ORİJİNAL ARAŞTIRMA ORIGINAL RESEARCH

DOI: 10.5336/sportsci.2020-76449

Association Between Motor Competence and Body Mass Index in Children Aged 10-13

10-13 Yaş Arası Çocuklarda Motor Yeterlik ve Beden Kitle İndeksi Arasındaki İlişki

Aslı CEYHAN[a], Mustafa SÖĞÜT[b]

[a]Department of Movement and Training Sciences, Kırıkkale University Institute of Health Sciences, Kırıkkale, TURKEY
[b]Department of Physical Education and Sports, Middle East Technical University Faculty of Education, Ankara, TURKEY

This study was produced from the Aslı Ceyhan's master thesis entitled "Association between motor coordination and body mass index (BMI) in children aged 10-13". Kırıkkale University, 2020.

ABSTRACT Objective: The purposes of this study were to examine the association between motor competence (MC) and body mass index (BMI) in children aged 10-13 and to determine gender-related differences in motor competence. **Material and Methods:** Participants were male (n=59) and female (n=44) children between the ages of 10 and 13 (12.1±1.2 years). Body height and weight were measured and BMI was calculated as dividing the body weight by the square of the body height. "Körperkoordinationstest für Kinder (KTK)" was used to assess the MC of the participants. The KTK includes four subtests; walking backward, hopping on one leg, jumping sideways, and moving sideways. The raw scores for each subset were converted to the age- and gender-specific motor quotient. The sum of four items was used to calculate the total KTK motor quotient scores. Finally, the total KTK motor quotient scores were utilized to classify the MC levels of children. **Results:** The results of the study indicated that 33% of participants performed below the normal level in motor competence. Further, there were no significant (p>0.05) differences between boys and girls in terms of anthropometric characteristics and the total KTK motor quotient scores. Regardless of gender, results revealed that MC was significantly (p=0.001) and negatively associated with BMI. **Conclusion:** Based on these findings, it may be stated that increasing BMI has a negative effect on MC in children aged 10-13.

Keywords: Motor competence; body mass index; children; KTK test battery

ÖZET Amaç: Bu araştırmanın amacı, 10-13 yaş arası çocuklarda motor yeterlik ve beden kitle indeksi (BKİ) arasındaki ilişkinin incelenmesi ve cinsiyete bağlı motor yeterlik farklılıklarının belirlenmesidir. **Gereç ve Yöntemler:** Araştırma grubunu, 10-13 yaşları arasındaki (12,1±1,2 yıl) erkek (n=59) ve kız (n=44) çocuklar oluşturmuştur. Araştırma grubunun boy uzunluğu ve vücut ağırlığı ölçülmüş ve vücut ağırlığının boy uzunluğunun karesine bölünmesi ile BKİ hesaplanmıştır. Motor yeterlik seviyelerinin belirlenmesinde "Körperkoordinationstest für Kinder (KTK)" testi kullanılmıştır. KTK 4 alt test içermektedir; geriye doğru yürüme, tek ayak atlama, yana sıçrama ve yana hareket etme. Alt testlerden elde edilen ham skorlar, yaşa ve cinsiyete özel motor katsayılarına dönüştürüldü. Dört alt testin skorlarının toplanması ile KTK toplam motor katsayı değeri hesaplandı. Son olarak, katılımcıların motor yeterlik seviyelerini sınıflandırmak için toplam KTK motor katsayı skorları kullanıldı. **Bulgular:** Araştırma sonuçları, katılımcıların %33'ünün normal seviyenin altında motor yeterlik performansı sergilediklerini göstermiştir. Ayrıca antropometrik özellikler ve toplam KTK motor katsayı skorlarında cinsiyete göre istatistiksel olarak anlamlı bir farklılık olmadığı (p>0,05) anlaşılmıştır. Sonuçlar, cinsiyetten bağımsız olarak, motor yeterlik seviyesi ile BKİ arasında istatistiksel olarak anlamlı ve negatif yönde bir ilişki olduğunu (p=0,001) göstermiştir. **Sonuç:** Bu bulgulara göre 10-13 yaş arası çocuklarda artan BKİ'nin, motor yeterlik üzerinde olumsuz etkisi olduğu düşünülebilir.

