RELATION BETWEEN BODY MASS INDEX AND MOTOR COORDINATION IN SCHOOL AGED CHILDREN

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Abstract

Objective. The purpose of this study was to detect the correlation between body mass index and motor coordination in school aged children. **Methods.** One hundred children ranged in age from 10-14 years participated in this study. They were selected according to body mass index to be normal weight and obese children. They were divided to two groups, group A 50 normal weight children and group B 50 obese children. Gross motor coordination was assessed by means of the Körperkoordinations test für Kinder. **Results.** Childhood obesity was found to result in poor KTK performances. **Conclusion.** It can be concluded that high body mass index has a negative effect on motor coordination in school-aged children.

Key words: Body mass index; Children; Motor coordination.

Introduction

In the long term, obese children are more likely to become obese adults. Longitudinal studies showed a risk that obese children will become obese adults, who, as a consequence, are exposed to an increased risk of comorbidity and premature mortality. It has been confirmed that obese children display a lower fitness. However, it is difficult to specify a cause-and-effect relationship which would scientifically justify this phenomenon [(1)].

Obesity, now classified as a disease by the American Medical Association **(AMA), so** Many authors have already stressed the crucial need for research on the topic to understand the causal nature of this adverse relationship [(2)]. Obesity consists 16% of children in the United States[(3)], and has led to a call for increased physical activity for children. Childhood overweight and obesity as well as lower motor skill levels have been linked with less active lifestyles [(1)].

Poor coordinative performance can affect the acquisition of motor skills and overall child development. In this regard, motor coordination has been included as a topic of discussion in different areas of research. Recently, there has been an increasing interest of researchers on the relationship between levels of physical activity and adiposity with motor coordination in children [(4, 5)].

Low levels of coordination may result in limited opportunities for engagement in physical activities, poor health-related fitness, and overall low motor skill competence, leading to increased weight and obesity. Low motor skill competence may result in disengagement in physical activities, as well as other sports activities in middle and later childhood. Consequently, a negative spiral of disengagement arises, characterized by adopting negative attitude towards pursuing a physically active lifestyle later in life [(6)].

Obesity is defined by body mass index (BMI) and evaluated in terms of fat distribution via the waist hip ratio [(7)].BMI is a measure of relative weight based on an individual's mass and height. Moreover, it is adopted by the British government in an effort to promote healthy eating. The BMI, with simplicity for its calculation, is the most common and widely used anthropometric measure ,for both children and adults[(8)].

It is calculated by dividing individual's weight in kilograms (kg) by his height in meters (m), then dividing the answer by his height again [(9)].

$$\text{BMI (kg/m}^2\text{)} = \text{Bodyweight (kg)} / \text{Height (m)}^2$$

In children, weight varies with age and sex, not only with height.. To account for variability by sex and age, BMI in children is compared with sex and age specific reference values [(10)].

Young children differ from adult in BMIs, they naturally start out with high body fat, but tend to get linear as they get older. Boys and girls also have different body compositions. To take into account the differences between girls and boys at different

ages, scientists have created a special BMI for children between the ages of two and 20 years figure (1, a,b) ,table (1) show the classification of children BMI. Each chart contains a set of curved lines indicating the child's percentile. The normal BMI range becomes higher for girls as they mature, because teenage girls normally have more body fat than teenage boys. A boy and girl of the same age may have the same BMI, but the girl could be of normal weight and the boy could be at risk for being overweight [(11)].

