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Relationship Between Body Mass Index and Development of Gross Motor Skills in 5-7-Year-Old Children

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Abstract

Background: Obesity in children and adolescents in the 21st century has become a major issue in the global health field. Previous studies showed that obese children have substantial adverse short- and long-term health consequences, including asthma, chronic low-grade systemic inflammation, diabetes, and numerous orthopedic complications. The purpose of this study was to investigate the relationship between body mass index (BMI) and the development of gross motor skills in 5-7-year-old children.
Methods: This was a cross-sectional study conducted on children 5 - 7 years old in Bojnourd, Iran. The sampling method was multistage. A checklist containing the demographic data and BMI of participants was completed. Ulrich's test of gross motor development (3rd edition) was also used to assess gross motor skills in children.
Results: The age range of participants was 5 - 7 years. The mean ± standard deviation (SD) of the participants' age was 6.24 ± 0.82 years. Furthermore, the participants' mean ± SD weight was 24.8 ± 3.68 g (range: 17.5 - 32.2 g). There was a significant statistical difference in gross motor skills scores in the three groups of obese, overweight, and optimal weight ($P < 0.0001$). There was also a significant difference in gross motor skills scores between the two gender groups ($P < 0.0001$).
Conclusions: Higher weight groups had lower motor skills scores. Therefore, it is necessary to adopt appropriate policies for physical activity and to reduce the prevalence of obesity and overweight in children.

Keywords: Body Mass Index, Children, Gross Motor Skills, Object Control Skill, Locomotor Skill

1. Background

The childhood overweight and obesity epidemic has become a global emergency in public health and a crucial challenge of the 21st century (1). The prevalence of overweight and obesity has increased in children and adolescents in developing countries, from 8.1% to 12.9% for males and from 8.4% to 13.4% for females (2). In a study in Iran, the prevalence of overweight and obesity in children aged 6 - 18 years was 10.1% and 4.79% according to national cut-offs, respectively (3).

Obesity in children increases the risk of chronic diseases, such as hypertension, hyperlipidemia, diabetes, cardiovascular disease, sleep apnea, arthritis, and multiple malignancies in adulthood (4, 5). Obesity in childhood also has long-lasting effects, such as detrimental socioeconomic and cardiovascular effects, and it keeps obesity up to adulthood (6). Factors such as nutrition, genetics, physical activity level, and performance in motor activity can be mentioned as elements related to overweight (7). However, few studies have focused on the efficacy of physical activity as a contributing factor to obesity (8).

According to some studies, obese children and adults have less physical activity and tend to have a more sedentary lifestyle and occupation, gradually a decrease in the physical activity leading to less energy burns and increased risk of obesity (9). Studies have shown that obese or overweight children are less likely to engage in physical activity than their normal-weight friends (10). In a literature review, Zacks et al. observed a relationship between increased weight and developmental motor delay in children, although they demonstrated that physical activity is a staple of healthy weight management (11).

Gross motor skills are the basic movements traditionally associated with human physical activity (12). Gross motor skills are the basis for many activities,

including running, skipping, jumping, throwing, hopping, and catching. Higher levels of gross motor skills are associated with better cardiorespiratory fitness, lower body mass index (BMI), higher physical activity, better language skills, higher social development, and enhanced cognitive development, according to previous studies (12, 13). It has previously been observed that poor motor skills have been linked with higher body weight in childhood (14). Gentier et al. showed that overweight and obese children present poorer gross motor skill performance and worse fine motor precision and manual dexterity than their healthy-weight peers (15).

In recent years, the prevalence of obesity in children has been largely dependent on energy imbalances (16). The epidemic of obesity in the past two decades is likely a result of a gradually increasing caloric intake and a decreasing level of physical activity (16). Although some studies have been carried out on the relationship between gross motor skills and different variables, such as social function, academic achievement, physical activity, and BMI in children (17-19), there is yet little conclusive supporting evidence for these associations. Additionally, few studies have investigated the relationship between obesity and gross motor skills in children (20).

2. Objectives

Therefore, the present study aimed to investigate the relationship between gross motor skills scores and BMI in children and identify obesity as one of the factors associated with gross motor skills.

