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Effects of Physical Activity on Anthropometric Characteristics in School-Age Children: A Review Study

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ABSTRACT

Background. Today, it is very speculative to talk about the percentage of obese children in the world because these figures change significantly from day to day, and there are even significant differences between respondents in the same country, according to geographical area and place of residence. A constant decline in the level of physical activity of children on a global level can be reported from the age when they start school. Energy intake of food is largely from energy consumption, which leads to an increase in body weight and obesity. Factors of overweight and obesity are associated with a sensitive comparison of health: a significantly increased risk of diabetes, disorders of the locomotor system, and increased social and psychological rights.

Methods and results. During the systematization of the research on the topic, the aim of the paper was to determine whether the influence of physical activity on anthropometric parameters in school-age children is reviewed by previous research. Nineteen types of studies were collected. The following electronic databases were used to search the literature: MEDLINE, SCOPUS, Web of Science SPORTS DISCUS in the period from 2004 to 2016. The respondents included in the research were school-age children.

Conclusion. The positive impact of various physical activity programs is aimed at reducing the parameters of anthropometric characteristics and obesity prevention.

Keywords: physical activity, school program, morphology, anthropomeric data, exercises.

INTRODUCTION

Research across the European region shows a low level of overall physical activity of many populations. More than 14 million children are overweight, and 3 million are obese (World Health Organization, 2006). The results of longitudinal studies indicate that a decrease in physical activity begins as early as age 9 (Hoos, Plasqui, Gerver, & Westerterp, 2003; Wickel, Eisenmann, & Welk, 2009). The data obtained show an acute decline in physical activity at all ages over the last few decades (Currie et al., 2004). Across Europe, only one-third of the surveyed school children are physically active at the level recommended by organizations and institutions involved in the promotion of physical exercise (Currie et al., 2004). Children spend more time indoors than ever before. Lack of physical activity and weight gain are also associated with significant health problems in the population of children and adolescents, and thus physical activity is an important factor in reducing the risk of morbidity and mortality in adulthood (Weiss & Caprio, 2005). Overweight and obesity today represent a new global challenge for public health (Hajmer, 2010).

Obesity is often the result of reduced physical activity, i.e., reduced physical exercise and aerobic fitness (Knöpfli et al., 2008). Acquiring and increasing knowledge and competence in the

field of physical activity, according to Stodden et al. (2008), is the basis for further physical activity in adulthood. Decreased level of physical activity is associated with an increased rate of obesity adiposity (Lioret, Maire, Volatier, & Charles, 2007; Riddoch et al., 2004) and decreased values of aerobic and anaerobic capacity (Lafortuna, Fumagalli, Vangeli, & Sartorio, 2002).