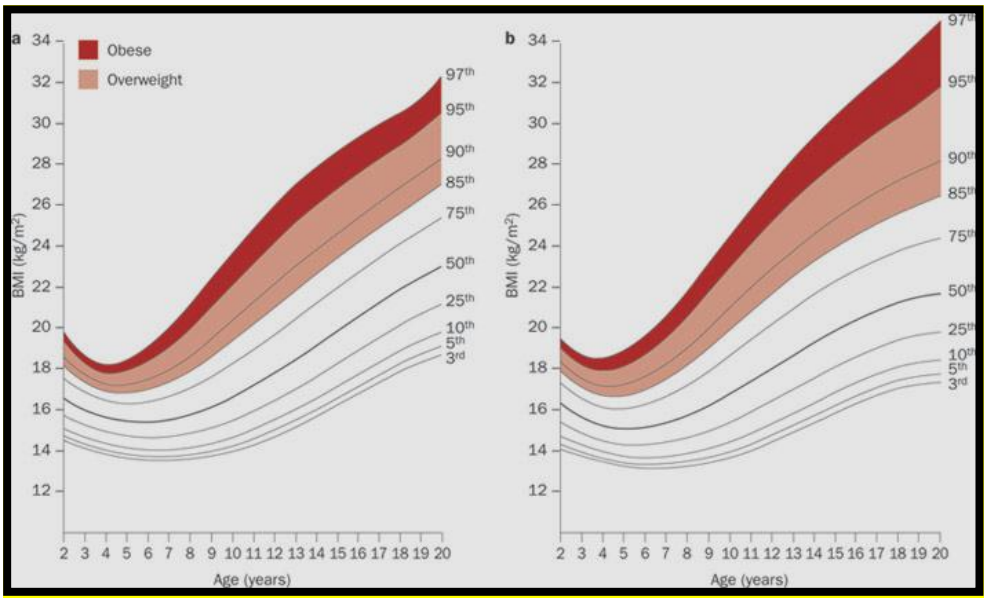


Fig. (1): chart for BMI-for-age chart for boys aged 2–20 years. b BMI-for-age chart for girls aged 2–20 years. [(12)].

Table (1): BMI classification for children [12]

BMI	Recommended Classification
< 5th Percentile	Underweight
5th – 84th Percentile	Healthy Weight
85th – 95th Percentile	Overweight
> 95th – 99th Percentile	Obesity
> 99th Percentile	Severe Obesity

The BMI for age growth charts for boys and girls take into account these differences and allow translation of a BMI number into a percentile for a child's or teen's age and sex [13].

Motor coordination is the harmonious functioning of body parts that involve movement, including gross motor movement, fine motor movement, and motor planning, motor coordination is favorably associated with health markers, such as physical activity (PA), cardiorespiratory fitness, muscular strength, endurance, and healthy weight status throughout childhood [14].

The level of motor skills and abilities promotes physical activity since early childhood. Children with better-developed motor skills may find it easier to be active and engage in more physical activity than those with less-developed motor skills. The relationship between motor abilities and skills and physical activity may most probably be a crucial determinant of complex mechanism of adopting a healthy lifestyle since childhood [15].

Subject, materials and methods

Study design:

This study is a correlational study which determine correlation between BMI and motor coordination.

Participants:

A hundred of normally developed children from both sexes with age ranged from 10 to 14 years selected according to percentile body mass index were divided into two groups according to weight status

Group A composed of 50 obese children (23 boys and 27 girls).

Group B composed of 50 normally weighted children (23 boys and 27girls).

Children were selected according to percentile body mass index from primary and elementary schools in Obour city, Egypt after permission and approval from The Ministry Of Education and The Educational administration of Obour city and its number is 42 at 3/4/ 2018. We divided subjects who (met the inclusive criteria) and into 2 groups normal weight group and obese group.

Inclusion criteria:

- Individuals without health limitations participated in school physical education twice a week.
- Children aged from 10 to 14 years old.
- The study was carried out at Back Line language School, Al-SayedaAysha primary and elementary school, Osman EbnAffan language school in Obour City.

Prior to data collection a written consent was granted from the parents. Details of the study were sent to parents with the appointment information and on attendance, parents gave informed consent form for participation. The selection of the samples and assessment were conducted in the children's school.

Measurment procedures:

A-For selection

Body mass index (anthropometric testing).

BMI is used differently for children. It is calculated by dividing individual's weight in kilograms (kg) by his height in meters (m),), then dividing the answer by his height again [9]as for adults, but then compared to typical values for other children of the same age, and then the BMI percentile allows comparison with children of the same sex and age[16] .

