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Body composition and motor abilities in 8-year-old children: a pilot study

Stefan Mijalković[1], Maša Antonijević[1], Ana Lilić[1], Ana Stanković[2], Daniel Stanković[1]

[1]Faculty of Sport and Physical Education, University of Niš, Niš, Serbia, [2]Artistic Gymnastics Club "NIŠ", Niš, Serbia

Abstract

The aim of this study was to determine the correlation between body composition and motor abilities in 8-year-old children. The sample of participants consisted of 15 children (8 boys and 7 girls) with a mean chronological age of 8.31±0.24 years. The children attended the second grade of the elementary school "Čegar" in the city of Niš and were participating in some form of sports activities. The following measures were taken to assess body composition: body height, body mass, body mass index, percentage of fat and muscle and daily metabolism. On the other hand, the following tests were used to assess motor abilities: sprint at 5, 10, and 20 m (speed), standing long jump (explosive power), push-ups, sit-ups (repetitive strength) and Yo-Yo Intermittent Recovery (IR) Test Level 1 (endurance). Pearson's correlation analysis was used to determine the correlation between body composition and motor abilities in 8-year-old children. The results of this study indicated a statistically significant correlation between body composition and motor abilities in 8-year-old children. Statistically significant negative correlations were found between the following variables of body composition and motor abilities in 8-year-old children: body mass with sit-ups (p=0.047), body mass index with sit-ups (p=0.007) and the Yo–Yo IR1 (p= 0.014), and between body fat percentage and the 10 m sprint (p=0.05), sit-ups (p=0.012) and the Yo–Yo IR1 (p=0.010). Namely, it could be concluded that increased body mass, body mass index and body fat percentage values were associated with reduced motor performance in 8-year-old children.

Keywords: *anthropometric characteristics, elementary school students, endurance, speed, strength*

Introduction

Childhood obesity is a significant public health challenge in many developed nations (Morrison et al., 2012). Despite being recognized as a complex trait influenced by various factors, physical inactivity is considered one of the main contributors to its emergence (Eisenmann 2006; McAllister et al., 2009; Must & Tybor, 2005). It is also suggested that an increasing number of children are physically inactive (Kavey et al., 2003; Morrison et al., 2012). Habits and attitudes towards physical activity are established in childhood and tend to endure throughout adulthood (Larsen et al., 2017). Regular physical activity in children has significant benefits for maintaining overall health status, preventing various chronic diseases, improving mental and physical well-being (Bencke et al., 2002; Pedersen & Saltin, 2006). One of the significant factors influencing the physical activity of children is their motor abilities performance (Morrison et al., 2012). Namely, it appears crucial to build a broad base of fundamental motor abilities in early to middle childhood to improve the capacity for engaging in physical activities, especially in recreational sports environments (Malina 2001; Okely, Booth, & Patterson, 2001). On the other hand, paying attention to body composition and anthropological characteristics is crucial since they form a necessary foundation for enhancing motor abilities (Mijalković, Mladenović, & Ilić, 2023). Specifically, insufficient development of basic motor abilities and low levels of physical activity have been demonstrated to relate to increased levels of body fat and body mass indexes in children (Deforche et al., 2003; Graf et al., 2004; Okely, Booth, & Chey, 2004).

Certainly, some studies that have investigated the relation between motor abilities and body composition in younger school-aged children have established a significant relation between these variables (Gökmen, Kivrak, Çiçekli, Nurten, &

Correspondence:

Montenegro Sport

S. Mijalković
University of Niš, Faculty of Sport and Physical Education, Čarnojevića 10A, 18000 Niš, Serbia
E-mail: stefimijalkovic@gmail.com

Murat, 2019; Lepes et al., 2014; Marmeleira, Veiga, Cansado, & Raimundo, 2017; Morrison et al., 2012; Webster, Sur, Stevens, & Robinson, 2021). Indeed, it is suggested that there is a relation between body composition and motor abilities of children (Gökmen et al., 2019; Marmeleira et al., 2017). Furthermore, children with higher body mass index values and increased body fat percentage, generally demonstrated lower motor performance in terms of speed, strength, agility and coordination compared to those with normal values of these body composition parameters (Marmeleira et al., 2017; Morrison et al., 2012). Additionally, Lepes et al., (2014) established that higher body weight and increased body fat percentage were related to lower motor abilities. Interestingly, an association between body height and motor abilities has been reported in girls (Lepes et al., 2014). Finally, too much body fat might limit the ability to move efficiently through space and influence the proficiency of motor abilities in younger school-aged children (Webster et al., 2021).