3. Methods

3.1. Subjects and Sampling Method

This study was a cross-sectional study and was conducted in the field method. The population of this study included children 5 - 7 years old living in Bojnourd, Iran. In this study, 100 children were selected through a multi-stage method. Samples were collected from kindergartens in Bojnourd. In the first stage, Bojnourd was divided into three zones according to municipality classification, and then, in each district, each kindergarten was considered one cluster. Among the clusters, a few clusters were chosen by a simple random method relative to the number of kindergartens in that area. In the next stage, in these selected areas, equal numbers of each age group (5, 6, and 7 years) and both genders were selected if they met the inclusion criteria, and after obtaining written consent from the parents of the child and if the child desired. The sample size was calculated to be 100 children.

The inclusion criteria were normal children aged from 5 - 7 years who could follow directions and comply during evaluation. The exclusion criteria were lack of cooperation for research, known developmental disability, mental or other clinically diagnosed impairment, and apparent deformity and orthopedic injury in both upper and lower extremities within 6 months.

3.2. Determination of the Level of Gross Motor Skills and Its Relationship with Body Mass Index

Ulrich's test of gross motor development (3rd edition) is used to assess gross motor skills in children. The translation steps, standardization, and localization of Ulrich's test of gross motor development (3rd edition) have already been determined in a previous study (21). This study also evaluated and approved the content validity index (0.8 -1), internal consistency ($\geq$ 0.85), and reliability ($\geq$ 90) of the test. A single evaluator who had been trained by the authors was involved in assessing gross motor skills among children aged 5 - 7 years.

Each child was then given a total of the Ulrich 2 motor test, and each child's score was calculated. The total score for each subscale was 48, and the total motor skills score was 96. Then, the relationship between BMI and gross motor skills was investigated using statistical methods. According to the purpose of the study, the BMI of children was considered the independent variable, and gross motor skills score was considered the dependent variable. In the present study, BMI was used to identify overweight and obese children. Height was measured in bare feet and in centimeters. Body mass was measured with digital scales in minimal clothing. By measuring both height and body mass in the present study, children's BMI was calculated using the following formula:

$$BMI = \frac{Weight}{Height^2} \quad (1)$$

In this formula, the weight is calculated in kg and height in meters.

The Ulrich 2 scale was used to qualitatively evaluate motor skills, as described previously by Mohammadi et al. (21).

In this study, the performance of basic motor skills in children was assessed by motor skills development test, and their scores were collected. To perform the test, the assessor thoroughly described how to perform each skill and then showed the skill to each child. The child was then asked to perform each skill; after twice observation, the test taker evaluated and scored the desired skill. In the end, the performance of the subjects in different groups was

compared based on different levels of BMI. The validity of this test is 96%, and its reliability for each subscale is 87% (12).

3.3. Statistical Analysis

The data were analyzed using SPSS software (version 23). The chi-square test was used to compare qualitative variables between groups. The independent *t*-test (normal distribution of data) and equivalent non-parametric tests were used to compare quantitative variables between groups. In all calculations, a P-value < 0.05 was considered the level of significance. Before sampling, the importance and necessity of this study were explained to parents, and consent was obtained from their parents voluntarily and consciously. All information obtained from children in the form of a questionnaire without anonymity and only with a questionnaire number was recorded and emphasized the keeping of volunteer secrets.

4. Results

The study included 100 children aged 5 to 7 years. In this study, 51 (51.3%) and 48 (49.7%) cases were female and male, respectively. The participants' mean BMI was 16.61 ± 1.59 kg/m^2 (BMI range: 13 - 20.26). In this study, the Ulrich-2 test was used to assess gross motor skills. The test has a total score and two subsets, including object control skill and locomotor skill, each of which consists of 6 subscales. Additionally, in this study, the mean and SD of total gross motor skills score and each of the subscales for object maintenance and motor skills were assessed in three groups of BMI, including optimal weight, overweight, and obesity. One-way analysis of variance (ANOVA) was used for this purpose (Figure 1).

Paired comparisons were made between the optimal, overweight, and obese groups based on the statistical analysis in terms of total gross motor skills score, object control skill, and locomotor skill. A significant correlation was observed in all these comparisons ($P < 0.0001$). The total gross motor skill scores were significantly lower in the higher-weight groups than in the lower-weight groups.