B-For assessment

Motor coordination:

1- The Körperkoordinationstestfür Kinder (KTK).

(The Body Coordination test for children)[17]

In the context of physical education (PE) and sports, a reliable instrument for the gross motor coordination, relatively independent from a child's physical capacities, is of great use. PE teachers could use such tests to evaluate the gross motor coordination of their pupils in a simple and objective way.The Test of Gross Motor Development [18] is a qualitative test instrument that can be used by the PE teacher. However, its focus is mainly on identifying children with motor development problems. One of the few tests that mainly focuses on gross motor coordination of both normal children without motor problems as well as children with motor and/or mental problems is the KörperkoordinationsTestfür Kinder (Body Coordination Test for Children, referred to as KTK from here on) published by [19]

It consists of four subtests that measure gross motor coordination: walking backwards on a balance beam of different widths **(KTK BEAM),** moving sideways on boxes **(KTK BOARD)**, hopping for height **(KTK HOP)** and jumping sideways with both feet together **(KTK JUMP).** The same tests are used for all age groups (5–15 years.), which is an advantage with respect to a longitudinal follow-up of the children tested. The test is easy to administer and takes about 15 min per child. The KTK allows an objective and straightforward evaluation of a child's gross motor coordination only, with only limited interference of the child's physical fitness, which discriminates this test from most other instruments.The raw test scores from each of the four tests can be transformed into motor quotients (MQ). The norms for the MQ are based on the performance of 1228 normally developing German children in 1974. The MQ score is standardized by age and gender. The total MQ (mean=100; SD=15) for the entire test batteryproduces a measure of the gross motor coordination of children, ranging from "gifted children" to "children with motor dysfunctions"[17].

Method of use

The assessment of the coordination consisted of the following KTK subtests:

- 1- walking backwards three times along each of three balance beams (3 m length; 6, 4.5 and 3 cm width,

respectively; 5 cm height). A maximum of 24 steps (eight per trial) were counted for each balance beam, which comprises a maximum of 72 steps (24 steps × 3 beams) for this test. The sum of steps in all trials determined the motor quotient 1.

- 2- moving across the floor in 20 s by stepping from one plate (25 cm × 25 cm × 5.7 cm) to the next, transferring the first plate, stepping on it, etc. The number of relocations was counted and summed over two trials. The sum of scores reached in the second task determined the motor quotient 2.
- 3- jumping from one leg over an increasing pile of pillows (60 cm × 20 cm × 5 cm each) after a short run-up. Three, two or one point(s) were/was awarded for successful performance on the first, second or third trial, respectively. A maximum of 39 points (ground level+12 pillows) could be scored for each leg, yielding a possible maximum score of 78 .The number of jumps performed correctly was summed over two trials to determine the motor quotient 3.
- 4- jumping laterally as many times as possible over a wooden slat (60 cm × 4 cm × 2 cm) in 15 s. The number of jumps over two trials was summed. Points obtained in two trials determined the motor quotient 4.
- And scoring by the summation of the 4 motor Quotients.

Administration and scoring of the KTK test according to the manual[(17)]:

According to the classification of Kiphard and Schilling,

1 -Children with motor Quotient (MQ) value between 86 and 115 are considered as having normal gross motor coordination.

2-Children scoring between 71 and 85 as having a moderate gross motor coordination disorder and

3-Children scoring 70 or less as having a severe gross motor coordination disorder. Children scoring between 116 and 130 are considered as having good motor coordination and

4 -Children scoring >131 as having a high MQ[(٢٤)].

Statistical analysis:

- Descriptive statistics and t-test were conducted for comparison of mean age, and BMI between both groups.
- Pearson Correlation Coefficient was conducted to determine the correlation between BMI and gross motor coordination scores.
- The level of significance for all statistical tests was set at $p < 0.05$.
- All statistical tests were performed through the statistical package for social studies (SPSS) version 19 for windows. (IBM SPSS, Chicago, IL,USA).

