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Relationship between physical activity and sleep habits with motor proficiency among school aged children in Iran

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Despite the importance of basic motor skills in preschool and elementary school children for developing specialized skills in adulthood, the factors influencing motor proficiency have not yet been fully identified, and there are contradictory findings regarding the influencing factors. Therefore, the present study aims to investigate the relationship between physical activity and sleep habits with motor proficiency among school aged children in Iran. In this descriptive and analytical cross-sectional study, 403 school-aged children living in Bushehr were selected using cluster random sampling method. Data collection tools included demographic form, physical activity questionnaire for older children, children's sleep habits questionnaire, anthropometric measurements and short-form Bruininks-Oseretsky test of motor proficiency. The data were analyzed using SPSS 19.0, descriptive statistics and analytical tests (simple and multiple univariate regression). The significance level was considered less than 0.05 in all cases. The mean age of the children participating in the study was 9.65 ± 1.72 years. Approximately half of the children (46.5%) were classified as overweight and obese. The simple regression analysis showed a significant statistical correlation between motor proficiency and child's age, parent's age, number of siblings, BMI and physical activity ($P<0.05$). The multiple regression analysis results indicated a significant correlation between motor proficiency and child's age ($\beta=0.462$, $P<0.001$), gender ($\beta=0.145$, $P=0.001$) and BMI ($\beta=-0.157$, $P<0.001$). Children with a higher BMI, younger age and female gender exhibited a lower level of motor proficiency. The obtained findings are of particular importance for raising awareness of school officials and health policymakers about various aspects of health such as growth and motor development, and developing necessary strategies to enhance girls' motor development and prevent obesity.

Keywords Physical activity, Sleep, Motor skills, Body mass index, Children

Abbreviations

BMI	Body mass index
BOT-2	Bruininks-Oseretsky test of motor
CSHQ	Children's sleep habits questionnaire
IPAQ	International physical activity questionnaire
MET	Metabolic equivalent
PAQ-C	Physical activity questionnaire for older children
TGMD-2	Test of gross motor development-second edition

Growth and development, as well as related disorders, are among the most important issues in childhood, which have a substantial impact on one's health throughout various life stages[1]. Motor development refers to changes in motor behavior and underlying processes that facilitate these changes[2]. Occasionally, certain factors

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lead to problems in the motor development, resulting in children experiencing difficulties in gross and fine motor skills and overall coordination. Developmental coordination disorder is among the most prevalent developmental disorders affecting these motor skills[3], with approximately 6% of children being affected by this condition worldwide[4]. The prevalence of developmental coordination disorder is reported to be about 5–8% among school-aged children. Various statistics have been reported regarding the prevalence of this disorder in different cities of Iran. A study conducted in several provinces of Iran reported the prevalence of this disorder as 2.7% among children aged 3–11 years old[5]. The development of basic motor skills during childhood is regarded as an essential element of interventions designed to improve fitness[6]. Motor performance deficits disrupt daily life skills, playing games, academic skills and recreational and social activities[7]. Insufficient development of basic motor skills among preschool and elementary school children often leads to a deficiency in specialized skills in adulthood, potentially threatening their future participation in sports and physical activities[8]. There is a common misconception that children instinctively acquire basic motor skills and automatically reach higher skill levels[9]. However, these skills should be acquired through instruction, and children should be provided with opportunities to practice such skills[10]. Early school years are an optimal period for developing these skills, as children have a remarkable capacity to learn and refine their motor skills during this stage[1]. Motor skills exhibit a sequential and predictable pattern that could be compared among children and are influenced by both intrinsic (biological, psychological) and extrinsic (social, environmental) factors[10]. Sleep and physical activity are considered among the intrinsic biological factors that significantly affect health indicators; and according to the results of a systematic review, sleep is important for motor development in childhood and may enhance motor skills acquisition in children[11,12]. Physical activity refers to any bodily movement produced by skeletal muscles that leads to energy expenditure[13] and increases blood flow to vital organs, as well as growth factors[14]. Moreover, it promotes growth and enhances neural function, modifies synaptic transmission and prevents neurodegenerative diseases in adulthood[15,16]. However, contemporary lifestyles have increasingly shifted toward sedentary behavior, with only one-third of children being sufficiently active[16]. Sleep is considered an intrinsic factor and basic human need and defined as a behavioral state, characterized by decreased reaction to external stimuli, occupying a substantial part of the 24-h day[17]. Additionally, growth hormone secretion, weight gain and improved growth in children occur during sleep[18]. Due to its impact on health and growth, sleep is likely to influence the development of children's motor skills as an indicator of their growth and development[11]. Sleep habits are a dynamic process shaped during childhood based on familial and cultural contexts. People try to maintain their sleep habits, although they may vary across different ages among individuals[19]. On the other hand, overweight, obesity and body composition could influence children's participation in physical activities and their motor skill development[20]. Numerous studies have investigated various factors affecting motor development. In their systematic review, Zeng et al.[21] found a significant correlation between physical activity and motor development among preschool children. Logan et al.[22] reported that the correlation between physical activity and motor skills during middle childhood was at a low to moderate level. Another study indicated a physical activity development program improved motor skills in a short period of time[23].

