

# RELATIONSHIP BETWEEN MOTOR COMPETENCE AND BODY COMPOSITION AMONG CHILDREN AND ADOLESCENTS: A SYSTEMATIC REVIEW

BRIGITA BANJAC, ALEKSANDAR KARAĆ

University of Novi Sad, Faculty of Sport and Physical Education, Serbia

## Correspondence:

Brigita Banjac, University of Novi Sad, Faculty of Sport and Physical Education, Serbia

brigita.banjac@gmail.com

**Abstract:** Context and objective: The scientific evidence on the association between motor competence and body composition among children and adolescents. The aim is to review the literature based on the association between motor competence and body composition to answer the question: does body mass index (BMI) has a negative impact on the Körperkoordinations test für Kinder (KTK) performance?

Data Sources and Study Selection: A systematic review from 4 electronic databases (i.e., PubMed, ScienceDirect, SciELO, and Scopus) was used to search for research articles. The study had to include the KTK battery test to evaluate motor competence (MC) and BMI for measuring body composition among children and adolescents written in the English language. A total of 7 research articles were included in the review.

Synthesis Methods and results: Two authors independently extracted the articles. The analyzed studies suggest that motor competence is negatively associated with body composition among children and adolescents. Thus, children with better BMI should have a higher MC score evaluated with the KTK assessment.

Conclusions: The findings suggest that motor competence and body mass index are negatively associated among children and adolescents. Further research should include another type of test for examining motor competence.

**Key words:** children, adolescents, body mass index, Körperkoordinations test für Kinder.

## INTRODUCTION

Sedentary behavior and lifestyle can easily lead to obesity (Doloma, Kambas, Aggeloussis, & Michalopoulou, 2020), which prevalence is increasing (Graf et al., 2004), and it is associated with cardiovascular risk factors (Andersen, Riddoch, Kriemler, & Hills, 2011). In addition, a lack of physical activity (PA) decreases children's motor competence (MC) levels (Bardid, Rudd, Lenoir, Polman, & Barnett, 2015; Fransen et al., 2014) and has a negative impact on their health (Moreira et al., 2019). Overweight and obese people have a high body mass index (BMI), which is widely used to measure body composition and weight, precisely adiposity (Freedman et al., 2005).

An adequate coordination level is essential for children's general development, health, psychosocial, and well-being reasons (Vandorpe et al., 2011). MC can be described as a complex human movement influenced by physical, psychological, maturational, sociological, and environmental constraints besides an individual's growth and development (Cattuzzo et al., 2016). Moreover, organized sports participation can predict an individual's MC (Eva D'Hondt et al., 2013).

On average, childhood MC is lower than the desired level, which is contrary to the scientific evidence that it is an important determinant of PA and fitness in adulthood (Bardid et al., 2015). Furthermore, children nowadays have a decline in coordination compared to their peers 40 years ago (Barnett et al., 2016; Cattuzzo et al., 2016; Vandorpe et al., 2011).

In the past decade, the interest increased to evaluate the relationship between MC and weight status among children and adolescents (E. D'Hondt et al., 2014). Numerous testing batteries are available for evaluating MC in the population mentioned above. Through this systematic study, MC was evaluated with a reliable, low cost (Moreira et al., 2019), standardized test battery called Körperkoordination Test für Kinder.

KTK test battery is an assessment instrument used in the clinic environment, school practice settings, physical education, sport, health sciences, medicine, and biomechanics. Furthermore, this measurement is appropriate for both

children with typical and atypical development. It can be used for investigation associations, testing the effect of different interventions and treatment, or even diagnostic. (Livonen, Säakslähti, & Laukkanen, 2016).

The KTK (Kiphard & Schilling, 1974) was created in Germany for measuring whole-body coordination with four subtests: Balancing Backwards (BB), Jumping Sideways (JS), Hopping for Height (HH), and Moving Sideways (MS). Results are presented in row scores (steps, jumps), which are, in the end, converted into motor quotient (MC). Thus, it allows comparison between different gender, ages, and population's norms. This test is provided with normative values from 6 to 15 years old children.