Results

Data obtained from both groups regarding gross motor coordination were statistically analyzed and compared. - Subjects demographic data: As observed in table (2) and demonstrated in figure (2), the mean ± SD age group A was 11.52 ± 1.38 years,. The mean ± SD age of group B was 11.92 ± 1.49 years, There was no significant difference between both groups in the mean age values (p = 0.16).

Table (2): Comparison of the mean values of age between group A and B.

Age (years)	Group A	Group B
$\overline{X}$ ± SD	11.52 ± 1.38	11.92 ± 1.49
Maximum	14	14
Minimum	10	10
MD	-0.4	
t-value	-1.38	
p-value	0.16	
Significance	NS	

$\overline{X}$: Mean MD : Mean difference p value : Probability value
SD : Standard deviation t value : Unpaired t value NS : Non significant

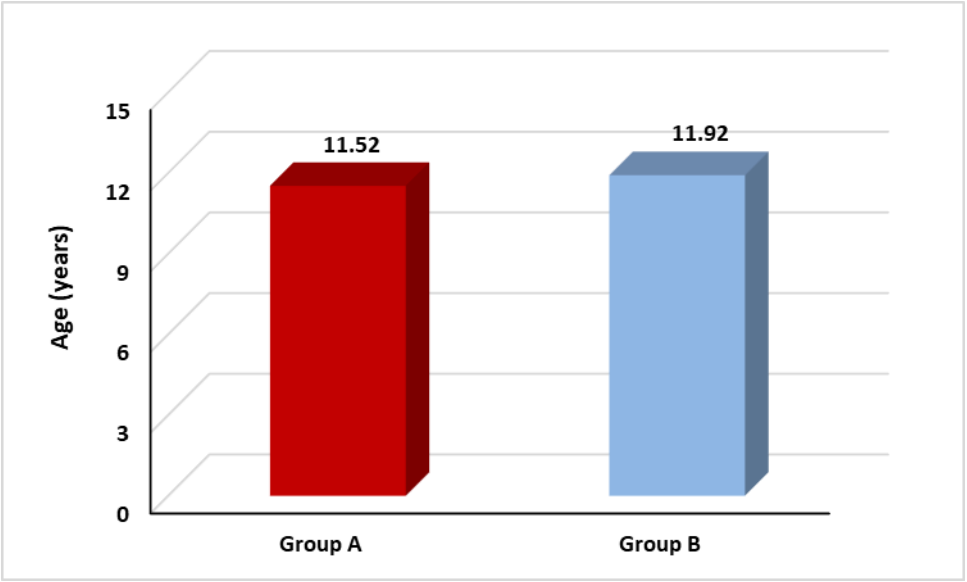


Figure (2). Mean age of group A and B.

The correlations between BMI and gross motor coordination

The correlations between BMI and gross motor coordination were moderate negative significant correlations with MQ score (r = 0.66, p = 0.0001), moderate negative significant correlations with balance beam **(KTK BEAM)** score (r = -0.63, p = 0.0001), moderate negative significant correlations with wooden slat **(KTK JUMP)** score (r = -0.45, p = 0.0001), weak negative significant correlations with moving the platform **(KTK BOARD)**score

(r = -0.25, p = 0.009), and moderate negative significant correlations with jumping on one leg **(KTK HOP)** score (r = -0.58, p = 0.0001) . (Table3,Figure (3,4 ,5 ,6 ,7)).

Table (1): Correlation between BMI and gross motor coordination:

	Gross motor coordination	r value	p value	Sig
BMI (kg/m²)	**Motor Quotient (MQ) score**	-0.66	0.0001	**S**
	Balance beam score(KTK BEAM)	-0.63	0.0001	**S**
	Wooden slat score(KTK JUMP)	-0.45	0.0001	**S**
	Moving the platform score(KTK BOARD)	-0.25	0.009	**S**
	Jumping on one leg score(KTK HOP)	-0.58	0.0001	**S**

r value: Pearson correlation coefficient **p value: Probabilityvalue** **S: significant**