However, Lovrić et al.[24] found no significant correlation between children's physical activity and their motor skills. In their systematic study on the relationship between sleep and motor development, Chaput et al.[25] reported no significant correlation between sleep components and cognitive and motor development among children aged 0–4 years old. However, Iemura et al.[26] reported a positive correlation between sleep and developmental patterns. Moreover, most studies have found a significant inverse correlation between BMI and motor proficiency[8]. Conversely, some studies have reported no correlation between BMI and motor skills[27]. Shirvani and Seifi[28] investigated perceptual-motor ability of children aged 7–11.5 years old and found that boys had greater perceptual-motor ability than girls. However, some studies have not found a statistically significant difference in children's motor skills based on gender[29]. Identifying the factors influencing growth and motor development could provide a foundation for planning interventions aimed at optimizing children's health. Additionally, it could help healthcare providers, especially pediatric nurses, deliver more comprehensive care[30].

Therefore, despite some conflicting findings in previous studies, and considering the importance of children's motor proficiency for health and development of an active lifestyle, as well as the potential positive correlation between motor skills and physical activity during childhood and adolescence, and that higher levels of motor skills, based on some studies, may have a protective effect on children's cardiovascular health, it is essential to investigate and monitor motor proficiency, particularly during early and middle childhood[31–34]. Since physical activity and sleep habits vary across different cultures and climates[35,36], cultural studies could provide valuable insights into the diversity of these two biological components. Given the importance of identifying the factors influencing children's motor proficiency, the present study aims to examine the relationship between physical activity and sleep habits with motor proficiency among school aged children in Iran.; and as a secondary objective, we sought to determine which other demographic or anthropometric variables, including BMI and gender, were associated with motor proficiency in school-aged children.

Methods

Study type and participants

This descriptive and analytical cross-sectional study was conducted on 403 elementary school students (199 boys and 204 girls) in grades 1–6 in Bushehr, one of the southern provinces of Iran, in 2019–2020. The participants were selected using cluster random sampling method. First, four elementary schools were randomly selected from each district of Bushehr, including two all-girls schools (public and private) and two all-boys schools (public and private). In total, 20 schools were selected as clusters. Then, the share of each school was determined based on the total number of students in schools within that district, categorized by gender (all-girls, all-boys), type (public and private) and grade level. The share of each grade level was determined based on the number of students at each grade level in each elementary school, ultimately establishing the share of each elementary school. Then, the research units at each grade level were randomly selected from the available records at the school.

The inclusion criteria for children were being within the age range of 6–12 years old and verified physical and mental health based on their school health records. The inclusion criteria for parents were being at least able to read and write in order to complete the questionnaire. The exclusion criteria for children were taking sleep medication recently, having upper respiratory problems, being blind or deaf, having developmental, neurological and skeletal disorders, lack of physical activity due to problems or illness in the past week, not completing the motor test by children for any reason and submitting incomplete questionnaire by parents.

Measures

Measuring anthropometric indices: The children's weight was measured using Beurer GS36 digital scale (Germany) with the accuracy of 100 g. Measurements were taken with the child standing barefoot and wearing minimal clothing in the middle of the scale. The students' height was measured in a standing position using a tape measure with the accuracy of 0.1 cm, without wearing shoes or hats, ensuring that the head was positioned at a 90° angle facing forward, and that the heels, buttocks, shoulders and back of the head touched the wall where the tape measure was installed[37]. Body mass index (BMI) was calculated by dividing weight (kg) by the square of height (m), to standardize which, the values were calculated based on age and gender (z-score), and the z-score was used as the anthropometric indices[38].

Physical activity was assessed using physical activity questionnaire for older children (PAQ-C), developed by Crocker et al.[39]. This self-reported questionnaire assesses the level of participation of children and adolescents aged 8–14 years old in various physical activities as well as daily activities during physical education classes, lunch breaks, after school, in the evenings and on weekends over the past seven days[40]. The questionnaire has also been used for children aged 6.6 to 7.6 years old[27]. PAQ-C consists of 10 items, only the total of 9 items is considered as a person's physical activity score. The minimum and maximum scores are 9 and 45, respectively; Higher scores indicating greater physical activity. The final question asks about inactivity during the past week and the reason for that. Previous studies have reported its validity and reliability at the desirable level[41]. Its Cronbach's alpha coefficient among Iranian children was obtained as 0.894[42]. In the present study, the questionnaire reliability was calculated as 0.824 using Cronbach's alpha coefficient.

