Journal of Physical Education and Sport ® (JPES), Vol. 22 (issue 3), Art 71, pp. 570 – 576, March 2022
online ISSN: 2247 - 806X; p-ISSN: 2247 – 8051; ISSN - L = 2247 - 8051 © JPES

Original Article

Effect of a 6-month volleyball activity program on body composition and physical fitness of overweight and obese children

STRAVA CRISTIAN-COSMIN[1], ORAVIȚAN MIHAELA[2], AVRAM CLAUDIU[3], MONEA DAN[4]
[1] PhD Student, Faculty of Physical Education and Sports, Babeș-Bolyai University, ROMÂNIA
[1,,2,3,] Physical Therapy and Special Motricity, Faculty of Physical Education and Sports, West University of Timișoara, ROMÂNIA
[4] Sports Games, Faculty of Physical Education and Sports, Babeș-Bolyai University, ROMÂNIA

Published online: March 31, 2022
(Accepted for publication March 15, 2022)
DOI:10.7752/jpes.2022.03071

Abstract
Unfortunately, obesity is becoming more common among children, and some children are affected very early in life. Therefore, there is an urgent need for actions at global, regional, and local levels, to improve diet and increase physical activity in general population. **Aim.** The aim of this study was to evaluate the impact of a 6-month volleyball-training program on body composition and fitness parameters in overweight and obese children. **Materials and methods.** A total of 28 overweight and obese girls (8 – 11 years old) were divided into two groups, the intervention and control group. The intervention group (14 girls, 9.4 ± 1 years old) was available to attend 3 volleyball training sessions per week. The control group (14 girls, 9.1 ± 0.9 years old) was not available to attend 3 training sessions per week. For both study groups, we applied initial and final testing, which consisted of anthropometric measurements and assessment of body composition and fitness, physical activity, and eating habits. **Results.** At the end of the study, we observed an improvement in body composition in the intervention group, with a significant decrease in fat percent (5.3%, $p < 0.001$) and a significant increase in skeletal muscle percent (3.07%, $p < 0.001$). In contrast, in the control group, body mean fat percent increased (2.43%, $p = 0.005$), leading to a significant increase in body mass index ($p = 0.005$). In addition, significant differences were observed in the physical performance parameters in the intervention group for all physical tests applied ($p < 0.001$). In the control group, the results obtained for the initial and final testing were very similar; the only difference was observed in the plate tapping test; i.e., we recorded an improvement of 2.45 s ($p < 0.001$). **Conclusions.** Our study shows that by participating in 3 volleyball workouts per week, for 6 months, significant results can be obtained in preventing weight gain and improving body composition and fitness in overweight and obese children without substantial dietary interventions. While at the beginning of the study, the intervention group was classified as obese, according to BMI percentiles, at the end of the study, the subjects in this group were ranked below the middle percentile of the overweight category.
Key Words: childhood obesity, intervention; body composition, physical fitness, children

Introduction

Obesity can be briefly defined as having an excess body weight for a certain height (Gadde, Martin, Berthoud, & Heymsfield, 2018). This is favored by an inappropriate lifestyle characterized by a high-calorie diet (Poston II & Foreyt, 1999), a misperception of weight status (De La O, et al., 2009; Strava, 2017) and last but not least, the lack of moderate or vigorous physical activity (Poston II & Foreyt, 1999).

Unfortunately, obesity is becoming more common among children, and some children are affected very early in life. An estimate made by Abarca-Gómez et al. (2017) highlighted that, globally, a total of 124 million children and adolescents aged 5-19 were obese, while in terms of overweight status, for the same age range mentioned above, it was estimated that there are around 213 million cases worldwide. According to the WHO, the number of obesity cases has tripled from 1975 to the 2010, and by 2020 a number of 39 million children will be diagnosed as overweight or obese (WHO, 2010). In Romania, between the years 2006-2015, almost one in four children was overweight or obese (Chirita-Emandi, et al., 2016). This trend was maintained in 2019, where out of a national sample of 10,393 children (7-9 years), 16.6 were overweight and 13.9 obese (INSP, 2020).
This situation is becoming even more alarming because there is a major risk that the obese child will become an obese adult with various associated medical conditions (Kumar & Kelly, 2017) like diabetes mellitus type 2, high blood pressure, cardiovascular diseases, osteoarthritis (Jurat, Potop, Timnea, & Potop, 2018). In addition to health issues, there are also psychological ones that occur. Thus, overweight or obese children develop a lack of confidence in physical qualities, moving even further away from physical activities and developing increasingly sedentary habits (Morano, Rago, & Raiola, 2019). To overcome this situation, regulatory authorities have initiated measures to promote the idea of adopting a healthy lifestyle by changing eating habits and increasing the level of daily physical activity (Kumar & Kelly, 2017).