Several studies used the KTK battery test for measuring MC over four decades (Livonen et al., 2016). Additionally, a few of them included the association between MC and BMI, as shown in Table 1. The purpose of this study is to systematically review the literature on the association between KTK and MC.

## METHODS

### *Study design and eligibility*

The PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) Statement (Liberati et al., 2009) was used to conduct and report this study. In addition, the PICO criteria is addressed for selecting the articles.

Eligibility criteria were used for inclusion or exclusion of the studies first based on the title and abstract, then on their full text. Inclusion criteria were: using the KTK battery test to measure general motor competence; BMI to determine body composition; children and adolescent population; written in the English language; article older than 1974. Articles were excluded if they were systematic review or meta-analysis; did not include KTK or BMI; evaluated another population than children or adolescents; measured another parameter besides motor competence and body composition.

### *Information source and search strategy*

We used four major electronic databases (i.e., PubMed (2004-2020), ScienceDirect (1974-2020), SciELO (2016-2020), and Scopus (2007-2020)) for the systematic literature search.

The search criteria for the published works were from 1974 to 10 September 2020. The search strategy included the following keywords: ("Körperkoordinationstest für Kinder" OR "Körperkoordinationstest" OR "KTK") AND ("body mass index" OR "BMI") AND ("children" OR "adolescents"). Restrictions by the database: 1) Pubmed: Full text, journal article, English, 2004-2020; 2) ScienceDirect: Research articles, 1974-2020; 3) SciELO: Article, English; 4) Scopus: Article, English.

Two reviewers (BB) and (AK) independently did the first (title and abstract) and second (full text) screening process. The disagreement was solved through a discussion and consensus.

## RESULTS

### *Study selection*

The selection process identified 89 articles combined from all databases, as shown in Figure 1. After identification, all duplicates (27) were removed with the Endnote program. Furthermore, through screening of the titles and abstracts, 41 articles were excluded. In addition to eligibility criteria across a screening of the left 21 study, based on their full text, 7 articles were finally accepted.

The selected studies are collected in Table 1, including their characteristics: authors, year of publication, sample characteristics (number, gender, age), the measurement for motor competence and body composition, and the general findings of the study.

## DISCUSSION

The paper aimed to review the literature based on the relationship between MC using KTK test battery (Kiphard & Schilling, 1974) and body composition evaluated through BMI. The analyzed articles suggest that MC inversely associated with body composition among children and adolescents (Antunes et al., 2015; E. D'Hondt et al., 2014; Doloma et al., 2020; V. P. Lopes, Malina, Maia, & Rodrigues, 2018; Vítor P. Lopes, Stodden, Bianchi, Maia, & Rodrigues, 2012; V. P. Lopes, Stodden, & Rodrigues, 2014).