Children's sleep habits questionnaire (CSHQ), developed by Owns et al.[43], was among the tools used in the study to identify prevalent sleep problems among children aged 4–12 years old. CSHQ provides information about nighttime sleep time, manner of waking up, daytime sleepiness, etc., over the past week. This questionnaire consists of 33 items, scored based on a Likert scale (usually, sometimes, rarely), ranging from 1 to 3. Thus, if a behavior occurs 5–7 days a week, it is marked as "usually" (score 3), if it occurs 2–4 times a week, it is marked as "sometimes" (score 2) and if it occurs 0–1 times a week, it is marked as "rarely" (score 1)[44–47]. The minimum and maximum scores are 33 and 99, respectively; with a higher score indicating a poorer sleep status. This tool does not have a validated cut-off point. Thus, the obtained raw scores were used for statistical analysis. The questionnaire validity and reliability were confirmed by Mehri et al. in Iran[48]. In the present study, its reliability was calculated as 0.772 using Cronbach's alpha coefficient.

Bruininks-Oseretsky test of motor proficiency (BOT) was used to assess children's motor proficiency. BOT is a normative-referenced test designed to assess the motor performance of children aged 4.5–14.5 years old. This questionnaire includes two complete and short forms. In the present study, the short form was utilized. The short form is applied when a general assessment of children's perceptual abilities is demanded. It evaluates children's overall motor skills, providing a total score that reflects both gross and fine motor skills[28]. The short form includes 14 items in 8 subtests, representing a part of the complete-form BOT with its 46 items. It assesses skills such as running speed and agility (1 item), static and dynamic balance (2 items), bilateral coordination (2 items), leg muscle strength (1 item), upper limb coordination (2 items), reaction time (1 item), visual-motor control (3 items) and upper limb agility and speed (2 items). Four subtests evaluate gross motor skills (subtests 1–4), three subtests evaluate fine motor skills (subtests 6–8) and one subtest assesses both types of motor skills (subtest 5). The test–retest reliability of the complete and short forms was reported as 0.78 and 0.86, respectively. Its validity was obtained as 0.84. Inter-rater agreement, measured by two independent observers, was used to determine motor skill reliability in 20 children in Bushehr, resulting in a high reliability score of 0.96 ($P<0.001$). Each item has a raw score, which is converted into a score according to the guideline table. Combining components of all eight subtests provides an index of overall motor skills[1]. A higher score indicates better motor development. According to the guideline table, raw scores, total scores and percentiles of these scores could be used for statistical analysis[49]. In this study, the obtained total score was used as a quantitative measure for statistical analysis. The total scores were converted into standardized scores based on the guidelines and norm table and, then, entered into statistical analysis. According to the table, the minimum and maximum standardized scores are 24 and 75, respectively.

Procedure

A written approval was obtained from Vice Chancellor for Research of Bushehr University of Medical Sciences and Education Department and presented to the school principals. After making the necessary arrangements, oral and written consent was obtained from the students and their parents for their participation in the study, respectively. The informed consent form, demographic information questionnaire and children's sleep habits questionnaire (CSHQ) were given to the children to take home for their parents to complete. The children were asked to submit the completed forms the next day to their teachers or school assistants. To collect data, the children were individually tested by the examiner and her assistants, who had been trained for the test.

PAQ-C was completed, anthropometric indices were measured and BOT was implemented during school hours when the students had free time. First, the students were clearly explained how to complete the physical activity questionnaire, each question was asked to the students and their answers were entered. Then, their height and weight were measured and recorded based on standard criteria. To administer the test of motor proficiency, items related to fine motor skills (items 6–8) were conducted in the classroom, while items related to gross motor skills (items 1–4) and item 5, combining both skills, were performed in the schoolyard. Each item was clearly explained to the children before it was performed, and the examiner demonstrated it in front of them. If errors occurred during the test or if the participant did not achieve the maximum score, the second attempt was made. However, in subtest 7, participants completed the first part only once and were not allowed to correct their responses. All test procedures and scoring of each item were carried out according to the guideline[1].