Anahtar Kelimeler: Motor yeterlik; beden kitle indeksi; çocuklar; KTK test bataryası

Over the last four decades, the mean BMI of children has an upward trend worldwide.[1] As noted in a recent study, for example, the increase in childhood obesity has more than tripled in a developed country during this period.[2] Physical inactivity is one of the major factors causing obesity in children.[3] Neverthe-

Correspondence: Mustafa SÖĞÜT
Department of Physical Education and Sports, Middle East Technical University Faculty of Education, Ankara, TURKEY/TÜRKİYE
E-mail: msogut@metu.edu.tr

Peer review under responsibility of Turkiye Klinikleri Journal of Sports Sciences.

Received: 18 May 2020 ***Received in revised form:*** 16 Oct 2020 ***Accepted:*** 09 Nov 2020 ***Available online:*** 15 Feb 2021

less, despite the well-documented health related benefits of physical activity sedentary life style is still prevalent in adolescent.[4,5]

Motor competence (MC) is defined as the proficiency of movement skills that facilitate enjoyable participation in physical activities.[6] In a recently introduced conceptual model level of motor skill competence was proposed as a key determinant of physical activity behavior, fitness, and obesity.[7] Moreover, a growing body of literature has documented that the development of MC in childhood has long term effects on physical activity participation, health-related physical fitness, and adiposity later in adolescence and young adulthood.[8-11] Therefore, evaluation of MC during childhood and understanding its major influencing factors may help to develop appropriate intervention strategies.[12-14]

Previous studies have reported various biological (age, weight status, gender), behavioral (physical activity), socioeconomic status (parents' education level), and environmental (access to sports facilities) correlates of MC.[13,15,16] Body mass index (BMI) is widely used anthropometric adiposity index and a good indicator of weight status in children.[17] Besides, it is one of the consistently studied biological correlates of MC. Current literature, on the other hand, showed no consensus regarding the association between MC and BMI in children and adolescents. Several studies[18,19] indicated no significant association, whilst a number of studies demonstrated a significant association.[20-23]

Gender of a child is another mostly examined biological determinant of MC. Similarly, controversial results were observed regarding the gender differences in MC. Some studies indicated that boys outperform girls in MC.[23,24] On the contrary, some others asserted comparable results.[25,26] Given the aforementioned evidence, more research is needed to gain greater insight into these interactions and differences. Therefore, the purpose of the study is twofold: first to determine the relationship between MC and BMI in children aged 10-13, and second to examine the gender-related differences in MC. The findings of the study may underline the importance of promoting MC on healthy weight status.

MATERIAL AND METHODS

DESIGN AND PROCEDURE

The research design of this study was cross-sectional and correlational. Participants were recruited from one private school. A sample of 289 students were invited to participate in the study. Among them, 103 children and parents gave their consent. Anthropometric measurements were taken by a single observer. Anthropometric and MC tests were performed respectively. All assessments were administered in an indoor gymnasium and completed in five days (~20 students/day).

PARTICIPANTS

A total of 103 children (boys=59, girls=44, mean age=12.1±1.2 years), without physical disability and attending regularly to physical education classes, participated in the study. In accordance with the Declaration of Helsinki all children and their parents were briefed about the assessment protocols and purpose of the study, and written informed consent was obtained. The Non-interventional Researches Ethics Board of Kırıkkale University approved the study (date: 08/02/2020, no: 2019.12.09).

MEASUREMENTS

A portable stadiometer (Seca 213, Hamburg, Germany) was used to measure body height to the nearest 0.1 cm. A digital weighing scale was utilized to evaluate body weight to the nearest 0.1 kg. BMI was calculated (kg/m^2). A revised version of the "Körperkoordinationstest für Kinder (KTK)" test battery was used to assess MC.[27] The KTK comprises four items; walking backward on beams (KTK_{Beam}), hopping on one leg (KTK_{Hop}), jumping sideways (KTK_{Jump}), and moving sideways on boards (KTK_{Board}). The raw scores for each item were converted to the age- and gender-specific motor quotient. The sum of four items was used to calculate total KTK motor quotient ($Total_{KTKMQ}$) scores. The $Total_{KTKMQ}$ enables categorization of MC into consecutive five levels (Table 1).

