movement of hand/arm; rotates hip and shoulders to a point where the non-throwing side faces the wall; weight is transferred by stepping with the foot opposite the throwing hand; follow-through beyond ball release diagonally across the body toward the non-preferred side.

Body Composition Measurements: Bare footed standing heights were measured to the nearest cm using Seca stadiometer-model 216. To measure the height, the subjects stood erect with their backs touching the stadiometer, their arms held laterally by their sides and their two feet closely apposed. The weight of each subject was measured to the nearest kilograms using Seca scale. The BMI was calculated from the height (m) and weight (kg) [weight/ height ²].

Statistical Analysis: Data were analyzed with the SPSS for windows 15 version. Variables analyzed included the mean (M), standard deviation (SD), minimum and maximum values of the variables were calculated. Pearson Product Moment Coefficient of Correlation (r) was used to determine the correlations among the raw scores of the two motor subtests and BMI.

RESULTS

The means and standard deviations of the fundamental movement skills of all participants (N= 200) were summarized in Table 1. Participants scored higher in the object control skills (M= 27.79, SD= 4.12) than locomotor skills (M= 25.72, SD= 3.67).

To find out the relationship between motor skill performance and the BMI, an analysis of correlation was performed among the raw scores of the two motor subtests and the BMI values (Table 2).

In Table 2, raw scores of the participants' fundamental movement skills were correlated with BMI in all 7- to 8 -Year-Old Children. Similarly, significant negative correlations were found between the raw scores of the locomotor skills subtest and BMI: the run (r = -0.46, p # 0.01), gallop (r = -0.14, p # 0.05), hop (r = -0.38, p # 0.01), horizontal jump (r = -0.28, p # 0.01) and overhand throw (r = -0.17, p # 0.05), whereas correlations were not found between strike, catch, kick and BMI.

Table 1: Descriptive Results of Fundamental movement skills (N= 200)

Fundamental movement skills	Mean	SD
Locomotor skills		
Run	6.79	2.02
Gallop	6.91	1.64
Hop	7.14	3.06
Horizontal jump	4.88	2.43
Sub-test score	25.72	3.67
Object control skills		
Strike	8.52	1.94
Catch	5.16	4.86
Kick	7.2	1.45
Overhand throw	6.91	1.51
Sub-test score	27.79	4.12

Table 2: Correlation between the fundamental movement skills and BMI (N = 200)

Fundamental movement skills	BMI
Run	-.46**
Gallop	-.14*
Hop	-.38**
Horizontal jump	-.28**
Strike	0.05
Catch	-0.13
Kick	-0.02
Overhand throw	-.17*

*. P# 0.05; **. P# 0.01

DISCUSSION

The results of this study revealed that overall FMS proficiency is inversely associated with BMI. These results agree with other studies in this area that have used both process- [19-21] and product-oriented [27] assessments in smaller samples and across narrower age ranges. The inverse relationship between fundamental movement skills and BMI is often explained from a mechanical point of view; because obesity influences body geometry and increases the mass of different body segments. Hence, noncontributory mass could lead to biomechanical movement inefficiency and could be detrimental for motor proficiency. As differences in fundamental movement skills between BMI-groups were most obvious for skills involving more body segments, our results partially confirm this weight-bearing hypothesis. Nevertheless, we believe that the reported negative relationship between motor skill and BMI is mediated by several alternative and possibly complementary, mechanisms.

As children with movement difficulties perceive themselves less competent than other children, they are less likely to be physically active and they show preference for sedentary pastime. Withdrawal from physical activities surely inhibits diversified movement

experiences and simultaneously opportunities promoting neuromotor development [7]. At the same time, physical inactivity contributes to a positive energy balance and is therefore related to the current increase in childhood overweight and obesity. An inactive lifestyle thus may bring the obese child into a vicious circle, concerning both the health problem perse and the reported movement difficulties that seem to be related with it.

The inverse relationship between overhand throw and BMI, That is, BMI was found to be inversely related to only locomotor skill proficiency and overhand throw; it was virtually unrelated to object-control skill proficiency. This finding supports the only other published study that has examined these differences. It was also indicated that, among grade 6 students, overweight or obese students performed selected locomotor skills more poorly than their leaner peers, but there was no difference in performance on object-control skills. There are several possible explanations for the significant findings for only locomotor skills. First, as locomotor movements require greater overall movement of body mass than object-control skills (which are more static in nature); they may be more difficult for overweight children to perform. It has been shown that obese children find it more difficult to move their larger body mass against gravity [28]. In addition, overweight children are more likely to have orthopedic complications, such as slipped capital femoral epiphyses [29], Blount's disease [30] and flat feet [28], which may lead to greater pain when performing physical activity and reduced participation.

The occurrence of a tendency toward a weaker performance of obese children for manual dexterity is not conform to the mechanical point of view that is generally postulated to explain differences in motor skill related to weight status. Because all manual dexterity items are performed while seated, no displacement of the extra body mass is needed and balance control is not challenged to a great extent. Still, fine motor skill performance of obese children seems to be inferior compared with normal-weight and overweight counterparts [31].

CONCLUSION

In general, according to the results, we concluded that obese children may suffer from perceptual motor coordination difficulties, because they show poorer motor behavior when sensory information is needed to plan and control movement. Therefore, hypothesis of a perceptual-motor deficit in obese children is rather speculative and must therefore be addressed further.

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