Data analysis

The data were analyzed using SPSS 19.0 and appropriate tests. Descriptive statistics, including mean, standard deviation and frequency tables, were used to describe the variables. Normality of distribution of the dependent variable was assessed using Kolmogorov–Smirnov test. Simple regression was first performed to analyze the data and examine the predictors of motor proficiency. Demographic variables, including child's age and gender, parents' age, having siblings, parents' educational level and occupation and economic status, and the reference scores of BMI, physical activity and sleep habits were separately entered as independent variables into the regression equation. Then, the variables associated with motor proficiency in the simple regression were included in the multiple univariate linear regression. Multiple regression assumptions were evaluated. In order to verify the normality of the residuals, both a QQ plot and the Kolmogorov–Smirnov test were utilized. The calculated value of the Durbin-Watson test, ranging from 1.5 to 2.5, confirmed the independence of the residuals. The maximum leverage index value did not indicate any observations in which the index exceeded 0.5, suggesting that there were no outliers for the independent variable. Additionally, to identify any outliers in the dependent data, the DfFit index was analyzed. The DfFit index revealed that none of the observations exceeded an index value of $2\sqrt{(p/n)}$, thereby confirming the absence of any outliers in the dependent data. To prevent multicollinearity, one variable from each pair of highly correlated variables was entered into the regression. The presence of multicollinearity was evaluated through the utilization of both tolerance and inflation indices. The tolerance index was found to be less than 0.1, while the inflation index did not exceed 10. These findings suggest the absence of multicollinearity in the data. The significance level was considered less than 0.05 in all cases.

Ethical considerations

This research was approved by Ethics Committee of Research Assistant of Bushehr University of Medical Sciences with reference no. IR.BPUMS.REC.1397.109. All ethical considerations, including obtaining approvals and written consent, explaining research objectives and maintaining the confidentiality of participants' information, were observed.

Results

In total, 403 students (199 boys and 204 girls) with the mean age of 9.65 ± 1.72 years were included in the study. The mean age of fathers and mothers was 41.32 ± 5.54 and 36.51 ± 4.81 years, respectively. About 48.6% of fathers and 43.4% of mothers had a university education. The majority of mothers were housewives (80.9%), while nearly half of the fathers were self-employed. More than half of the participants reported their economic status as moderate. Table 1 presents other demographic characteristics of the research participants.

As indicated in Table 2 regarding BMI-for-age, nearly half of the children (46.5%) were overweight and obese, with most of them being classified as overweight. Additionally, a small percentage were underweight and severely underweight (1.7%). Since the weight-for-age index could only be assessed in the age range of 5–10 years old, students older than 10 years old were excluded from this assessment (Table 2).

The overall mean scores of physical activities, sleep habits and motor proficiency were obtained as 28.13 ± 5.51, 48.32 ± 7.59 and 53.81 ± 13.80, respectively. The mean scores of gross and fine motor skills were 29.18 ± 7.52 and 28.00 ± 5.17, respectively.

In the next step, motor proficiency was entered into the linear regression as the dependent variable, while the main variables of physical activity, sleep habits, reference score of BMI-for-age, as well as demographic variables of parent's age, child's age and gender, grade level, number of children in the family, parents' educational level and occupation and economic status, were included in the linear regression as independent variables. In the simple regression analysis, a statistically significant correlation was observed between motor proficiency and child's age, father's age, mother's age, number of children, physical activity and BMI. However, no statistically significant correlation was found between motor proficiency and sleep habits ($P = 0.546$, $\beta = 0.030$) (Table 3). Although there was a correlation between motor proficiency and father's and mother's age in the simple regression, only the father's age was included in the regression analysis due to multicollinearity effect. Among the variables included in the multiple regression, child's age in the first ($p = < 0.001$, $\beta = 0.462$) and second ($p = < 0.001$, $\beta = 0.456$) models, male gender in the first ($P = 0.001$, $\beta = 0.145$) and second ($P = 0.001$, $\beta = 0.144$) models and BMI in the first ($p = < 0.001$, $\beta = -0.157$) and second ($p = < 0.001$, $\beta = -0.158$) models were directly correlated with motor proficiency ($P < 0.001$). The multiple regression results showed no statistically significant correlation between physical activity ($P = 0.068$, $\beta = 0.082$) and motor proficiency in both models (Table 4).