The integration between the progression of obesity and declining levels of physical activity highlights the need for research examining the effects of physical activity. Anthropometric characteristics are one of the ways in which obesity can be tested. The thickness of skin folds represents better parameters and is a better indicator in the assessment of obesity in children in relation to the values of body fat index (Nooyens et al., 2007). Yin et al. (2005) obtained the results which are said to be an additional program of physical activity that students applied during one school year and it had a positive effect on their body composition, i.e. anthropometric data and values that indicated cardiovascular diseases. A program of physical activity lasting 10 weeks leads to the regulation of the body composition of obese children of younger school age (Riddiford-Harland et al., 2016). The Dutch obesity prevention program for school-age children has had beneficial effects on subcutaneous adipose tissue values in both boys and girls (Singh, Chinapaw, Brug, & Van Mechelen, 2009). The physical activity program applied after school activities in nine-year-old children shows that subjects who were overweight significantly reduced the results in subscapular subcutaneous adipose tissue as well as the body fat index (Messiah et al., 2015). Also, additional physical activity that was applied twice a week for one year, in addition to standard school hours, showed effects on anthropometric values and physical abilities (Kriemler et al., 2010). Longitudinal studies using a physical activity program, alone or with an additional diet program, have shown positive effects on anthropometric characteristics (Deforche et al., 2003; Korsten-Reck et al., 2007; Lazaar et al., 2007; Wong et al., 2008). However, there are studies in which the program of physical activity lasting 28 weeks did not show statistical differences in the values of subcutaneous adipose tissue in boys and girls aged 9 and 10 years (Aguilar et al., 2010). Several review studies have found that a six-month physical activity program in children 6 to 10 years of age did not show positive changes in anthropometric characteristics, but did positively in terms of children's aerobic and anaerobic abilities (Dobbins, Husson, DeCorby, & LaRocca, 2013; Harris, Kuramoto, Schulzer, & Retallack, 2009). An extracurricular program lasting four weeks in a study by Matvienko and Ahrabi-Fard, (2010) conducted on first graders showed effects in physical fitness and motor skills, but not anthropometric characteristics. Today, it is very speculative to talk about the percentage of obese children in the world, because these figures change significantly from day to day, and there are even significant differences between respondents in the same country, according to geographical area and place of residence. A constant decline in the level of physical activity of children on a global level can be reported from the age when they start school (Tremblay et al., 2015). Monitoring the nutritional status of children in primary school age is necessary in order to prevent obesity, and thus preserve human health at an early school age. Children who are obese or who have increased body weight are more prone to reduced physical activity, or reduced physical activity is the cause of weight gain (Planinsec & Matejek, 2004).

The aim of this study was to determine whether there is an impact of physical activity on anthropometric parameters in school-age children by reviewing previous research.

METHODS

The following electronic databases were used to search the literature: MEDLINE, SCOPUS, Web of Science SPORTS DISCUS in the period from 2004 to 2016. The search was performed using the following keywords (alone or in combination): physical activity, school program, morphology, obesity, children, disorder. The search strategy was modified for each electronic database, where possible, in order to increase sensitivity. All titles and abstracts are reviewed for potential papers to be included in the systematic review. Also, the lists of references of previous review and original research were reviewed. The selection of works was performed on the basis of certain criteria. The analysis included papers that met the defined criteria for inclusion and exclusion from the research.

Table 1. **Criteria for inclusion and exclusion of respondents**

Inclusion criteria	Exclusion criteria
1. effects of physical activity program	1. papers examining the relationship between physical activity and anthropometric parameters
2. longitudinal research	2. research articles written in a language other than English
3. research in English	3. children older than 14 years
4. school-age children	4. effects of physical activity program (sports activities) with children who practice some sports