The study also assessed the total gross motor skill and each of the subscales of object control skill and locomotor skill in the two male and female gender groups (Table 1). As can be seen, the total gross motor skill score was significantly different between the two groups ($P < 0.0001$). The total score of motor skills and each of its subscales was higher in the female group than in the male group.

This study also compared motor skills in different age groups using a one-way ANOVA test (Table 2). Significant differences were observed between the three groups ($P < 0.0001$), although the total score of motor skills and each of its subscales increased in older children.

The relationship between motor skills and BMI was determined according to gender. The results, as shown in Table 3, indicate that there are significant statistical differences between the BMI and motor skills except for the locomotor skill in the female group. In the male group, there was a significant difference between motor skills score and BMI (Table 4).

5. Discussion

The purpose of this study was to investigate the relationship between BMI and gross motor development in 5 - 7-year-old children in Bojnourd. The present study showed that there were significant differences in object control, locomotor, and total gross motor skills between children with optimal weight and obese children ($P < 0.05$). The results of the present study also indicated that the relationship between motor skill scores and BMI was significantly different between children of different ages and genders ($P < 0.05$).

Nervik et al., in a study on 3-5-year-old children, showed lower motor skill scores in the group with higher BMI (22), which is similar to the results of the present study. Khalaj and Amri also observed similar results in a study of 160 children aged 4 to 8 years (23). In a study, Dokic and Meedović compared motor development in obese girls to normal-weight girls and showed that obese girls had less motor development than normal-weight girls (24). Truter and Du Toit also examined the relationship between motor skills and BMI in the two groups of 4 - 6 years, compared to the 6 - 8 years; however, contrary to the present study, only a significant difference was observed in some parts of the study (25). In a study using 7- and 8-year-old children, only some parts showed a significant relationship (26).

The present study showed that gross motor skills have a significant relationship with age, as the motor skills score increases with increasing age. Truter and Du Toit also obtained similar results in their studies, with the difference being that the mean of motor skills in the group 6 to 8 years was higher than in the group 4 to 6 years (25). It was also shown in this study that gross motor skill scores had a significant relationship with gender, and girls had higher average motor skill scores than boys. Shams and Vameghi obtained a different result in a study on 3- to 5-year-old children, as the mean score of boys was higher than girls (27). However, in the aforementioned study, a motor assessment scale (OSU-SIGMA qualitative scale) different from the present study (Ulrich's test of gross motor development) was chosen.

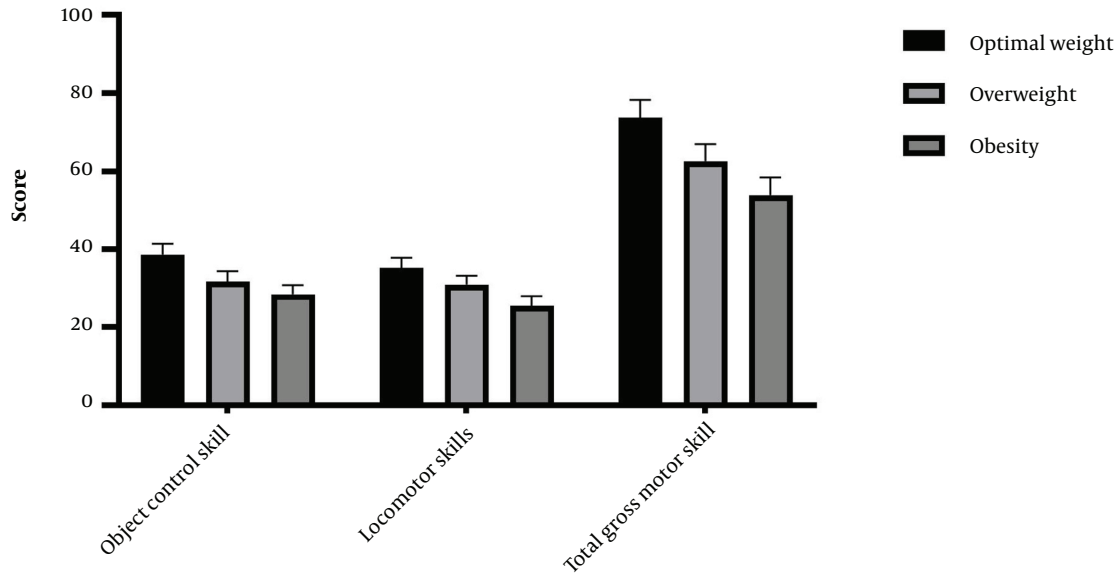

Figure 1. Relationship between body mass index and gross motor skills. There are significant differences in object control, locomotor, and total gross motor skills between children with optimal weight and obese children. The data are expressed as mean.