STATISTICAL ANALYSIS

Statistical Package for Social Sciences (IBM-SPSS-v.24) for Windows was used to conduct data analysis.

TABLE 1: Classification of motor competence level according to motor quotient scores of Körperkoordinationstest für Kinder.

Motor quotient scores	Classification
131-145	High
116-130	Good
86-115	Normal
71-85	Moderate
56-70	Impairment

The Kolmogorov-Smirnov and Levene tests were used to test the normality and homogeneity assumptions respectively. An independent sample t-test was used to ascertain gender-related differences. In order to ascertain the magnitude of differences effects sizes (based on Cohen's d values) were calculated. Effect sizes were considered as trivial (0.0-0.19), small (0.20-0.49), medium (0.50-0.79), and large (0.80 and greater).[28] The Pearson correlation coefficient was used to analyze the associations between MC and BMI. The statistical significance level was set at $p<0.05$.

RESULTS

The means and standard deviations and gender differences in anthropometric characteristics are given in Table 2. The results revealed that none of the variables differed significantly ($p>0.05$) between boys and girls.

The MC level of the participants is presented in Table 3. The results showed that 33% of participants performed below normal in MC.

The means and standard deviations and gender-related differences in KTK scores are presented in Table 4. The results revealed that none of the variables differed significantly ($p>0.05$) between boys and girls.

The correlations between the MC level and BMI are given in Table 5. The results showed that $Total_{KTKMQ}$ and KTK_{Beam} scores were found to be significantly ($p=0.001$) and negatively associated with BMI in both boys and girls.

DISCUSSION

The main aim of this cross-sectional study was to determine the association between MC and BMI in children aged 10-13. Regardless of gender, results revealed that MC was significantly and negatively associated with BMI. This result contrasts with the findings of previous researches.[18,19] For example, Derer and Ballı examine the relationship between MC and BMI in primary school children and found no significant association between variables.[19] They explained this result by the absence of overweight and obese children in their research group. On the other side, results of the current study is in accordance with the findings of the earlier investigations.[20-23] Considering this negative correlation, Lopes et al. emphasized the importance of providing children appropriate time and environment on the development of MC and healthy weight status.[23] Supportively, several studies reported significant differences in MC and fitness between overweight/obese and normal-weight children in favor of children with healthy weight status.[29,30]

The results showed no significant differences between boys and girls in terms of the four KTK items and the total KTK motor quotient scores. Previous research into gender differences is equivocal.[23-26,31] For example, Lopes et al examined the KTK performances of children aged 6-14 and noted the superiority of boys across all ages.[23] Notwithstanding, in line with the findings of the present study, Söğüt reported no significant gender effect in children between the ages of 6-14.[26] Söğüt asserted that when boys and girls trained

TABLE 2: Descriptive statistics for anthropometric characteristics by gender, t-test results, and effect size values.

Gender	Boys (n=59)	Girls (n=44)	t value	p value	d value	qualitative
Age (years)	12.3±1.2	11.9±1.9	1.799	0.075	0.36	small
Height (cm)	156.5±11.1	155.4±8.9	0.539	0.591	0.11	trivial
Weight (kg)	46.2±11.3	45.5±12.4	0.279	0.781	0.06	trivial
BMI (kg/m^2)	18.7±3.3	18.6±3.6	0.147	0.883	0.03	trivial

BMI: Body mass index.

TABLE 3: Motor competence levels of the participants.