Discussion

This study was conducted to investigate the relationship between physical activity and sleep habits with motor proficiency among school aged children in Iran. The results showed the mean score of children's motor proficiency was slightly above moderate. The level of motor proficiency reported in the study by Milne et al.[50] on children aged 5–7 years old in Queensland and in the study by Alexander et al.[51] in the Niagara region was

Variable	Variable levels	Frequency (Percent)/Mean + SD*
Age of child (year)		9.65 ± 1.72*
Mother age (year)		36.51 ± 4.81*
Father age (year)		41.32 ± 5.54*
Sex	Boy	199 (49.4)
	Girl	204 (50.6)
Father education	Under the diploma	69 (17.1)
	Diploma	138 (34.2)
	Above the diploma	196 (48.7)
Mother education	Under the diploma	66 (16.4)
	Diploma	162 (40.2)
	Above the diploma	175 (43.5)
Job of father	Officer	172 (42.7)
	Worker	27 (6.7)
	Free job	183 (45.4)
	Unemployed	21 (5.2)
Job of mother	Housewife	326 (80.9)
	Employed	77(19.1)
Economic status	Low	28 (6.9)
	Moderate	244 (60.5)
	High	131 (32.5)

Table 1. Frequency distribution of demographic variables of participants. *Value is Mean ± SD; SD = standard Deviation.

variable (number analyzed)	Category	Frequency	Percent
Body mass index for age(403)	Very obese	14	3.5
	Obese	68	16.9
	Overweight	105	26.1
	Normal	209	51.9
	Thin	6	1.5
	Very thin	1	0.2
Height for age(403)	*Severely tall	5	1.2
	Normal	384	95.3
	Short	13	3.2
	Severely short	1	0.2
Weight for age up to ten years (234)	**Possible growth disorder	91	38.9
	Normal	143	61.1

Table 2. Frequency of normal condition and height, weight and body mass index disorders of the participants. *A child or teenager who is in this range is very tall. Being tall is rarely considered a problem, unless it is severe enough to suggest endocrine problems. **A child whose weight for his age is in this range, may have growth problems. This issue is better evaluated through body mass index (BMI) for age.

consistent with the present work. On the other hand, the level of motor proficiency reported in the study by Kazemi's study[27] on 7-year-old girls was lower than that in the present study. It should be noted that this study assessed motor skills only among 7-year-old girls and the level of motor skills could vary at different ages[8]. Thus, it could be the reason why the level of motor proficiency of the children participating in Kazemi's study was lower than the present study. Jírovec et al. investigated the motor proficiency of children aged 8–11 years old using both the complete and short forms of Bruininks-Oseretsky test and reported a lower level than the present study, the reason for which could be attributed to the small sample size (n = 153) and or using both forms in assessing motor proficiency. Although the complete form provides a more detailed and accurate assessment of motor skills, it does not necessarily yield higher scores. When examining each subtest in the complete form, we could see that participants should complete multiple items in each subtest. This means that participants encounter more motor experiences throughout the test, which could potentially create challenges in scoring[52]. Additionally, children may have more time to adapt to the tasks. Moreover, two points should be taken into account regarding motor proficiency scores. First, despite the validation of this test and its widespread use in various countries, it should be noted that the test scores were originally standardized on American children.

Independent variable	B	Beta	T	Sig	0.95%Confidence Interval for B
Age(year)	0.216	0.442	9.878	< 0.001	(0.173)–(0.259)
Baby gender (male)	3.395	0.169	3.426	0.001	(1.447)–(5.343)
Father age(year)	− 0.319	− 0.128	− 2.587	0.010	(− 0.562)–(0.077)
Mother age(year)	− 0.398	− 0.139	− 2.802	0.005	(− 0.677)–(0.119)
Number of sibling	− 1.789	− 0.112	− 2.261	0.024	(− 3.344)–(0.233)
Job of mother (reference: Employed)	1.674	0.065	1.312	0.190	(− 0.834)–(4.182)
Job of father (reference: Unemployed)					
Officer	1.896	0.093	0.812	0.417	(− 2.693)–(6.485)
Worker	2.546	0.063	0.866	0.387	(− 3.231)–(8.322)
Free job	2.514	0.124	1.081	0.281	(− 2.060)–(7.088)
Father education (references: Above diploma)					
Under diploma	1.728	0.065	1.225	0.221	(− 1.046)–(4.503)
Diploma	0.633	0.030	0.565	0.573	(− 1.570)–(2.835)
Mother education (references: Above diploma)					
Under diploma	2.481	0.091	1.706	0.089	(− 0.378)–(5.339)
Diploma	0.496	0.024	0.452	0.652	(− 1.662)–(2.653)
Economic status (reference: high)					
Low	− 0.151	− 0.005	− 0.101	0.920	(− 3.095)–(2.793)
Moderate	− 0.151	− 0.005	− 0.101	0.920	(− 3.095)–(2.793)
BMI z score	− 1.919	− 0.188	− 3.834	< 0.001	(− 2.903)–(0.935)
Physical activity score	0.370	0.148	2.998	0.003	(0.127)–(0.613)
Sleep quality score	0.055	0.030	0.604	0.546	(− 0.124)–(0.233)

Table 3. Results of simple regression to determine factors related to motor proficiency in study participants. Dependent variable: motor proficiency.