Table 1. Relationship Between Gross Motor Skills and Gender [a]

Item (Mean ± SD)	Male	Female	P-Value
Total score of gross motor skill	63.69 ± 5.38	66.05 ± 5.74	< 0.0001
Moving skill	29.23 ± 2.63	30.61 ± 2.95	< 0.0001
Object maintenance skill	34.45 ± 3.16	35.44 ± 3.42	< 0.0001

Abbreviation: SD, standard deviation
[a] The total score of motor skills and each of its subscales were significantly different between female and male subjects (P < 0.0001).

Table 2. Relationship Between Motor Skills and Age [a]

Item (Mean ± SD)	7-Year-Old	6-Year-Old	5-Year-Old	P-Value
Object maintenance skill	36.33 ± 3.06	35.40 ± 2.73	32.94 ± 3.27	< 0.0001
Moving skill	30.63 ± 1.95	30.04 ± 3.05	29.05 ± 3.40	< 0.0001
Total score of motor skill	66.96 ± 4.14	65.45 ± 5.15	61.66 ± 6.50	< 0.0001

Abbreviation: SD, standard deviation.
[a] The total score of motor skills and each of its subscales were significantly different between children of different ages (P < 0.0001).

The low sample size due to the non-cooperation of children to participate in the study, concerns about the possibility of harming children during the test, and little cooperation by kindergartens and schools to achieve outcomes were some of the limitations of this study. The problems related to the non-cooperation of children were solved by assistance from kindergarten educators and encouragement through small awards. The safety of children was also increased by conducting all stages of testing in rooms covered with tatami mats. This cross-sectional study was conducted to evaluate the variables of BMI and motor skills, which might lead to a misinterpretation of the dependent and independent variables examined in the present study. Additionally, many underlying factors might affect the relationship between the variables due to the cross-sectional nature of the study design.

Table 3. Relationship Between Motor Skills and Body Mass Index in Female Subjects [a, b]

Items	Optimal Weight (1)	Overweight (2)	Obesity (3)	P-Value	
				1 and 3	1 and 2
Total score of motor skill	69.10 ± 4.13	64.23 ± 4.00	58.55 ± 5.57	< 0.0001	0.005
Moving skill	31.82 ± 2.71	30.00 ± 1.91	27.55 ± 3.16	< 0.0001	0.10
Object maintenance skill	37.27 ± 2.44	34.23 ± 2.61	31.00 ± 2.78	< 0.0001	0.002

[a] These data show a significant relationship between the total score of motor skills and each of its subscales with body mass index (BMI) in the female group, except for the moving skill.
[b] The data are expressed as mean ± standard deviation (SD).

Table 4. Relationship Between Motor Skills and Body Mass Index in Male Subjects [a, b]

Items	Optimal Weight (1)	Overweight (2)	Obesity (3)	P-Value	
				1 and 3	1 and 2
Total score of motor skill	66.30 ± 4.87	60.92 ± 4.32	59.00 ± 3.85	0.001	0.003
Moving skill	30.46 ± 2.51	27.85 ± 2.21	27.25 ± 1.98	0.004	0.005
Object maintenance skill	35.84 ± 2.92	33.07 ± 2.84	31.75 ± 2.18	0.002	0.012

[a] These data show a significant relationship between the total score of motor skills and each of its subscales with body mass index (BMI) in the male group.
[b] The data are expressed as mean ± standard deviation (SD).

5.1. Conclusions

The results showed that there was a significant relationship between BMI and motor skills. This finding might be due to two modes. One is that high BMI in obese children is due to low physical activity (or weaker motor skills); another mode is that their high BMI has reduced their motor skills.