	Boys		Girls		Total	
KTK levels	n	%	n	%	%	Total (%)
High	1	1.7	-	0.0	1	1.0
Good	5	8.5	1	2.3	6	5.8
Normal	36	61.0	26	59.1	62	60.2
Moderate	9	15.2	16	36.3	25	24.3
Impairment	8	13.6	1	2.3	9	8.7

KTK: Körperkoordinationstest für Kinder.

equally they may have similar motor coordination performance.[26] The physical activity preferences and available opportunities may cause these variations.[13]

The results regarding the total KTK motor quotient scores demonstrated that the mean value of all participants was 92.1 (±15.9). Previously, similar findings were observed for non-athletic but healthy-weight children.[20,24] On the other hand, various former examinations reported relatively higher values for the athletic population.[32,33] In their study, for instance, Vandorpe et al. found 133.7 (±4.3) for elite female gymnast.[33] Moreover, KTK test battery was recommended in the context of talent identification and selection of young athletes.[34] It seems that engagement in sporting activities provides an environment for children to enhance their MC.

CONCLUSION

In conclusion, this study indicated inverse relationships between MC and BMI in boys and girls aged 10-13. These results emphasized the possible adverse influence of increased BMI on MC in children. However, there are some limitations to consider in the present study. Firstly, determining physical activity behavior and sport participation status would increase the inference of the study. Secondly, in addition to BMI, evaluation of body composition would provide a more comprehensive understanding regarding the weight status. Future studies are warranted to expand this observation through a large sample and with a wide range of ages.

Source of Finance

During this study, no financial or spiritual support was received neither from any pharmaceutical company that has a direct connection with the research subject, nor from a company that provides or produces medical instruments and materials which may negatively affect the evaluation process of this study.

Conflict of Interest

No conflicts of interest between the authors and / or family members of the scientific and medical committee members or members of the potential conflicts of interest, counseling, expertise,

TABLE 4: Descriptive statistics for the KTK scores by gender, t-test results, and effect size values.

Gender	Boys (n=59)	Girls (n=44)	t value	p value	d value	qualitative
KTK_{Beam}	47.1±13.0	50.7±9.6	-1.541	0.126	-0.31	small
KTK_{Hop}	56.5±15.8	52.2±9.0	1.595	0.114	0.32	small
KTK_{Jump}	71.9±16.7	70.0±13.0	0.634	0.528	0.13	trivial
KTK_{Board}	49.1±8.5	47.5±4.6	1.133	0.260	0.23	small
$Total_{KTKMQ}$	94.1±18.5	89.5±11.2	1.453	0.149	0.29	small

KTK: Körperkoordinationstest für Kinder.

TABLE 5: Correlation results between motor competence and body mass index.

	Boys		Girls		Total	
Variables	r value	p value	r value	p value	r value	p value
KTK_{Beam}	-0.380	0.003	-0.455	0.002	-0.398	0.001
KTK_{Hop}	-0.579	0.001	0.110	0.477	-0.339	0.001
KTK_{Jump}	-0.147	0.265	0.015	0.921	-0.082	0.408
KTK_{Board}	-0.208	0.113	-0.092	0.553	-0.162	0.102
$Total_{KTKMQ}$	-0.513	0.001	-0.479	0.001	-0.477	0.001

KTK: Körperkoordinationstest für Kinder.

working conditions, share holding and similar situations in any firm.

Authorship Contributions

Idea/Concept: *Aslı Ceyhan, Mustafa Söğüt;* ***Design:*** *Aslı Ceyhan, Mustafa Söğüt;* ***Control/Supervision:*** *Mustafa Söğüt;* ***Data Collection and/or Processing:*** *Aslı Ceyhan, Mustafa Söğüt;* ***Analysis and/or Interpretation:*** *Aslı Ceyhan, Mustafa Söğüt;* ***Literature Review:*** *Aslı Ceyhan, Mustafa Söğüt;* ***Writing the Article:*** *Aslı Ceyhan, Mustafa Söğüt;* ***Critical Review:*** *Mustafa Söğüt;* ***References and Fundings:*** *Aslı Ceyhan, Mustafa Söğüt;* ***Materials:*** *Aslı Ceyhan, Mustafa Söğüt*.