Model	Predictive variable	B	Standardized coefficients (β)	T	Sig.	0.95% confidence interval
Model1	Constant	28.812		6.198	< 0.001	(19.673)–(37.951)
	Child's age(year)	0.225	0.462	10.296	< 0.001	(0.182)–(0.268)
	Baby gender male	2.913	0.145	3.255	0.001	(1.154)–(4.671)
	Mother age(year)	− 0.033	− 0.016	− 0.341	0.733	(− 0.223)–(0.157)
	number of children	− 0.201	− 0.017	− 0.378	0.706	(− 1.251)–(0.848)
	BMI z score	− 1.174	− 0.157	− 3.615	< 0.001	(− 1.812)–(− 0.535)
	Physical activity	0.149	0.082	1.831	0.068	(− 0.011)–(0.310)
Model2	Constant	26.936		6.033	< 0.001	(18.158)–(35.715)
	Child's age(year)	0.223	0.456	10.092	< 0.001	(0.179)–(0.266)
	Baby gender male	2.908	0.144	3.250	0.001	(1.149)–(4.667)
	Father age(year)	0.028	0.016	0.332	0.740	(− 0.140)–(0.197)
	number of children	− 0.305	− 0.026	− 0.564	0.573	(− 1.370)–(0.759)
	BMI z score	− 1.180	− 0.158	− 3.634	< 0.001	(− 1.819)–(− 0.542)
	Physical activity	0.151	0.083	1.858	0.064	(− 0.009)–(0.311)

Table 4. Results of multiple univariate regression to determine factors related to motor proficiency in study participants. Dependent variable: motor proficiency. Adjusted R Square for model 1 = 0.244, Adjusted R Square for model 2 = 0.244, F for model 1 = 22.673, p value < 0.001, F for model 2 = 22.672, p value < 0.001.

Thus, caution should be exercised when interpreting these scores for children from other countries. Second, more than two decades have passed since standardization of these scores, during which fine motor skills such as computer games have significantly increased among children[49]. Therefore, re-standardizing the scores could yield different results.

Furthermore, the results indicated a moderate level of physical activity among school-aged children in Bushehr and a correlation was found between physical activity and motor proficiency. However, the regression analysis showed no significant correlation between physical activity and motor proficiency considering demographic variables. In line with the present work, Abbas Rashid et al.[53] who investigated female students aged 13–14 years old in Tehran and Afthentopoulou et al.[54] who studied children aged 6–9 years old in Athens reported no statistically significant correlation between physical activity and motor proficiency among children. Also, Lovrić et al. found no correlation between children's physical activity and motor proficiency and suggested that this lack of correlation might be attributed to omitting the quality assessment of physical activity. They emphasized that, in addition to the level of physical activity, assessing the quality and method of implementation is essential[24].

Inconsistent with the present study, Vazini Taher et al. conducted a study on students aged 6–12 years old in Qazvin to evaluate the relationship between physical activity and development of basic motor skills using TGMD-2 and physical activity questionnaire from the past year. They reported a significant correlation between these two components[55]. Van Niekerk et al.[56] investigated motor skills using BOT-2 and assessed physical activity using IPAQ among adolescents aged 13–14 years old in Potchefstroom and found a statistically significant correlation between physical activity and motor skills. The reason for discrepancy in findings could be attributed to the tools used for measuring the variables[55]. The reason for the difference in findings of previous studies may be due to differences in the methods and tools used to measure physical activity and motor development, the age range of participants; or the effect of biological modifiers such as body mass index, culture, and ethnicity on physical activity and motor development. In most studies, due to the use of objective tools to measure physical activity and its amount and intensity, the use of process-oriented tools to assess children's motor development, in contrast to the present study, a significant relationship was observed. Motor behavior experts suggest that process-oriented tools are more appropriate in assessing basic motor skills because they more accurately assess the specific characteristics of movement and the form of skill execution[55]. The reason for the difference in findings from previous studies may be due to differences in the methods and tools used to measure physical activity and motor development, the age range of participants, and the effect of biological modifiers such as body mass index, culture, and ethnicity on physical activity and motor development. In most studies, due to the use of objective tools to measure physical activity and its amount and intensity such as metabolic equivalent (MET), the use of process-oriented tools to examine children's motor development, in contrast to the present study, a significant relationship was observed. In the present study, due to the use of outcome-based tools in measuring motor development, the 7-day recall questionnaire in measuring physical activity, which may not be a good reflection of children's regular physical activity, and the possibility that children did not accurately record their physical activity information and the need to recall activities from each day of the past week may introduce a degree of recall bias. Moreover, the fact that children at this age participate in organized activities for a short time that does not affect their motor development, may influenced the research results. Also, considering that motor development is a continuous process starting from early childhood and may be influenced by several factors such as genetic factors, assessing physical activity within a specific time frame in this study could be another possible reason for the lack of correlation.