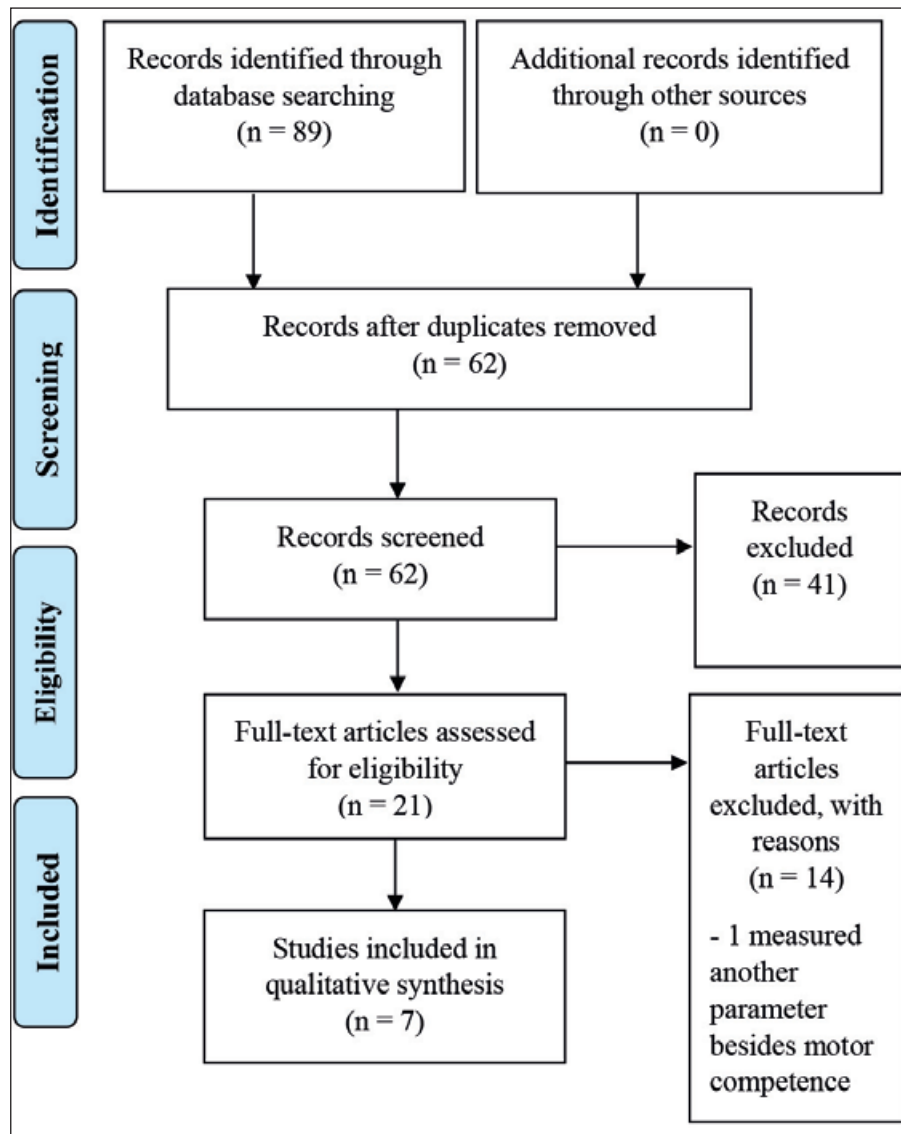


Figure 1. Data collection process with Flow Diagram

As shown in Table 1., the seven included research articles in the systematic review were published between 2012 and 2020 years. According to these studies' context and purpose, the sample sizes varied in the range of 27 and 7175.

KTK test battery has been shown as a great tool for evaluating motor coordination for the whole spectrum of children aged between 6-15 years (Vandorpe et al., 2011). Furthermore, the level of gross motor coordination was strongly related over time to children's weight status (Eva D'Hondt et al., 2013).

In most studies, obesity, such as being overweight, is a limitation for motor tests (Antunes et al., 2015; Doloma et al., 2020). It can explain that overweight and obese children have lower MC scores on KTK in contrast to their normal-weight or thin peers. Those results suggest an inverse association between body weight status and MC level (Fransen et al., 2014), which explains that decreasing MC usually resulted in increased BMI in children (V. P. Lopes et al., 2018).

It is interesting to note that besides BMI, gender differences can also affect the prediction of children's motor coordination (Doloma et al., 2020). In addition, differences in age, culture, socioeconomic status, physical education, and active transport might have the power to enhance the low level of MC (Barnett et al., 2016; Fransen et al., 2014).

As expected, overweight and obesity status is associated with lower gross motor development and endurance performance. However, an active lifestyle is positively correlated with gross motor development in first-grade children (Graf et al., 2004). In addition, MC across childhood and adolescence positively impacts on cardiorespiratory and musculoskeletal fitness (Fransen et al., 2014) in both genders.