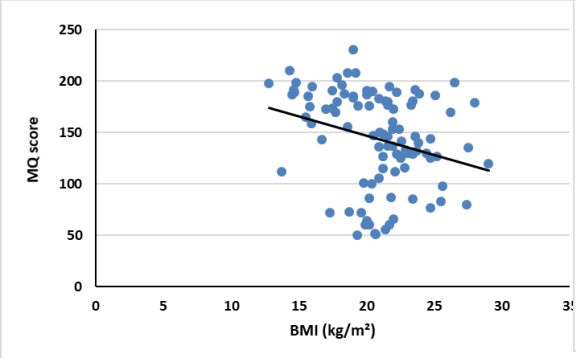


Figure (3). Correlation between BMI and MQ score.

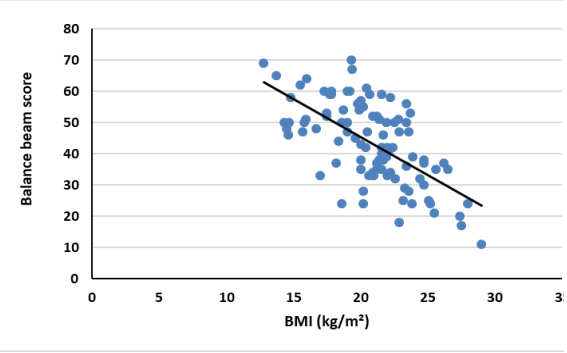


Figure (4). Correlation between BMI and balance beam (KTK BEAM) score.

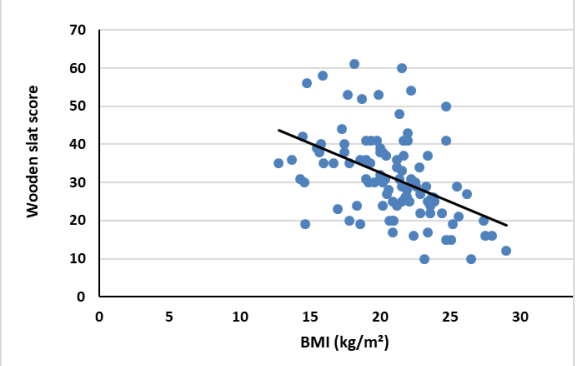


Figure (5)Correlation between BMI and wooden slat (KTK JUMP) score.

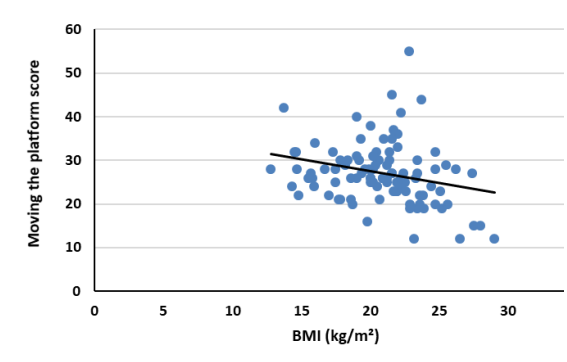
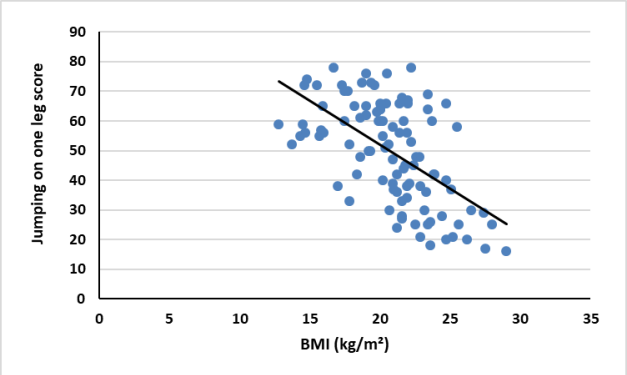


Figure (6). Correlation between BMI and moving the platform (KTK BOARD)



kFigure (7). Correlation between BMI and Jumping on one leg (KTK HOP) score.