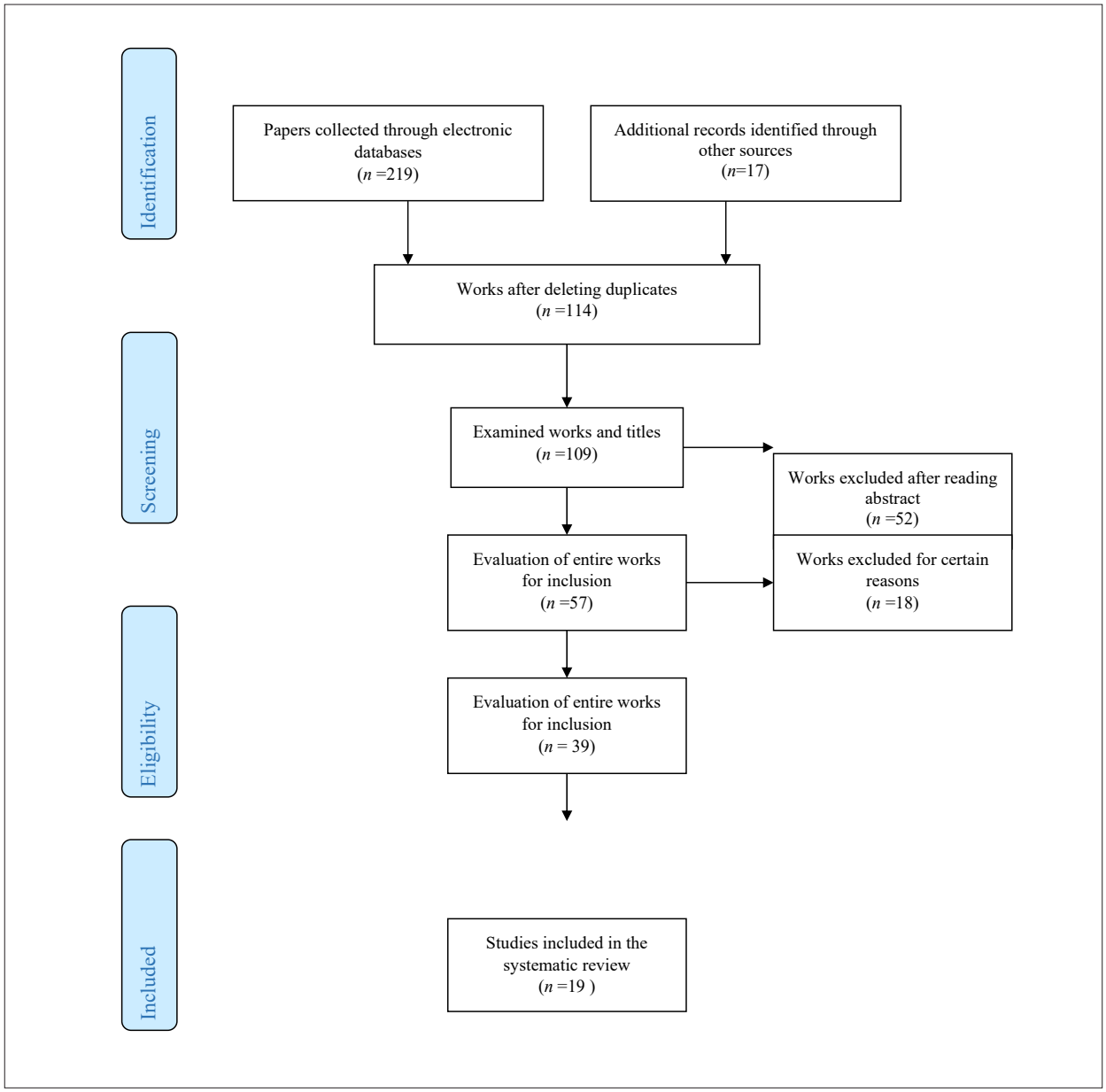

Figure 1. **Schematic procedure for the collection, analysis and elimination of works (Moher, Liberati, Tetzlaff, Altman, & The PRISMA Group, 2010)**