It is essential to monitor body composition parameters and motor abilities in younger school-aged children. Even though this topic has been covered in a certain number of scientific papers (Gökmen, Kivrak, Çiçekli, Nurten, & Murat, 2019; Morrison et al., 2012; Webster, Sur, Stevens, & Robinson, 2021), there is still a lot of interest in it. A growing percentage of children nowadays struggle with obesity, which may be related to decreased motor abilities. Therefore, the aim of this study was to determine the correlation between body composition and motor abilities in 8-year-old children.

Methods

Sample of participants

There were 15 children included in the study (8 boys and 7 girls) whose mean chronological age was 8.31±0.24 years. The children attended the second grade of the elementary school "Čegar" in the city of Niš and were involved in some form of sports activities. During the testing period, all children had to be in good health. The participants' parents or guardians gave permission for their child to participate in the study because participants were minors. The study followed Declaration of Helsinki's ethical criteria.

Testing procedure

The participants' assessments were carried out in the sports center of the elementary school "Čegar" in the city of Niš. First, the anthropometric characteristics of the participants were assessed. The participants wore basic clothing and were barefoot. Martin's GMP 101 anthropometer with an accuracy of 0.01 cm was used to measure each participant's body height. McKenna, Straker, & Smith (2013) have previously reported the validity and reliability of this instrument. On the other hand, the bioelectrical impedance Omron BF511 with an accuracy of 0.1 kg was used to assess participants' body mass index, body mass, percentage of fat and muscle and daily metabolism. Dehghan & Merchant (2008) have reported the validity and reliability of the instrument.

A 15-minute warm-up program that included static and dynamic stretching exercises along with some light running was administered to the participants. The warm-up protocol was followed by a speed assessment. The speed was assessed using 5, 10, and 20-meter sprints. Witty photocell gates (Microgate, Italy) with 0.01 s accuracy were used for measuring the sprints. Rumpf, Cronin, Oliver, & Hughes (2011) have reported the validity and reliability of these sprints. The photocells were placed at the starting line, 5, 10 and 20 meters (finish line). The participants were instructed to aim for the quickest time by covering the required distance from a standing position and starting to run as soon as the measurer signaled. Additionally, the standing long jump was used for assessing explosive power. Participants were instructed to perform a standing long jump starting from a position behind the starting line. The test was performed with participants in a high starting position, with their knees slightly bent. Upon the measurer's signal, the participant was required to jump as far as possible. They used arm swing momentum. After completing the long jump, the measurer measured the distance using a measuring tape. The best outcome was noted after the test had been performed three times. The standing long jump's validity and reliability have been previously reported by Ab Rahman, Kamal, Noor, & Geok, (2021). Additionally, repetitive strength of the upper limbs and repetitive strength of the body were assessed in this study. Repetitive strength of the upper limbs was assessed by push-ups and repetitive strength of the body was assessed by sit-ups for one minute (Potter, Spence, Boulé, Stearns, & Carson, 2017). Push-ups were performed with the participants in a plank position with their hands slightly wider than shoulder width. The participants lowered their body almost to the ground with their arms bent at the elbow joint, and then returned to the starting position. They were required to do the maximum number of push-ups in a time interval of one minute. Sit-ups were performed with the participants lying on their backs with knees bent and feet on the ground. The participants' arms were positioned behind their heads. The participant's task was to lift the shoulders and upper back up using the abdominal muscles, and then return down to the starting position. The maximum number of sit-ups for one minute was registered. In these tests, time was measured using a handheld stopwatch, whose validity and reliability were reported by Hetzler, Stickley, Lundquist, & Kimura (2008).

Participants' endurance was assessed by using the Yo-Yo Intermittent Recovery Test Level 1 (Yo–Yo IR1). Initially, the cones were positioned 16 meters apart. The participants stood behind the cones, and each of them had their own cone to follow. The participants followed the measurer's instructions and ran to the opposite cone and back at his signal. The level was considered completed only when the participant ran to and from the opposite cone, covering a distance of 32 meters. The test may be stopped whenever the participants desired, and they could be late for a maximum of twice before they were eliminated. Reliability and validity of Yo–Yo IR1 was previously reported by Ahler, Bendiksen, Krustrup, & Wedderkopp, (2012).