*Table 1. An overview of the basic's characteristics from the selected articles*

Title of the study	Authors	Year of publication	Sample characteristics	Measure of motor competence	Measure of body composition	Main results
Correlation between BMI and motor coordination in children	Vítor P. Lopes, David F. Stodden, Mafalda M. Bianchi, Jose A.R. Maia, and Luis P. Rodrigues	2012	Data were collected from 7175 children: boys N=3616 and, girls N=3559, aged 6–14 years.	KTK	BMI	MC has an inverse relationship with BMI. The strength of this negative relationship increased through childhood, but on the contrary, decreased during early adolescence. Overweight and obese children demonstrated significantly lower MC compared to normal-weight peers.
Body mass index and motor coordination: Non-linear relationships in children 6–10 years	V. P. Lopes, R. M. Malina, J. A. R. Maia, and L. P. Rodrigues	2018	Number of respondents was 3738. Of these, 1912 boys, and 1826 girls, aged from 6 to 10 years.	KTK	BMI	The general conclusion is that decrease in MC lead to an increase in BMI. Moreover, on average, children with normal weight had a higher MQ in both genders than overweight and obese peers. The highest MQ results were also detected in normal-weight children, with a few exceptions.
Gross Motor Coordination and Weight Status of Portuguese Children Aged 6–14 Years	António M. Antunes, José A. Maia, Mikis D. Stasinopoulos, Élvio R. Gouveia, Martine A. Thomis, Johan A. Lefevre, Alexandra Q. Teixeira, and Duarte L. Freitas	2015	The total number of the participants was 1276 in the study. Of this sample: 619 boys and 657 girls participated, aged between 6 and 14 years.	KTK	BMI	Normal-weight boys and girls scored better compared to their obese peers. Moreover, overweight children performed better than obese individuals. In conclusion, being overweight or obese was a major limitation in MC tests, and for their health and performance-related physical fitness.
A Longitudinal Study for the Relationship between Motor Coordination and Body Mass Index in Primary School Children	Dimitra Doloma, Antonios Kambas, Nikolaos Aggeloussis, and Maria Michalopoulou	2020	The total number of the sample was 42. The study included 20 boys and 22 girls, aged from 5 to 14 years.	KTK	BMI	They examined the correlation between BMI and KTK. Increases in BMI were correlated with decreases in a rating of the KTK results, and every year there was a statistically significant interaction between MC and BMI. Furthermore, a sedentary lifestyle and physical inactivity lead to weight gain and deficit in MC.

Relationship between body mass index and gross motor skill in four to six-year-old children	Fabrizio Zandonadi Catenassi, Inara Marques, Carina Barbiero Bastos, Luciano Basso, Enio Ricardo Vaz Ronque, and Aline Mendes Gerage	2007	In this study, 27 children participated. Precisely, 16 boys and 11 girls. Their mean age was 5.64 ± 0.67 years.	KTK	BMI	This work concluded that even children with low BMI could perform adequately or even better rough motor tasks. So, tasks involving gross motor skills did not relate to BMI. Besides, there was no significant interaction when the gender distinction was taken into consideration.
Weight status is associated with cross-sectional trajectories of motor coordination across childhood	V. P. Lopes, D. F. Stodden, and L. P. Rodrigues	2014	The total number of respondents was 6625. Of these, 3344 were boys, and 3281 were girls, aged from 6 to 11 years.	KTK	BMI	Interpreting the results, children with higher MC results demonstrated lower BMI values. In addition, children with low MC levels have a higher risk of being overweight or obese. It is important to note that that risk is dramatically increasing with age in both boys and girls.
A Longitudinal Study of Gross Motor Coordination and Weight Status in Children	Eva D'Hondt, Benedicte Deforche, Ilse Gentier, Joke Verstuyf, Roel Vaeyens, Ilse De Bourdeaudhuij, Renaat Philippaerts, and Matthieu Lenoir	2014	The research was conducted on 2517 children (5-13 years, 52.8% of boys, and 47,2 % girls.	KTK	BMI	This study suggests that children's weight status negatively influences the future level of gross MC. Analyzing the results, lower performance at the baseline on the KTK predicted an increase in BMI scores and, a high baseline in BMI values predicted a decrease in the evaluating MC through the KTK battery test.