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Footnotes

Authors' Contribution: Author Contributions: Study concept and design: SH.SH.; data collection: SH.SH.; analysis and interpretation of data: H. NA.; drafting of the manuscript: H.NA.; critical revision of the manuscript for important intellectual content: SH.SH., approved the final version of the manuscript: SH.SH. and H.NA.

Conflict of Interests: The authors declare that there is no conflict of interest.

Data Reproducibility: The dataset presented in the study is available on request from the corresponding author during submission or after publication.

Ethical Approval: The present study was conducted under the Declaration of Helsinki and with approval from the Ethics Committee of North Khorasan University of Medical Sciences, Bojnourd, Iran (970146).

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Informed Consent: A document was signed by the children's parents indicating their voluntary consent for their children to participate in the study after being informed of the purpose, procedures, and potential risks and benefits of the study.

References

1. Nittari G, Scuri S, Gamo Sagaro G, Petrelli F, Grappasonni I. Epidemiology of obesity in children and adolescents. *Teamwork in Healthcare*. IntechOpen; 2021. https://doi.org/10.5772/intechopen.93604.
2. Ng M, Fleming T, Robinson M, Thomson B, Graetz N, Margono C, et al. Global, regional, and national prevalence of overweight and obesity in children and adults during 1980-2013: a systematic analysis for the Global Burden of Disease Study 2013. *Lancet*. 2014;**384**(9945):766–81. [PubMed ID: 24880830]. [PubMed Central ID: PMC4624264]. https://doi.org/10.1016/S0140-6736(14)60460-8.
3. Mirmohammadi SJ, Hafezi R, Mehrparvar AH, Rezaeian B, Akbari H. Prevalence of overweight and obesity among iranian school children in different ethnicities. *Iran J Pediatr*. 2011;**21**(4):514–20. [PubMed ID: 23056841]. [PubMed Central ID: PMC3446144].
4. Jastreboff AM, Kotz CM, Kahan S, Kelly AS, Heymsfield SB. Obesity as a disease: The obesity society 2018 position statement. *Obesity (Silver Spring)*. 2019;**27**(1):7–9. [PubMed ID: 30569641]. https://doi.org/10.1002/oby.22378.