REFERENCES

1. NCD Risk Factor Collaboration (NCD-RisC). Worldwide trends in body-mass index, underweight, overweight, and obesity from 1975 to 2016: a pooled analysis of 2416 population-based measurement studies in 128•9 million children, adolescents, and adults. Lancet. 2017;390(10113):2627-42. [Pubmed] [PMC]
2. Anderson PM, Butcher KF, Schanzenbach DW. Understanding recent trends in childhood obesity in the United States. Econ Hum Biol. 2019;34:16-25. [Crossref] [Pubmed]
3. Sahoo K, Sahoo B, Choudhury AK, Sofi NY, Kumar R, Bhadoria AS. Childhood obesity: causes and consequences. J Family Med Prim Care. 2015;4(2):187-92. [Crossref] [Pubmed] [PMC]
4. Hallal PC, Andersen LB, Bull FC, Guthold R, Haskell W, Ekelund U; Lancet Physical Activity Series Working Group. Global physical activity levels: surveillance progress, pitfalls, and prospects. Lancet. 2012;380(9838):247-57. [Crossref] [Pubmed]
5. Janssen I, Leblanc AG. Systematic review of the health benefits of physical activity and fitness in school-aged children and youth. Int J Behav Nutr Phys Act. 2010;7:40. [Crossref] [Pubmed] [PMC]
6. Goodway JD, Ozmun JC, Gallahue DL. Understanding motor development: Infants, children, adolescents, adults. 8th ed. New York: Jones & Bartlett Learning; 2019. p. 411.
7. Stodden DF, Goodway JD, Langendorfer SJ, Roberton MA, Rudisill ME, Garcia C, et al. A developmental perspective on the role of motor skill competence in physical activity: An emergent relationship. Quest. 2008;60(2):290-06. [Crossref]
8. Barnett LM, Van Beurden E, Morgan PJ, Brooks LO, Beard JR. Does childhood motor skill proficiency predict adolescent fitness? Med Sci Sports Exerc. 2008;40(12):2137-44. [Crossref] [Pubmed]
9. Barnett LM, van Beurden E, Morgan PJ, Brooks LO, Beard JR. Childhood motor skill proficiency as a predictor of adolescent physical activity. J Adolesc Health. 2009;44(3):252-9. [Crossref] [Pubmed]
10. Lima RA, Pfeiffer KA, Bugge A, Møller NC, Andersen LB, Stodden DF. Motor competence and cardiorespiratory fitness have greater influence on body fatness than physical activity across time. Scand J Med Sci Sports. 2017;27(12):1638-47. [Crossref] [Pubmed]
11. Stodden D, Langendorfer S, Roberton MA. The association between motor skill competence and physical fitness in young adults. Res Q Exerc Sport. 2009;80(2):223-9. [Crossref] [Pubmed]
12. Bardid F, Rudd JR, Lenoir M, Polman R, Barnett LM. Cross-cultural comparison of motor competence in children from Australia and Belgium. Front Psychol. 2015;6:964. [Crossref] [Pubmed] [PMC]
13. Barnett LM, Lai SK, Veldman SLC, Hardy LL, Cliff DP, Morgan PJ, et al. Correlates of Gross Motor Competence in Children and Adolescents: A Systematic Review and Meta-Analysis. Sports Med. 2016;46(11):1663-88. [Crossref] [Pubmed] [PMC]
14. Wiart L, Darrah J. Review of four tests of gross motor development. Dev Med Child Neurol. 2001;43(4):279-85. [Crossref] [Pubmed]
15. Erwin HE, Castelli DM. National physical education standards: a summary of student performance and its correlates. Res Q Exerc Sport. 2008;79(4):495-505. [Crossref] [Pubmed]
16. Niemistö D, Finni T, Cantell M, Korhonen E, Sääkslahti A. Individual, Family, and Environmental Correlates of Motor Competence in Young Children: Regression Model Analysis of Data Obtained from Two Motor Tests. Int J Environ Res Public Health. 2020;17(7):2548. [Crossref] [Pubmed] [PMC]
17. Barlow SE. Expert committee recommendations regarding the prevention, assessment, and treatment of child and adolescent overweight and obesity: summary report. Pediatrics. 2007;120(4):164-92. [Crossref] [Pubmed]
18. Catenassi FZ, Marques I, Bastos CB, Basso L, Ronque ERV, Gerage AM. Relationship between body mass index and gross motor skill in four to six year-old children. Rev Bras Med Esporte. 2007;13(4):203-6. [Crossref]
19. Derer A, Ballı ÖM. İlkokul öğrencilerinin motor yeterlik düzeylerinin fiziksel aktiviteye katılım, yaş, cinsiyet ve beden kütle indeksi ilişkisi [Elementary school students' motor proficiency level relationship with physical activity participation, age, gender and body mass index]. Hacettepe Journal of Sport Sciences. 2018;29(4):196-04. [Link]
20. Chagas DV, Batista LA. Associations between motor coordination and BMI in normal weight and overweight/obese adolescents. J Hum Growth Dev. 2016;26(3):380-4. [Crossref]
21. Graf C, Koch B, Kretschmann-Kandel E, Falkowski G, Christ H, Coburger S, et al. Correlation between BMI, leisure habits and motor abilities in childhood (CHILT-project). Int J Obes Relat Metab Disord. 2004;28(1):22-6. [Crossref] [Pubmed]
22. Okely AD, Booth ML, Chey T. Relationships between body composition and fundamental movement skills among children and adolescents. Res Q Exerc Sport. 2004;75(3):238-47. [Crossref] [Pubmed]
23. Lopes VP, Stodden DF, Bianchi MM, Maia JA, Rodrigues LP. Correlation between BMI and motor coordination in children. J Sci Med Sport. 2012;15(1):38-43. [Crossref] [Pubmed]
24. Mores G, Nunes AS, Moura RJ, Corona LFP, Habitante CA. Relationships between motor performance and body composition of school adolescents. J Hum Growth Dev. 2019;29(1):75-82. [Crossref]
25. Clark CC, Moran J, Drury B, Venetsanou F, Fernandes JF. Actual vs. perceived motor competence in children (8-10 years): an issue of non-veridicality. J Funct Morphol Kinesiol. 2018;3(2):20. [Crossref]
26. Söğüt M. Gross motor coordination in junior tennis players. J Sports Sci. 2016;34(22):2149-52. [Crossref] [Pubmed]
27. Kiphard EJ, Schilling F. Körperkoordinationstest für Kinder. Weinheim: Beltz Test GmbH; 2007. [Link]
28. Cohen J. A power primer. Psychol Bull. 1992;112(1):155-9. [Crossref] [Pubmed]