**Legend:** KTK Körperkoordinations Test, BMI body mass index

Children with low levels of MC have a higher risk (which is increasing with age) of being overweight or obese (V. P. Lopes et al., 2014). Moreover, children's weight status negatively influences the future level of gross motor coordination (E. D'Hondt et al., 2014).

Surprisingly, only one research article reported contrary findings for the relationship between weight status and MC. They discovered an equally (it was not detected significant differences) performance on motor tasks between normal-weight and overweight or obese children. Also, the gender distinction does not have a role in distinguishing children based on their motor performance (Catenassi et al., 2007).

Special attention is required for overweight and obese children to promote regular participation in PA (Eva D'Hondt et al., 2013; Graf et al., 2004). Accordingly, the key to improving motor coordination could be participation in organized physical activities (Doloma et al., 2020), sport, or even just to be active throughout the day and reach the daily recommended limit of PA.

### CONCLUSION AND LIMITATIONS

The findings suggest that MC and BMI are negatively associated among children and adolescents, which means that an increased BMI usually results in lower performance on the KTK test battery.

It is important to mention that our findings, based on the used literature, do not defend the stereotype of obese or overweight children as not skilled. Thus, they can do various motor tasks, but on average, with a lower result. Further research should include another type of test for examining motor competence.



## REFERENCES

- Andersen, L. B., Riddoch, C., Kriemler, S., & Hills, A. (2011). Physical activity and cardiovascular risk factors in children. *British Journal of Sports Medicine*, 45(11), 871-876. doi:10.1136/bjsports-2011-090333
- Antunes, A. M., Maia, J. A., Stasinopoulos, M. D., É, R. G., Thomis, M. A., Lefevre, J. A., . . . Freitas, D. L. (2015). Gross motor coordination and weight status of Portuguese children aged 6-14 years. *American Journal of Human Biology*, 27(5), 681-689. doi:10.1002/ajhb.22715
- Bardid, F., Rudd, J. R., Lenoir, M., Polman, R., & Barnett, L. M. (2015). Cross-cultural comparison of motor competence in children from Australia and Belgium. *Frontiers in Psychology*, 6, 964. doi:10.3389/fpsyg.2015.00964
- Barnett, L. M., Lai, S. K., Veldman, S. L., Hardy, L. L., Cliff, D. P., Morgan, P. J., . . . D, N. R. (2016). Correlates of gross motor competence in children and adolescents: a systematic review and meta-analysis. *Sports Medicine*, 46(11), 1663-1688. doi:10.1007/s40279-016-0495-z
- Catenassi, F. Z., Marques, I., Bastos, C. B., Basso, L., Ronque, E. R. V., & Gerage, A. M. (2007). Relationship between body mass index and gross motor skill in four to six year-old children. *Revista Brasileira de Medicina do Esporte*, 13(4), 203e-206e+227-230. doi:10.1590/S1517-86922007000400003
- Cattuzzo, M. T., Henrique, R. d. S., Ré, A. H. N., Oliveira, I. S. d., Melo, B. M., Moura, M. d. S., . . . Stodden, D. (2016). Motor competence and health related physical fitness in youth: A systematic review. *Journal of Science and Medicine in Sport*, 19(2), 123-129. doi:10.1016/j.jsams.2014.12.004
- D'Hondt, E., Deforche, B., Gentier, I., Bourdeaudhuij, I. D., Vaeyens, R., Philippaerts, R., & Lenoir, M. (2013). A longitudinal analysis of gross motor coordination in overweight and obese children versus normal-weight peers. *International Journal of Obesity*, 37(1), 61-67. doi:10.1016/j.ridd.2014.03.011