Discussion

The current study showed thatthereis moderate negative correlations between MC and BMI.

In fact, during pubertal years it is expected that the relationship between MC and BMI can be dramatically altered by the rapid and individualized changes in somatic growth that result in changes in muscle mass (boys) and adipose tissue (girls) [(18)].

In the current study we use the body mass index for assessing weight status in children BMI is a simple, inexpensive, and noninvasive surrogate measure of body fat.

Determining BMI represents a simple method recommended even for school practice, despite its application, is burdened with certain limitations. These are bound especially with the fact that the BMI value stems from the ratio of body weight and height, and does not discriminate between fat and muscle mass, and also does not indicate the fat distribution in the body [(20)].

Krebs et al., (2007) [(21)] consider BMI to be a scientifically justified means of obesity determination in children and adolescents at the age from two years to 19 years.

The present study demonstrated low to moderate negative correlations between MC and BMI. Data also indicate markedly poorer motor coordination (MC) for obese children of both sexes compared to normal weight children. Overall, these data agree with most other data that demonstrate an inverse relationship between childhood body weight status and various measures of MC**.**

Similarly to the results of our study, **D'Hondt et al.,(2010)**[(1)] reported that childhood overweight and obesity significantly contributed to a lower level of motor abilities as assessed by the KTK testing battery.

Okely et al., (2004) [(22)] found that, despite a general inverse relationship between body composition and overall MC, there were virtually no associations with object-control coordination. That is, the correlation occurred only with locomotor coordination. Thus, the MC tests assessed in this study generally align with the types of locomotor tests used in Okely et al.[(22)]

In line with our study**, Graf et al.,** [(25)] confirmed a moderate inverse

correlation between coordination abilities (KTK test) and BMI.

According to **(Okely et al., 2004) [(22)]** and **(Barnett et al., 2008) [(23)],** they suggested that instruction and improvement of motor skill might be a key component in both prevention and management of childhood overweight and obesity. Next to intervention programs related to clinical practice, there is a crucial need for community- and school-based initiatives to provide various opportunities for motor skill development through physical activities.

Conclusion

From the obtained results of this study supported by the relevant literature, it can be concluded that there is negative correlations between MC (motor coordination) and BMI.

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Reference

1- **D'Hondt, E., Deforche, B., Gentier, I., De Bourdeaudhuij, I., Vaeyens, R., Philippaerts, R., and Lenoir, M.** A longitudinal analysis of gross motor coordination in overweight and obese children versus normal-weight peers. *International Journal of Obesity*,2013, *37*(1), 61–67.

2- **Poulsen, A. A., Desha, L., Ziviani, J., Griffiths, L., Heaslop, A., Khan, A., and Leong, G. M.** Fundamental movement skills and self-concept of children who are overweight. *Pediatric Obesity*,2011, *6*(2Part2).

3- **Ogden, C. L., Carroll, M. D., Kit, B. K., and Flegal, K. M.** Prevalence of obesity and trends in body mass index among US children and adolescents, 1999-2010. *Jama*, *307*(5),2012, 483–490.

4- **Logan, S. W., Robinson, L. E., Wilson, A. E., and Lucas, W. A.** Getting the fundamentals of movement: a meta-analysis of the effectiveness of motor skill interventions in children. *Child: Care, Health and Development*,2012, *38*(3), 305–315.

5- **Robinson, L. E., Stodden, D. F., Barnett, L. M., Lopes, V. P., Logan, S. W., Rodrigues, L. P., and D'Hondt, E.** Motor competence and its effect on positive developmental trajectories of health. *Sports Medicine*,2015, *45*(9), 1273–1284.

6- **Stodden, D., Langendorfer, S., and Roberton, M. A.**The association between motor skill competence and physical fitness in young adults. *Research Quarterly for Exercise and Sport*, *80*(2),2009,223–229.

7- **Sweeting H.** Measurement and Definitions of Obesity In Childhood and Adolescence: A field guide for the uninitiated,2007, Nutr J 6 (1).