The first author name, year	Respondents			Experimental program					
	No. respondents	Years	Sex	Exercise program	Frequency	Intensity	Variables for estimating anthropometric characteristics	Results	Conclusion
1. Park, J. (2012)	29	12.2±1	M-F	C E (A and P)	3 times a week 12 weeks	50%–70% MHR	Waist circumference	E and C = ↑↑	The exercise program significantly affected the reduction of waist circumference.
2. Nassis, G. (2005)	74	13.05±1.75	M-F	$E_{1,2}$ (Games)	3 times a week 12 weeks	150 $HR/_{min}$	Waist circumference, sum of seven skin folds	$E_{1,2}$ (Waist circumference) = ↑ $E_{1,2}$ (sum of seven skin folds) = ↔	The applied game program had positive effects on waist circumference, but not on sum of seven skin folds.
3. Yin, Z. (2005)	601	8.7	M-F	C E (Games)	2 times a week 8 Months	149 $HR/_{min}$	Waist circumference	E and C = ↔	The application of games in the aerobic zone did not give a statistically significant difference between E and C in waist circumference.
4. Vizcaíno, V. (2008)	1119	9.4±0.7	M-F	$M_{E,C}$ (A and P) $F_{E,C}$ (A and P)	3 times a week 24 weeks	Accelerometer1345 steps per workout	Skin folds of the triceps	$M_{E,C}$ = ↔ $F_{E,C}$ = ↔	No differences were shown in either boys or girls in the skin folds of the triceps after the application of the training program.
5. Riddiford-Harland, D. (2016)	34	8.5±1.4	M-F	$C_{1,2}$ $E_{1,2}$ (Jumping, crawling, running, skipping)	3 times a week 10 weeks		Foot length Foot width	$E_{1,2}$ (Foot length) = ↑ $C_{1,2}$ (Foot length) = ↑ $E_{1,2}$ (Foot width) = ↔ $C_{1,2}$ (Foot width) = ↔	It was determined that there are no differences between E1,2 and C1,2 in foot width, while in foot length there is. However, the authors found that K has a higher pressure on the foot itself and therefore the risks are higher.
6. Zrnzević, N. (2016)	88	7	M-F	$E_{1,2}$ (effects of physical education teaching)	3 times a week 6 Months		Arm length, leg length, shoulder width, pelvic width, wrist width, chest circumference, upper arm circumference, thigh circumference, skin folds of the triceps, skin folds subscapularis, abdomen skinfold	$E_{1,2}$ (Arm length, leg length, shoulder width, pelvic width, wrist width, chest circumference, upper arm circumference, thigh circumference,) = ↑↑ $E_{1,2}$ (skin folds of the triceps, skin folds subscapularis, abdomen skinfold) = ↔	Physical education classes at the final measurement had effects on arm length, leg length, shoulder width, wrist width, chest circumference, upper arm circumference, thigh circumference in relation to the initial measurement, while no statistically significant data were shown in the variables skin folds of the triceps, skin folds subscapularis, abdomen skinfold.
7. Thivel, D. (2011)	57	6–10	M-F	$C_{N,O}$ $E_{N,O}$ (P, Coordination, speed, A) $C_{1,2}$ $E_{1,2}$	2 times a week 6 Months	Moderate intensity	Waist circumference, sum of four skin folds	$C_{N,O}$ (Waist circumference, sum of four skin folds) = ↔ $C_{1,2}$ (Waist circumference, sum of four skin folds) = ↔ $E_{1,2}$ (Waist circumference) = ↑ $E_{1,2}$ (sum of four skin folds) = ↑↑	The application of programs P, Coordination, speed and A gave positive effects on waist circumference and sum of four skin folds.