29. D'Hondt E, Deforche B, Vaeyens R, Vandorpe B, Vandendriessche J, Pion J, et al Gross motor coordination in relation to weight status and age in 5- to 12-year-old boys and girls: a cross-sectional study. Int J Pediatr Obes. 2011;6(2-2):e556-64. [Crossref] [Pubmed]

30. Söğüt M, Clemente FM, Clark CCT, Nikolaidis PT, Rosemann T, Knechtle B. Variations in Central Adiposity, Cardiovascular Fitness, and Objectively Measured Physical Activity According to Weight Status in Children (9-11 Years). Front Physiol. 2019;10:936. [Crossref] [Pubmed] [PMC]

31. Haga M. The relationship between physical fitness and motor competence in children. Child Care Health Dev. 2008;34(3):329-34. [Crossref] [Pubmed]

32. Söğüt M. A Comparison of Serve Speed and Motor Coordination between Elite and Club Level Tennis Players. J Hum K inet. 2017;55:171-6. [Crossref] [Pubmed] [PMC]

33. Vandorpe B, Vandendriessche JB, Vaeyens R, Pion J, Lefevre J, Philippaerts RM, et al. The value of a non-sport-specific motor test battery in predicting performance in young female gymnasts. J Sports Sci. 2012;30(5):497-505. [Crossref] [Pubmed]

34. O'Brien-Smith J, Tribolet R, Smith MR, Bennett KJM, Fransen J, Pion J, et al. The use of the Körperkoordinationstest für Kinder in the talent pathway in youth athletes: A systematic review. J Sci Med Sport. 2019;22(9):1021-9. [Crossref] [Pubmed]