Some studies have investigated the impact of selected motor programs, playing games and daily activities on motor skills and indicated the selected motor programs have a greater effect on the development of children's motor skills compared to daily activities due to the enrichment of the environment, improved educational quality, adequate time for practice and provision of resources and environmental conditions and availability of opportunities for practice[57]. Childhood games, as a form of physical activity, play a significant role in children's motor development[58]. The local games of Bushehr are a blend of sports and performing arts. However, these local games have recently undergone changes due to the society's shift towards modern tools[59]. Therefore, perhaps by examining the relationship between structured physical activities and motor development and comparing the impacts of structured physical activities and daily physical activities on motor development could provide more precise information regarding the correlation between these two concepts.

The results indicated sleep disturbances among the studied children were at a low level, and no significant correlation was observed between sleep habits and motor proficiency. In line with the present study, Mindell and Lee[60] found no significant correlation between infants' sleep and developmental outcomes such as communication skills, fine and gross motor skills, problem-solving abilities and social interactions. Similarly, in their systematic study, Chaput et al.[25] found no significant correlation between sleep components and cognitive and motor development among children aged 0–4 years old. Inconsistent with our findings, Kordi[29] used a researcher-made questionnaire and Denver-II test to assess the relationship between environmental factors such as sleep and gross and fine motor skills and reported a positive and significant correlation between daily sleep duration and kicking performance among children aged 3–6 years old in Tehran. These two studies could not be compared due to differences in the research population, children's age, sampling method (convenience sampling method), type of motor test and the use of the researcher-made questionnaire, consisting of six items about children's sleep and nutrition. Discrepancy in results may be attributed to these factors. Iemura et al.[26] reported a positive correlation between sleep and developmental patterns among 18-month-old children. They examined the relationship between sleep duration and all developmental patterns, not exclusively motor development. It could be the reason why their findings were inconsistent with those of the present study. Sleep is an important component and primarily affects memory, learning, daily performance and individual's behavior[60].

In the present study, a small percentage of children were reported to have sleep disturbances, which may have influenced the lack of correlation between sleep and motor proficiency. Additionally, Parents were also asked to complete the questionnaire regarding their child's sleep habits and possible sleep problems based on the child's sleep pattern over the past week, and if their child was sick or had a specific problem at home during the past week, they were asked to consider another week; however, recalling the child's sleep status again introduces recall bias. Also, it is even possible that some parents may not be fully aware of some of their child's sleep-related behaviors, because most children in the present study had their own bedrooms, and parents may not be aware of their child's sleep patterns after they go to bed; Or, the parents' understanding of the child's sleep habits or behaviors may not be the same as the child her/himself, which could also be a limitation of the study.

Furthermore, definitive conclusions regarding the lack of correlation could not be drawn due to the cross-sectional nature of the study and the point that the questionnaire used in the present study assessed children's sleep habits over the past week, while changes in motor proficiency require a longer time frame. Conducting longitudinal studies that take into account the factors influencing sleep may yield more accurate results.

The results indicated nearly half of the children were overweight, obese and severely obese. Additionally, the results showed the standardized score of BMI affected motor proficiency, with children having a higher BMI exhibiting poorer performance in motor skills. These results aligned with some previous studies[8].

In a study, gross motor coordination impairment was found to be greater in underweight and overweight children compared to those with normal weight[61]. However, some studies have reported no correlation between these variables[27]. Ma and Luo. found BMI was not potentially related to fundamental motor skill or physical activity in preschool years. Likewise, Lin and Yang reported that the effect of BMI on locomotor, object control and fundamental motor skill levels of children aged 3–7 year-old was very limited[62,63].

This discrepancy may be due to differences in the motor tests used in various studies, as motor tests may not be uniform in assessing motor skills[28]. Individuals with different BMIs exhibit varying levels of motor skills due to differences in body geometry, mass distribution in different body segments and biomechanical factors[64]. Obesity affects body geometry and disproportionately increases body volume, which could result in inefficient biomechanical movements and potentially be detrimental to motor skills[28].

Therefore, it is essential to implement appropriate health and nutritional measures to manage overweight and reduce the intake of high-calorie foods among children. Additionally, families should take necessary actions to ensure that their children maintain a balanced diet and engage in physical activity. Therefore, educating families about dangers of childhood obesity and preventive strategies should be prioritized by health authorities.

Based on the results and previous studies, motor skills tend to improve with age[65]. Age is one of the variables related to motor development, and individuals at different ages exhibit varying levels of growth and development[8], which could be attributed to the development of various bodily systems and the increase in individuals' experiences[29].