The first author name, year	Respondents			Experimental program					
	No. respondents	Years	Sex	Exercise program	Frequency	Intensity	Variables for estimating anthropometric characteristics	Results	Conclusion
8. Messiah, S. (2015)	349	8,9	M-F	$O_{1,2}$ (Games) $N_{1,2}$ (Games)	2 times a week 10 Months	Moderately high intensity	Waist circumference, skin folds of the triceps, skin folds biceps, skin folds subscapularis, skin folds suprailiac, sum of four skin folds	$N_{1,2}$ (Waist circumference, skin folds biceps) = ↔ $N_{1,2}$ (skin folds of the triceps, sum of four skin folds) = ↑↑ $N_{1,2}$ (skin folds subscapularis, skin folds suprailiac) = ↑ $O_{1,2}$ (Waist circumference, skin folds of the triceps, skin folds biceps, skin folds suprailiac, sum of four skin folds) = ↔ $O_{1,2}$ (skin folds subscapularis) = ↑↑	In the group of normally fed students, the program of the game program showed better results in anthropometric characteristics than in the group of obese.
9. Lazaar, N. (2007)	425	6–10	M-F	$C_{N,O}$ $E_{N1,O1}$ (Games, coordination) $E_{N2,O2}$	2 times a week 6 Months	Moderately high intensity	Waist circumference, sum of four skin folds	$E_{N1,O1} - E_{N2,O2}$ (Waist circumference, sum of four skin folds) = ↑↑	The application of physical exercise significantly influenced the anthropometric characteristics of waist circumference and sum of four skin folds.
10. Kriemler, S. (2010)	502	6.9–11.3	M-F	$C_{1,2}$ $E_{1,2}$ (P,Coordination, jumping)	2 times a week 6 Months		Waist circumference, sum of four skin folds	$C_{1,2}$ (Waist circumference) = ↔ $E_{1,2}$ (Waist circumference, sum of four skin folds) = ↔ $C_{1,2}$ (sum of four skin folds) = ↑↑	Values of C in the second measurement (sum of four skin folds) = ↑↑, but there was an increase in the value compared to the first measurement.
11. Zorba, E. (2011)	40	11±1	M	$C_{1,2}$ $E_{1,2}$ (A,T)	3 times a week 12 Months	60%–65% MHR	Chest circumference, upper arm circumference, lower leg circumference, waist circumference, hip circumference, elbow joint width, knee joint width	$C_{1,2}$ (Chest circumference, arm circumference, lower leg circumference, waist circumference, hip circumference, elbow joint width, knee joint width) = ↑↑ $E_{1,2}$ (Chest circumference, arm circumference, lower leg circumference, waist circumference, hip circumference, elbow joint width, knee joint width) = ↑↑	The physical activity program had positive effects on anthropometric characteristics in E, while in C there is a significant difference, but there was an increase in all variables
12. Aguilar, F. (2010)	1044	9–10	M-F	$M_{E,C}$ (Jumping, dance) $F_{E,C}$ (Jumping, dance)	3 times a week 28 Months	Accelerometer1345 steps per workout	Skin folds of the triceps	$F_{E,C}$ (Skin folds of the triceps) = ↑↑ $M_{E,C}$ (Skin folds of the triceps) = ↑↑	Physical exercise had a positive effect on both M and F. In subject E, there was a decrease in the value in skin folds of the triceps.

The first author name, year	Respondents			Experimental program					
	No. respondents	Years	Sex	Exercise program	Frequency	Intensity	Variables for estimating anthropometric characteristics	Results	Conclusion
13. Magnusson, K. (2012)	321	7.3±0.3	M-F	C E(additional classes of PE and education)	3 times a week 2 years		5 skin folds sum, waist circumference	E and C = ↔	After two years of applying an additional hour of physical education, E showed better results than C, but they were not statistically significant enough.
14. Bocca, G. (2012)	75	3–5	M-F	C E (Games, dance)	3 times a week 12 Months		Waist circumference, hip circumference	E and C (waist circumference) = ↑↑	There are positive effects of the applied exercise program.
15. Kain, J. (2004)	3086	10.6±2.6	M-F	C E (Soccer, coordination, volleyball)	3 times a week 6 Months	Moderately high intensity	Waist circumference, Skin folds of the triceps	E and C (Waist circumference) = ↑↑ E and C (Skin folds of the triceps) = ↔	The program of physical activity had a positive effect on the reduction of waist circumference in E.
16. Nemet, D. (2005)	46	10–11	M-F	C E (Games, running)	2 times a week 3 Months		2 skin fold sum	E and C (2 skin fold sum) = ↑	There was a decrease in subcutaneous adipose tissue in E, while in C there was an increase in values.
17. Blüher, S.(2014)	257	10.5-11.4	M-F	$E_{1,2}$ (A,P)	2 times a week 12Months		Waist circumference	$E_{1,2}$ (waist circumference) = ↑	The exercise program led to statistically significant changes between the first and second measurements.
18. Kain, J. (2009)	2039	8–12	M-F	C E (A)	2 years		Waist circumference, Skin folds of the triceps	E and C (Waist circumference, Skin folds of the triceps) = ↔	Aerobic exercises did not show statistically significant differences between E and C.
19. Pelemiš, V. (2016)	211	6–7	M-F	C1 C2 E (Directed motor activities)	2 times a week 24 Months		Chest circumference, upper arm circumference, lower leg circumference, abdomen skinfold, skin folds of the triceps, skin folds subscapularis	E and C1 (Upper arm circumference) = ↑↑ E and C1,C2 (Lower leg circumference) = ↑↑ E and C2 (Abdomen skinfold) = ↑↑ E and C2 (skin folds of the triceps) = ↑↑ E and C1,C2 (Chest circumference, skin folds subscapularis) = ↔	There is an influence of the experiment which is reflected in the reduced values of anthropometric characteristics.