- D'Hondt, E., Deforche, B., Gentier, I., Verstuyf, J., Vaeyens, R., Bourdeaudhuij, I. D., . . . Lenoir, M. (2014). A longitudinal study of gross motor coordination and weight status in children. *Obesity (Silver Spring)*, 22(6), 1505-1511. doi:10.1002/oby.20723
- Doloma, D., Kambas, A., Aggeloussis, N., & Michalopoulou, M. (2020). A longitudinal study for the relationship between motor coordination and body mass index in primary school children. *International Journal of Instruction*, 13(3), 511-524. doi:10.29333/iji.2020.13335a
- Fransen, J., D'Hondt, E., Bourgeois, J., Vaeyens, R., Philippaerts, R. M., & Lenoir, M. (2014). Motor competence assessment in children: Convergent and discriminant validity between the BOT-2 Short Form and KTK testing batteries. *Research in Developmental Disabilities*, 35(6), 1375-1383. doi:10.1016/j.ridd.2014.03.011
- Freedman, D. S., Wang, J., Maynard, L. M., Thornton, J. C., Mei, Z., Pierson, R. N., . . . Horlick, M. (2005). Relation of BMI to fat and fat-free mass among children and adolescents. *International Journal of Obesity*, 29(1), 1-8.
- Graf, C., Koch, B., Kretschmann-Kandel, E., Falkowski, G., Christ, H., Coburger, S., . . . Tokarski, W. J. I. j. o. o. (2004). Correlation between BMI, leisure habits and motor abilities in childhood (CHILT-project). 28(1), 22-26.
- Kiphard, E. J., & Schilling, F. (1974). *Körperkoordinationstest für Kinder*. Weinheim: Beltz Test GmbH.
- Liberati, A., Altman, D. G., Tetzlaff, J., Mulrow, C., Gøtzsche, P. C., Ioannidis, J. P. A., . . . Moher, D. (2009). The PRISMA Statement for Reporting Systematic Reviews and Meta-Analyses of Studies That Evaluate Health Care Interventions: Explanation and Elaboration. *PLoS Medicine*, 6(7), e1000100. doi:10.1371/journal.pmed.1000100
- Livonen, S., Sääkslahti, A., & Laukkanen, A. (2016). A review of studies using the Körperkoordinationstest für Kinder (KTK). *European Journal of Adapted Physical Activity*, 8(2), 18-36.
- Lopes, V. P., Malina, R. M., Maia, J. A. R., & Rodrigues, L. P. (2018). Body mass index and motor coordination: Non-linear relationships in children 6–10 years. *Child: Care, Health and Development*, 44(3), 443-451. doi:10.1111/cch.12557
- Lopes, V. P., Stodden, D. F., Bianchi, M. M., Maia, J. A. R., & Rodrigues, L. P. (2012). Correlation between BMI and motor coordination in children. *Journal of Science and Medicine in Sport*, 15(1), 38-43. doi:10.1016/j.jsams.2011.07.005
- Lopes, V. P., Stodden, D. F., & Rodrigues, L. P. (2014). Weight status is associated with cross-sectional trajectories of motor co-ordination across childhood. *Child: Care, Health and Development*, 40(6), 891-899. doi:10.1111/cch.12127
- Moreira, J. P. A., Lopes, M. C., Miranda-Júnior, M. V., Valentini, N. C., Lage, G. M., & Albuquerque, M. R. (2019). Körperkoordinationstest Für Kinder (KTK) for Brazilian Children and Adolescents: Factor Analysis, Invariance and Factor Score. 10(2524). doi:10.3389/fpsyg.2019.02524
- Vandorpe, B., Vandendriessche, J., Lefèvre, J., Pion, J., Vaeyens, R., Matthys, S., . . . Lenoir, M. (2011). The Körperkoordinationstest für kinder: Reference values and suitability for 6–12-year-old children in Flanders. *Scandinavian Journal of Medicine and Science in Sports*, 21(3), 378-388. doi:10.1111/j.1600-0838.2009.01067.x

Primljen: 19. septembar 2020. / Received: September 19, 2020  
Prihvaćen: 16. novembar 2020. / Accepted: November 16, 2020