8- **Keys, A., Fidanza, F., Karvonen, M. J., Kimura, N., and Taylor, H. L.** Indices of relative weight and obesity. *International Journal of Epidemiology*,2014, *43*(3), 655–665.

9- **Nuttall, F. Q.** Body mass index:

obesity, BMI, and health: a critical review. Nutrition today,2015, 50(3), 117.

10- **Dietz W. and Bellizzi M.** The use of body mass index to assess obesity in children. Am J Clin Nutr ,1999,70:123S–5S.

11- **Stephanie W.**Body Mass Index - http:/ /health. howstuffworks. com/wellness/diet-fitness/weight-loss/bmi2.htm,2013.

12- **Louise A. , Briony H. and Vanessa A.** Assessment and management of obesity in childhood and adolescence ,Nature Reviews Gastroenterology & Hepatology,2011, 8, 635-645 (November).

13- **Mei Z. , Grummer L. , Pietrobelli A. , Goulding A. , Goran M. , Dietz W.** Validity of body mass index compared with other body composition screening indexes for the assessment of body fatness in children and adolescents. American Journal of Clinical Nutrition,2002 ;7597–985.

14- **Cattuzzo, M. T., dos Santos Henrique, R., Ré, A. H. N., de Oliveira, I. S., Melo, B. M., de Sousa Moura, M., and Stodden, D.** Motor competence and health related physical fitness in youth: A systematic review. *Journal of Science and Medicine in Sport*,2016, *19*(2), 123–129.

15- **Williams, H. G., Pfeiffer, K. A., O'neill, J. R., Dowda, M., McIver, K. L., Brown, W. H., and Pate, R. R.** Motor skill performance and physical activity in preschool children. Obesity,2008, 16(6), 1421–1426.

16- **Samaras S. and Thomas T**.Human Body Size and the Laws of Scaling: Physiological, Performance, Growth, Longevity and Ecological Ramifications. New York: Nova Science,2007, ISBN 978-1-60021-408-0.

17- **Schilling, F., & Kiphard, E. J.** The body coordination test. Journal of physical education and recreation,1976 47(4), 37-39.

18- **Ulrich, D. A.** Test of gross motor development . Austin,2000, TX: PRO-ED. Inc.

19- **Kiphard, E. J., and Schilling, F. (2007).** Körperkoordinationstest für kinder:KTK. Beltz-Test.

20- **Kaplowitz PB.** Link between body fat and the timing of puberty. Pediatrics,2008, 2 ;121(Suppl. 3):S208–17.

21- **Krebs, J. H. Himes, D. Jacobson, T. A. Nicklas, P. Guilday, et al**. "Assessment of child and adolescent overweight and obesity," Pediatrics,2007, vol. 120 (suppl. 4), pp. 193–228, doi: 10.1542/peds.2007-2329D.

22- **Okely, A. D., Booth, M. L., & Chey, T**. Relationships between body composition and fundamental movement skills among children and adolescents. Research quarterly for exercise and sport,2004, 75(3), 238-247.

23- **Barnett, L. M., Van Beurden, E., Morgan, P. J., Brooks, L. O., and Beard, J. R**. Does childhood motor skill proficiency

predict adolescent fitness? Medicine & Science in Sports & Exercise,2008, 40(12), 2137–2144.

24- **Vandorpe, B., Vandendriessche, J., Lefèvre, J., Pion, J., Vaeyens, R., Matthys, S., and Lenoir, M.** The Körperkoordinationstest für kinder: Reference values and suitability for 6--12-year-old children in Flanders. *Scandinavian Journal of Medicine & Science in Sports*,2011, *21*(3), 378–388.

25- **Graf, B. Koch, G. Falkowski, S. Jouck, H. Christ, et al.,** "Effects of a school-based intervention on BMI and motor abilities in childhood," J. Sports Sci. Med.,2005, vol. 4(3), pp. 291–299, http://www.jssm.org/vol4/11/v4n3-11text.php.