Notes: M-men; F-women; C-control group; E-experimental group, MHR-maximal heart rate; A- aerobic activities; P-power; I-games; HR-heart rate beats; $E_{1,2}$-experimental group first and second measurements; ↑↑ - p <.01; ↑ - p <.05; ↔ - no statistical significance; $M_{E,C}$ - male experimental and control group;, $F_{E,C}$ -women experimental and control group; $C_{N,O}$- normal fed and obese control group ; $E_{N,O}$- normal fed and obese control group experimental group; $C_{1,2}$- control group 1st and 2nd measuring; $O_{1,2}$- obese 1st and 2nd measuring; $N_{1,2}$- normal fed1st and 2nd measuring; $E_{N1,O1}$- normal fed and obese experimental group 1st measuring; $E_{N2,O2}$- - normal fed and obese experimental group 2nd measuring; PE-physical education; C1- control group 1; C2- control group 2.

RESULTS

After searching the available scientific databases, 114 papers were collected, which were originally selected by search. After reviewing these papers due to the subject and goal of certain papers that do not include the subject and goal of our research, based on exclusion criteria, we had to reject 94 papers because they did not deal with the impact of a physical activity program on anthropometric characteristics. The total number of studies that are included in the systematization is 19, where boys and girls are included, and the research is related to the effects of physical exercise programs on anthropometric characteristics. The subjects included in the study were school-age children. The programs of physical activity that were taken into the analysis of the review work are: activities that include the elementary type of locomotion (jumping, crawling, running, skipping), strength development exercises, coordination exercises, speed exercises, ball games (football, basketball, volleyball), dance, as well as the effects of physical education classes themselves. The duration of the experimental program was at least ten weeks (Riddiford-Harland et al., 2016), while the longest program lasted two years (Kain et al., 2009; Magnusson et al., 2012). The frequency of training was 2 to 3 times a week. Pelemis (2016); Blüher et al. (2014); Nemet et al. (2005); Kriemler et al. (2010); Lazaar et al. (2007); Messiah et al. (2015); Thivel et al. (2011); Yin et al. (2005) in these studies the physical activity program was applied twice a week, while in the studies (Cain et al., 2004; Bocca, Corpeleijn, Stolk, & Sauer, 2012; Aguilar et al., 2010; Magnussonet et al., 2012; Zorba, Cengiz, & Karacabey, 2011; Zrnzevic & Zrnzevic, 2016; Riddiford-Harland et al., 2016; Vizcainoet et al., 2008; Nassis et al., 2005; Park et al., 2012) frequency physical activity program was three times a week. The intensity of physical activity was moderate intensity (Zorba et al., 2011; Thivel et al., 2011; Nassis et al., 2005; Park et al., 2012; Yin et al., 2005) to moderately high intensity (Kain et al., 2004; Messiah et al., 2015; Lazaar et al., 2007).