Data analysis

IBM SPSS Statistics 20 was used for the data analysis in this study. The One-Sample Kolmogorov-Smirnov Test was used to determine the distribution's normality after the descriptive statistics for the variables under observation were provided. Consequently, the correlation between the 8-year-old children's motor abilities and body composition was determined using Pearson's correlation analysis. According to Hopkins, Marshall, Batterham, & Hanin, (2009) the correlation coefficient was displayed as follows: trivial ($0 < r < 0.1$), small ($0.1 < r < 0.3$), moderate ($0.3 < r < 0.5$), large ($0.5 < r < 0.7$), very large ($0.7 < r < 0.9$) and almost perfect ($0.9 < r < 1$).

Results

Table 1 presents the descriptive statistics of monitored variables of body composition (body height, body mass, body mass index, percentage of fat and muscle and daily metabolism) and motor abilities (sprint at 5, 10 and 20 meters, standing long jump, push-ups, sit-ups and Yo–Yo IR1). Also, Table 1 contains the results of One-Sample Kolmogorov-Smirnov Test.

Table 1. Descriptive statistics and One-Sample Kolmogorov-Smirnov Test.

	Mean±Std. Deviation	KS Test
BH	133.43±6.68	0.72
BM	31.27±8.58	0.73
BMI	17.31±3.35	0.92
%fat	19.75±8.62	0.98
%muscle	29.97±3.34	0.63
DM	1135.13±146.13	0.88
5m (s)	1.65±0.12	0.87
10m (s)	2.71±0.20	0.88
20m (s)	4.92±0.48	0.64
SLJ (cm)	110.60±18.03	0.99
push-ups (1min)	14.87±9.51	0.98
sit-ups (1min)	32.33±11.06	0.61
Yo-Yo (m)	394.67±269.27	0.56

Legend: KS Test - One-Sample Kolmogorov-Smirnov Test; BH – body height; BM – body mass; BMI – body mass index; %fat - fat percentage; %muscle - muscle percentage; DM -daily metabolism; 5m - 5 meter sprint; 10m – 10 meter sprint; 20m – 20 meter sprint; SLJ - standing long jump; Yo-Yo - Yo-Yo Intermittent Recovery Test Level 1.

According to the results of One-Sample Kolmogorov-Smirnov Test, data were normally distributed. Therefore, Pearson's correlation analysis was employed to determine the correlation between body composition and motor abilities in 8-year-old children. The results of the Pearson's correlation analysis are shown in Table 2.

Table 2. Pearson's correlation analysis.

Monitored variables	5m (s)	10m(s)	20m(s)	SLJ (cm)	push-up (1min)	sit-ups (1min)	Yo-Yo (m)
BH	-0.078	-0.111	-0.134	0.164	-0.178	-0.136	-0.189
BM	0.172	0.232	0.213	-0.198	-0.408	-0.519*	-0.504
BMI	0.295	0.403	0.384	-0.393	-0.474	-0.660*	-0.618*
%fat	0.380	0.506*	0.486	-0.473	-0.488	-0.631*	-0.641*
%muscle	-0.175	-0.271	-0.299	0.091	0.113	0.089	-0.123
DM	0.047	0.048	0.036	-0.073	-0.184	-0.335	-0.474

Legend: * - statistical significance ($p < 0.05$); BH – body height; BM – body mass; BMI – body mass index; %fat - fat percentage; %muscle - muscle percentage; DM -daily metabolism; 5m - 5 meter sprint; 10m – 10 meter sprint; 20m – 20 meter sprint; SLJ - standing long jump; Yo-Yo - Yo-Yo Intermittent Recovery Test Level 1.

Based on the results of Pearson's correlation analysis presented in Table 2, it could be concluded that there was a statistically significant correlation between body composition and motor abilities in 8-year-old children. More precisely, a statistically significant negative correlation was identified between body mass and sit-ups (p=0.047), emphasizing that children with lower body mass would perform better this motor ability test. Furthermore, a statistically significant negative correlation was identified between body mass index and sit-ups (p=0.007) and the Yo–Yo IR1 (p=0.014). Finally, a statistically significant negative correlation was determined between body fat percentage and the 10 m sprint (p=0.05), sit-ups (p=0.012) and the Yo–Yo IR1 (p=0.010). This indicates that children with lower body mass index and lower body fat percentage may potentially achieve better motor performance compared to children with higher values of these body composition variables. The correlation coefficients indicated that it was a large correlation.