Moreover, the obtained results of the present study indicated boys performed better than girls in motor skills. Several studies have investigated the impact of gender on motor skills[22]. In one study, girls outperformed boys in fine motor skills, while boys excelled in gross motor skills[8]. However, some studies have found no differences in motor skill performance among children based on gender[29]. The results of a study revealed that there were no significant differences in perceived movement skills competence as well as locomotor and object control perceived competence scores between preschool girls and boys[66]. Indeed, boys typically participate more in diverse physical activities than girls, which provides them with the opportunity to gain experience and develop a wide range of motor skills[28]. Girls generally demonstrate advanced motor abilities at a younger age, but their subsequent motor development is often influenced by cultural stereotypes and societal expectations regarding both genders. Sociological factors and behavior habits may contribute to gender differences in proficiency in object control. Studies have shown a correlation between fundamental motor skills proficiency and physical activity levels in children. It has been shown that girls are significantly less likely to participate in physical activity than boys during the preschool years, especially at moderate to high intensity. Therefore, different levels of physical activity may be responsible for the gender differences in object control scores. Previous studies have indicated that girls tend to lack opportunities to practice ball games, while boys generally spend more time participating in these games, which may also be related to parental educational attitudes[67]. While a Turkish study didn't find a significant association between social media addiction and physical activity in adolescents, it did reveal a correlation between gender and exercise levels. Researchers recommended further investigation across different regions and age groups[68]. In our society, boys traditionally take part more in sports and games involving throwing, jumping and striking the ball, while girls have fewer opportunities and conditions to engage in such activities. This is likely due to differences in the types of games and sports preferred by girls and boys, as well as the greater attention from parents and teachers toward the motor development of boys, resulting in higher levels of motor proficiency among boys[10]. Regular physical activity helps improve cardiovascular fitness, muscular strength, and endurance. It also promotes a healthy body weight. Engaging in physical activity can also improve mental well-being and motor development. The need to ensure equal participation of girls and boys in physical activity is important[69].

Strengths and limitations

The present study objectively investigated motor proficiency among school-aged children in Bushehr for the first time. Strengths of this study included a sufficient sample size and its random selection, as well as simultaneous investigation of multiple factors influencing motor proficiency. However, it also faced certain limitations. This research encountered the constraints of cross-sectional research, i.e., the identified relationships could not be casually interpreted. Also, findings should be generalized to other populations with caution due to the specific socio-cultural environment, in which the study was conducted. Using 7-day recall questionnaire to assess physical activity and sleep habits (without measuring the quantity and intensity by objective tools) could reduce data accuracy. Additionally, the completion of sleep habits questionnaire by parents may be limited by their potential lack of awareness regarding their children's sleep patterns. Also, there was no opportunity to measure the children's weight in the early morning after fasting, which may have affected the accuracy of weight measurements. Given that more than a decade has passed since the standardization of motor skill test scores, this issue could impact the results. Re-standardizing and localizing the scores could potentially yield different results.

Conclusions

The results revealed a significant correlation only between motor proficiency and age, gender and BMI, so that children with a higher BMI, younger age and female gender exhibited lower levels of motor proficiency. These findings are of particular importance for raising awareness of school officials and health policymakers about various health aspects, including motor development, and developing necessary strategies to enhance girls' motor development and prevent obesity. Given the cross-sectional nature of the present study, it is suggested that longitudinal and prospective research be designed in future. Also, it is recommended that future studies utilize objective measurement tools to assess the quantity and intensity of physical activity and employ actigraphy to evaluate sleep duration and quality. Since the present research utilized outcome-based tools to assess children's motor proficiency, and considering that process-oriented tools more accurately determine specific characteristics of movement, thereby better reflecting skill development rather than just physical growth, it is recommended that future studies employ process-oriented assessment tools to measure children's motor skills.

Data availability

The datasets used and/or analysed during the current study available from the corresponding author on reasonable request.

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Author contributions
Research design by MR, RB, ZR; data collection by ZR; research execution by M.R., R.B., Z.R.; data analysis by R.B.; documentation by M.R., R.B., Z.R.; and primary responsibility for the final content by M.R., R.B., Z.R. All the authors have read and approved of the final manuscript.

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Declarations

Competing interests
The authors declare no competing interests.

Ethics approval and consent to participate
The study was conducted according to the guidelines of the Declaration of Helsinki and approved by the ethics committee (code: IR.BPUMS.REC. 1397.109) of Bushehr University of Medical Sciences, Bushehr, Iran. Informed consent was obtained from all the participants involved in the study or their legal guardians. The authors do not have any conflict of interest to declare.

Additional information
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