DISCUSSION

The aim of this study was to determine whether there is an impact of physical activity on anthropometric parameters in school-age children by reviewing previous research. When it comes to the effects of the applied program of physical activity, application of games, duration of eight months and application twice a week, it was found that there was no statistically significant difference between the experimental and control group in values of waist circumference (Yin et al., 2005). Also, Kriemler et al. (2010) found that the program lasting six months with a frequency of twice a week did not show significant differences in the first and second measurements in the experimental and control groups in the parameters of waist circumference and total value of four skin folds. Physical activity did not give significant results on anthropometric characteristics. However, in several studies the application of different types of physical activity (ball games, coordination, strength) twice a week showed positive changes (Pelemis, 2016; Thivel et al., 2011; Lazaar et al., 2007; Messiah et al., 2015). Pelemis (2016) obtained results in which the experimental group after the program of motor activities significantly differed from the control group in upper arm circumference, lower leg circumference, abdomen skinfold, and skin folds of the triceps ($p < .01$). When it comes to the application of games and coordination exercises lasting six months, waist circumference and the total value of the four skin folds in the first and second measurements indicated significant changes in both obese and normal weight students ($p < .01$) (Lazaar et al., 2007). The same anthropometric characteristics were found in the study of Thivel et al. (2011) in the group of students who applied the program of strength, speed, coordination and aerobic exercise, as well as differences in the initial and final measurements (waist circumference ($p < .05$) and the sum of four skin folds ($p < .01$). The application of games influenced the difference between the first and second measurements in skin folds subscapularis ($p < .05$) in obese subjects and skin folds of the triceps, sum of four skin folds ($p < .05$), skin folds subscapularis, skin folds suprailiac ($p < .01$) in normal weight students (Messiah et al., 2015). Vizcaíno et al. (2008), Magnusson et al. (2012), Kain et al. (2009) with the frequency of physical activity three times a week found no effects on anthropometric characteristics. Foot lengths of the first and second measurements were significant in both the experimental group and the control group ($p < .05$) (Riddiford-Harland et al., 2016). The effects of physical education classes (Zrnzević & Zrnzević, 2016) lasting six months with the frequency of three times a week had a positive

effect on arm length, leg length, shoulder width, pelvic width, wrist width, chest circumference, upper arm circumference, thigh circumference between initial and final measurements ($p < .01$), while in the variables such as skin folds of the triceps, skin folds subscapularis, abdomen skinfold no effects of physical education were found. Activities such as jumping and dancing show that there was a difference between the control group and the group that applied the physical activity program in skin folds of the triceps ($p < .01$) in both boys and girls (Aguilar et al., 2010). However, Kain et al., 2004 did not show statistically significant differences in skin folds of the triceps, while the differences between the control and experimental groups in waist circumference were observed ($p < .01$). Also, these differences in waist circumference ($p < .01$) can be seen in other studies (Bocca et al., 2012).

Middle school students whose planned physical activity program had a frequency of twice a week showed that there were differences in anthropometric characteristics (Blüher et al., 2014; Nemet et al., 2005). Blüher et al. (2014) found that there was a difference in the initial and final measurements when applying the program of strength exercises and aerobic exercise waist circumference ($p < .05$). Nemet et al. (2005) found that the exercise program, which included the application of games and running exercises with the duration of three months, showed differences between the control and experimental groups in skin fold sum ($p < .05$). Studies where experimental treatment lasted for twelve weeks, which included strength exercises, running exercises in games, indicated positive changes in anthropometric characteristics (Nassis et al., 2005; Park et al., 2012; Zorba et al., 2011). According to Zorba et al. (2011), for participants who applied aerobic exercises and running exercises, the results in the initial and final measurements differed significantly in chest circumference, upper arm circumference, lower leg circumference, waist circumference, hip circumference, elbow joint width, and knee joint width ($p < .01$). The variable waist circumference in the study of Park et al. (2012) indicated differences ($p < .01$) between the group of students who participated in the exercise program and the control group of students. Also, Nassis et al. (2005) indicated that there were differences between games in the waist circumference ($p < .05$), but not in the variable sum of seven skin folds which did not indicate differences.

CONCLUSION

Based on the reviewed papers, it was determined that physical activity had a positive effect on anthropometric parameters in children of middle school age, but not in children of younger school age. The proposal and conclusion are that, in order to obtain the most accurate results, due to the period of growth and development in which school-age children are, in addition to anthropometric characteristics, further research also should include indices of body composition to determine the level of changes. Are these changes caused by an increase in muscle mass and loss of fat deposits or is it the other way around?

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