Discussion

The aim of this study was to determine the correlation between body composition and motor abilities in 8-year-old children. Based on Pearson's correlation analysis, it could be concluded that there was a statistically significant negative large correlation between body composition and motor abilities in younger school-aged children. Namely, a statistically significant correlation has been found between body mass and sit-ups, body mass index and sit-ups, as well as the Yo-Yo IR1 test, and body fat percentage with a 10-meter sprint, sit-ups and the Yo-Yo IR1 test. More specifically, higher values for body composition parameters were related to lower motor abilities, whereas lower values of the body composition parameters were related to higher levels of motor abilities. Therefore, it is crucial to monitor both body composition and motor abilities in this population.

When discussing body mass as an aspect of body composition, the results of our study indicated a negative correlation between body mass and the achieved maximum number of sit-ups within a one-minute time interval. This potentially indicates that children with higher body mass may be less successful in this test of motor abilities compared to children with normal values of this parameter. These results are in line with the findings reported by Esmaeilzadeh & Ebadollahzadeh (2012). A negative correlation between body mass and the number of sit-ups performed in one minute was also established in their study. These findings suggest that monitoring body mass from early childhood is of great importance to have better repetitive strength and be more successful in sports activities. Also, the results of our study indicate a statistically significant negative correlation between body mass index and the achieved maximum number of sit-ups and the Yo-Yo IR1 endurance test. Butterfield, Lehnhard, & Coladarci (2002) also found a negative correlation between body mass index and the achieved maximum number of sit-ups in children. In addition, Ørntoft et al., (2018) found that children with higher body mass and body mass index were less successful in performing the Yo-Yo IR1. This is in line with our results, as higher values of body mass index were also related to lower endurance at the present study. Also, engaging in physical activity is a primary mechanism for the development of motor abilities and the regulation of children's body composition (Lohman et al., 2008; Stodden et al., 2008). It has been established that children of physically inactive parents are also less physically active, have inferior motor performance, are more susceptible to obesity and participate less frequently in sports and recreational activities than children of physically active parents (Zahner et al., 2009). Consequently, parents are advised to enroll their children in some form of sports activities to improve body composition values and thereby enhance motor abilities performance.

Finally, the results of our study also revealed a negative correlation between body fat percentage and a 10-meter sprint, the maximum number of achieved sit-ups, and the Yo-Yo IR1 endurance test. Several studies have reported similar findings (Gökmen et al., 2019; Lepes et al., 2014; Marmeleira et al., 2017). Indeed, it was established that higher percentages of body fat were negatively correlated with the performance of motor abilities such as speed, repetitive strength and endurance. Having too much body fat and a sedentary lifestyle, along with less physical activity among today's children and youth, clearly shows that having a higher percentage of body fat negatively affects the motor abilities of younger school-age children (Lepes et al., 2014). It has been established that regular physical activity leads to improvements in physical fitness, health behavior, and overall lifestyle in children and leads to a reduction in body fat percentage (Andersen, Wedderkopp, Hansen, Cooper, & Froberg, 2003; Pate, Trost, Levin, & Dowda, 2000; Zahner et al., 2009). Namely, one of the most important factors for children's participation in sports activities is the influence of parents and coaches (Webster, Sur, Stevens, & Robinson, 2021). Therefore, coaches and parents can be advised to pay attention to the lifestyle and body fat percentage of their children to ensure better motor performance and overall health.

The limitation of this study primarily lies in the small number of participants involved in the testing. The testing was conducted at the end of the school semester which could be one of the reasons for the small number of participants. Also, a large number of children at the time of testing had health issues. Due to the small number of participants, the results cannot be generalized and applied to the entire age population. Taking everything in consideration, this study is a pilot study that will serve as a starting point for further research.

Conclusion

This study advances our knowledge of the relations between 8-year-old children's motor abilities and body composition. More precisely, a statistically significant correlation between younger school-aged children's motor abilities and body composition was identified in this study. Understanding these relations can contribute to the development of training programs and strategies to improve motor abilities and reduce body composition in this population. It is important to assess both motor abilities and body composition parameters in younger school-aged children because children can improve their athletic performance in this way.

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

Ethical Approval
The study was approved by the Faculty of Sport and Physical Education, University of Niš Ethical Committee (04-1955/2).