5. Fikry FEED, Mohamed AA, Mohamed AM, El-said SM. Assessment of overweight and obesity among preschool children in day care centers in Alexandria-Egypt. *Int J Novel Res Healthc Nurs*. 2019;**7**(3):577–95.
6. Smith JD, Fu E, Kobayashi MA. Prevention and management of childhood obesity and its psychological and health comorbidities. *Annu Rev Clin Psychol*. 2020;**16**:351–78. [PubMed ID: 32097572]. [PubMed Central ID: PMC7259820]. https://doi.org/10.1146/annurev-clinpsy-100219-060201.
7. Hodge SR VA. Health, nutrition, and physical activity. *Handbook of urban education*. Routledge; 2021. p. 64–83.
8. Tsuda E, Goodway JD, Famelia R, Brian A. Relationship between fundamental motor skill competence, perceived physical competence and free-play physical activity in children. *Res Q Exerc Sport*. 2020;**91**(1):55–63. [PubMed ID: 31469346]. https://doi.org/10.1080/02701367.2019.1646851.
9. Zhu YC, Wu SK, Cairney J. Obesity and motor coordination ability in Taiwanese children with and without developmental coordination disorder. *Res Dev Disabil*. 2011;**32**(2):801–7. [PubMed ID: 21109392]. https://doi.org/10.1016/j.ridd.2010.10.020.
10. Deforche B, Lefevre J, De Bourdeaudhuij I, Hills AP, Duquet W, Bouckaert J. Physical fitness and physical activity in obese and nonobese Flemish youth. *Obes Res*. 2003;**11**(3):434–41. [PubMed ID: 12634442]. https://doi.org/10.1038/oby.2003.59.
11. Zacks B, Confroy K, Frino S, Skelton JA. Delayed motor skills associated with pediatric obesity. *Obes Res Clin Pract*. 2021;**15**(1):1–9. [PubMed ID: 33268277]. https://doi.org/10.1016/j.orcp.2020.10.003.
12. Wang JH. A study on gross motor skills of preschool children. *J Res Child Educ*. 2004;**19**(1):32–43. https://doi.org/10.1080/02568540409595052.
13. Veldman SL, Jones RA, Okely AD. Efficacy of gross motor skill interventions in young children: an updated systematic review. *BMJ Open Sport Exerc Med*. 2016;**2**(1). e000067. [PubMed ID: 27900154]. [PubMed Central ID: PMC5117028]. https://doi.org/10.1136/bmjsem-2015-000067.
14. Cheng J, East P, Blanco E, Sim EK, Castillo M, Lozoff B, et al. Obesity leads to declines in motor skills across childhood. *Child Care Health Dev*. 2016;**42**(3):343–50. [PubMed ID: 27059409]. [PubMed Central ID: PMC4841726]. https://doi.org/10.1111/cch.12336.
15. Gentier I, D'Hondt E, Shultz S, Deforche B, Augustijn M, Hoorne S, et al. Fine and gross motor skills differ between healthy-weight and obese children. *Res Dev Disabil*. 2013;**34**(11):4043–51. [PubMed ID: 24036485]. https://doi.org/10.1016/j.ridd.2013.08.040.
16. Singhal V, Schwenk WF, Kumar S. Evaluation and management of childhood and adolescent obesity. *Mayo Clin Proc*. 2007;**82**(10):1258–64. [PubMed ID: 17908531]. https://doi.org/10.4065/82.10.1258.
17. Robinson LE, Goodway JD. Instructional climates in preschool children who are at-risk. Part I: object-control skill development. *Res Q Exerc Sport*. 2009;**80**(3):533–42. [PubMed ID: 19791639]. https://doi.org/10.1080/02701367.2009.10599591.
18. Cattuzzo MT, Dos Santos Henrique R, Re AH, de Oliveira IS, Melo BM, de Sousa Moura M, et al. Motor competence and health related physical fitness in youth: A systematic review. *J Sci Med Sport*. 2016;**19**(2):123–9. [PubMed ID: 25554655]. https://doi.org/10.1016/j.jsams.2014.12.004.
19. Holloway JM, Long TM, Biasini F. Relationships between gross motor skills and social function in young boys with autism spectrum disorder. *Pediatr Phys Ther*. 2018;**30**(3):184–90. [PubMed ID: 29727358]. [PubMed Central ID: PMC6013349]. https://doi.org/10.1097/PEP.0000000000000505.
20. Jaffe M, Kosakov C. The motor development of fat babies. *Clin Pediatr (Phila)*. 1982;**21**(10):619–21. [PubMed ID: 6180859]. https://doi.org/10.1177/000992288202101011.
21. Mohammadi F, Bahram A, Khalaji H, Ghadiri F. The validity and reliability of test of gross motor development - 3rd edition among 3-10 years old children in Ahvaz. *Jundishapur Sci Med J*. 2017;**16**(4):379–91. https://doi.org/10.22118/jsmj.2017.51022.
22. Nervik D, Martin K, Rundquist P, Cleland J. The relationship between body mass index and gross motor development in children aged 3 to 5 years. *Pediatr Phys Ther*. 2011;**23**(2):144–8. [PubMed ID: 21552075]. https://doi.org/10.1097/PEP.0b013e318218d356.
23. Khalaj N, Amri S. Mastery of gross motor skills in preschool and early elementary school obese children. *Early Child Dev Care*. 2013;**184**(5):795–802. https://doi.org/10.1080/03004430.2013.820724.
24. Djokic Z, Medjedovic B. Relationship between overweight, obesity and the motor abilities of 9-12 year old school children. *Fizicka kultura*. 2013;**67**(2):91–102. https://doi.org/10.5937/fizkul1302091D.
25. Truter L, Pienaar AE, Du Toit D. The relationship of overweight and obesity to the motor performance of children living in South Africa. *S Afr Fam Pract*. 2014;**54**(5):429–35. https://doi.org/10.1080/20786204.2012.10874266.
26. Siahkouhian M, Mahmoodi H, Salehi M. Relationship between fundamental movement skills and body mass index in 7-to-8 year-old children. *World Applied Sci J*. 2010;**15**.
27. Shams A, Vameghi R. Effect of age and body mass index on performance quality of motor skills among children with 3-5 years-old. *J Shahrekord Univ Med Sci*. 2017;**19**(5):1–12. Persian.