Future research
This pilot study is raising the need for future research. Future research should include a larger number of participants as well as a greater variety of tests to assess motor abilities. This way, the results can be generalized.

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References

Ab Rahman, Z., Kamal, A. A., Noor, M. A. M., & Geok, S. K. (2021). Reliability, validity, and norm references of standing broad jump. *Revista Geintec-Gestao Inovacao E Tecnologias*, *11*(3), 1340-1354.

Ahler, T., Bendiksen, M., Krustrup, P., & Wedderkopp, N. (2012). Aerobic fitness testing in 6-to 9-year-old children: reliability and validity of a modified Yo–Yo IR1 test and the Andersen test. *European journal of applied physiology*, *112*, 871-876.

Andersen, L. B., Wedderkopp, N., Hansen, H. S., Cooper, A. R., & Froberg, K. (2003). Biological cardiovascular risk factors cluster in Danish children and adolescents: the European Youth Heart Study. *Preventive medicine*, *37*(4), 363-367.

Bencke, J., Damsgaard, R., Saekmose, A., Jørgensen, P., Jørgensen, K., & Klausen, K. (2002). Anaerobic power and muscle strength characteristics of 11 years old elite and non-elite boys and girls from gymnastics, team handball, tennis and swimming. *Scandinavian journal of medicine & science in sports*, *12*(3), 171-178.

Butterfield, S. A., Lehnhard, R. A., & Coladarci, T. (2002). Age, sex, and body mass index in performance of selected locomotor and fitness tasks by children in grades K-2. *Perceptual and motor skills*, *94*(1), 80-86.

Deforche, B., Lefevre, J., De Bourdeaudhuij, I., Hills, A. P., Duquet, W., & Bouckaert, J. (2003). Physical fitness and physical activity in obese and nonobese Flemish youth. *Obesity research*, *11*(3), 434-441.

Dehghan, M., & Merchant, A. T. (2008). Is bioelectrical impedance accurate for use in large epidemiological studies?. *Nutrition journal, 7*(1), 1-7.

Eisenmann, J. C. (2006). Insight into the causes of the recent secular trend in pediatric obesity: common sense does not always prevail for complex, multi-factorial phenotypes. *Preventive medicine*, *42*(5), 329-335.

Esmaeilzadeh, S., & Ebadollahzadeh, K. (2012). Physical fitness, physical activity and sedentary activities of 7 to 11 year old boys with different body mass indexes. *Asian journal of sports medicine*, *3*(2), 105.

Gökmen, M. H., Kivrak, B., Çiçekli, C., Nurten, D. İ. N. Ç., & Murat, T. A. Ş. (2019). The Evaluation of The Connectıon Between Motor Performance Skills and Body Composition of 6-10 Year Old Children. *Sportive*, *2*(2), 16-26.

Graf, C., Koch, B., Kretschmann-Kandel, E., Falkowski, G., Christ, H., Coburger, S., ... & Dordel, S. (2004). Correlation between BMI, leisure habits and motor abilities in childhood (CHILT-project). *International journal of obesity*, *28*(1), 22-26.

Hetzler, R. K., Stickley, C. D., Lundquist, K. M., & Kimura, I. F. (2008). Reliability and accuracy of handheld stopwatches compared with electronic timing in measuring sprint performance. *The Journal of Strength & Conditioning Research, 22*(6), 1969-1976.

Hopkins, W., Marshall, S., Batterham, A., & Hanin, J. (2009). Progressive statistics for studies in sports medicine and exercise science. *Medicine+ Science in Sports+ Exercise, 41*(1), 3.

Kavey, R. E. W., Daniels, S. R., Lauer, R. M., Atkins, D. L., Hayman, L. L., & Taubert, K. (2003). American Heart Association guidelines for primary prevention of atherosclerotic cardiovascular disease beginning in childhood. *Circulation*, *107*(11), 1562-1566.

Larsen, M. N., Nielsen, C. M., Ørntoft, C. Ø., Randers, M. B., Manniche, V., Hansen, L., ... & Krustrup, P. (2017). Physical fitness and body composition in 8–10-year-old Danish children are associated with sports club participation. *Journal of strength and conditioning research*, *31*(12), 3425.

Lepes, J., Halasi, S., Mandaric, S., Tanovic, N., Lepes, J., Halasi, S., ... & Tanovic, N. (2014). Relation between body composition and motor abilities of children up to 7 years of age. *Int. J. Morphol*, *32*(4), 1179-1183.

Lohman, T. G., Ring, K., Pfeiffer, K., Camhi, S., Arredondo, E., Pratt, C., ... & Webber, L. S. (2008). Relationships among fitness, body composition, and physical activity. *Medicine and science in sports and exercise*, *40*(6), 1163.

Malina, R. M. (2001). Physical activity and fitness: pathways from childhood to adulthood. *American Journal of Human Biology: The Official Journal of the Human Biology Association*, *13*(2), 162-172.

Marmeleira, J., Veiga, G., Cansado, H., & Raimundo, A. (2017). Relationship between motor proficiency and body composition in 6-to 10-year-old children. *Journal of paediatrics and child health*, *53*(4), 348-353.

McAllister, E. J., Dhurandhar, N. V., Keith, S. W., Aronne, L. J., Barger, J., Baskin, M., ... & Allison, D. B. (2009). Ten putative contributors to the obesity epidemic. *Critical reviews in food science and nutrition*, *49*(10), 868-913.

McKenna, L., Straker, L., & Smith, A. (2013). The inter-tester reliability of anthropometric measurement with portable tools. *The European Journal of Physiotherapy, 15*(1), 34-41.

Mijalković, S., Mladenović, K., & Ilić, T. (2023). Body Composition And Motor Abilities Of Young Football Players. *Journal of Anthropology of Sport and Physical Education*, *7*(2), 19-22.

Morrison, K. M., Bugge, A., El-Naaman, B., Eisenmann, J. C., Froberg, K., Pfeiffer, K. A., & Andersen, L. B. (2012). Inter-relationships among physical activity, body fat, and motor performance in 6-to 8-year-old Danish children. *Pediatric exercise science*, *24*(2), 199-209.

Must, A., & Tybor, D. J. (2005). Physical activity and sedentary behavior: a review of longitudinal studies of weight and adiposity in youth. *International journal of obesity*, *29*(2), S84-S96.

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

Okely, A. D., Booth, M. L., & Patterson, J. W. (2001). Relationship of physical activity to fundamental movement skills among adolescents. *Medicine and science in sports and exercise*, *33*(11), 1899-1904.

Ørntoft, C., Larsen, M. N., Madsen, M., Sandager, L., Lundager, I., Møller, A., ... & Krustrup, P. (2018). Physical fitness and body composition in 10–12-year-old Danish children in relation to leisure-time club-based sporting activities. *BioMed research international*, *2018*.

Pate, R. R., Trost, S. G., Levin, S., & Dowda, M. (2000). Sports participation and health-related behaviors among US youth. *Archives of pediatrics & adolescent medicine*, *154*(9), 904-911.

Pedersen, B. K., & Saltin, B. (2006). Evidence for prescribing exercise as therapy in chronic disease. *Scandinavian journal of medicine & science in sports*, *16*(S1), 3-63.

Potter, M., Spence, J. C., Boulé, N. G., Stearns, J. A., & Carson, V. (2017). Associations between physical activity, screen time, and fitness among 6-to 10-year-old children living in Edmonton, Canada. *Applied physiology, nutrition, and metabolism*, *42*(5), 487-494.

Rumpf, M. C., Cronin, J. B., Oliver, J. L., & Hughes, M. (2011). Assessing youth sprint ability–Methodological issues, reliability and performance data. *Pediatric exercise science*, *23*(4), 442-467.

Stodden, D. F., Goodway, J. D., Langendorfer, S. J., Roberton, M. A., Rudisill, M. E., Garcia, C., & Garcia, L. E. (2008). A developmental perspective on the role of motor skill competence in physical activity: An emergent relationship. *Quest*, *60*(2), 290-306.

Webster, E. K., Sur, I., Stevens, A., & Robinson, L. E. (2021). Associations between body composition and fundamental motor skill competency in children. *BMC pediatrics*, *21*(1), 1-8.

Weiss, M. R. (2013). Back to the future: Research trends in youth motivation and physical activity. *Pediatric exercise science*, *25*(4), 561-572.

Zahner, L., Muehlbauer, T., Schmid, M., Meyer, U., Puder, J., & Kriemler, S. (2009). Association of sports club participation with fitness and fatness in children. *Medicine+ Science in Sports+ Exercise*, *41*(2), 344.