Corresponding Author: STRAVA CRISTIAN-COSMIN, E-mail: strava_cosmin@yahoo.com

In this regard, in 2010 The World Health Organization (WHO) recommended for children a minimum of 60 minutes of moderate or vigorous daily physical activity. Two years after the publication of this recommendations by the WHO, a study conducted in five European countries by Verloigne et al. (2012) showed that approximately 4.6% of girls and 16.8% of boys between the ages of 10 and 12 complied with WHO recommendations. Consequently, in order to ensure a higher rate of applicability of the WHO recommendations of having a physically active lifestyle, these must be continuously promoted. These recommendations were established based on scientific studies, such as that of Poitras et al. (2016) which highlights the positive effects of regular physical activity on the cardiovascular system, bone system, mental health but also on weight status, being an important means of preventing and combating obesity (Bielik, et al., 2017). Also, scientific literature data confirms that childhood obesity is more common in children with reduced physical activity compared to those who are physically active (Jiménez-Pavón, Kelly, & Reilly, 2010; Wittmeier, Mollard, & Kriellaars, 2008). Increasing the level of physical activity by practicing physical activities in an organized setting, for a period of at least 6 months, had a positive impact on the BMI and body composition of subjects from different groups of participants in 3 studies (children 8-12 years) (Morano, et al., 2012; Morano, et al., 2014; Morano, Rutigliano, Rago, Pettoello-Mantovani, & Campanozzi, 2016).

Therefore, due to the high prevalence of obesity on global children, there is an urgent need for actions at global, regional, and local levels to improve diet and increase physical activity in general population.

The aim of this study was to evaluate the impact of a 6-month volleyball-training program on body composition and fitness parameters in overweight and obese children.

Materials and methods

Subjects

A total of 28 girls (age 8 – 11 years) were selected from an initial group of 50 girls, enrolled in our program based on an informed consent from their parents, which responded to our invitation via parents groups organized on social media. The study inclusion criteria were based on the following characteristics: overweight and obese children (according to *body mass index percentiles*), aged between 8 to 11 years, not having any other metabolic, cardiac or respiratory condition which interfere with the ability of performing physical activities. We excluded subjects who were involved, at the time of the study, in other intervention lifestyle programmes such as additional nutritional counseling, special diet and exercise training programmes.

Thereafter, the selected subjects were divided into two groups:

- Intervention group (14 girls, 9.4 ± 1 years old) who was available to attend 3 volleyball training sessions per week,
- Control group (14 girls, 9.1 ± 0.9 years old) who was not available to attend 3 training sessions per week.

Testing protocols

For both study groups, we applied initial and final testing, which consisted of anthropometric measurements and assessment of body composition and fitness, physical activity and eating habits.

Anthropometric measurements and assessment of body composition

The height (cm) was measured using a portable stadiometer (Seca model 213, Germany) with precision of 1 mm. For weight (kg) and body composition, we used a multi-frequency bioimpedance analyser (InBody 720, South Korea). We recorded total body water, total skeletal muscle mass, body fat percentage, total body fat, segmental lean mass and fat mass. The subjects were asked to wear lightweight clothing (shorts and T-shirt), and also they were being restricted from eating and drinking water at least 2 hours before the test. The BMI was determined using the online software provided by the CDC (CDC, 2022), requiring the introduction of the following information: the child's date of birth and gender, height, body weight and the date when the last two previously mentioned parameters were evaluated.

Physical fitness

Fitness assessment was performed using tests from the EUROFIT test set (Eurofit, 1993) which evaluate body balance (Flamingo balance), running speed – agility (Shuttle run: 10 x 5 metres), speed of limb movement (Plate tapping), trunk strength (Sit-ups), explosive power (Standing broad jump).

Assessment of eating habits and level of physical activity

For this stage of the test protocol we used the questionnaire developed by Golan & Weizman (1998) in order to identify family eating and activity habits. This questionnaire consists of 21 items, providing information about the frequency on which family members are engaged in physical activity and sedentary (items 1-4), the amount and types of food they eat (items 5-12), eating style (items 13-16) and eating habits (items 17-21). The questionnaire was sent to the parents and the mothers filled in the necessary information, for the entire family.

Study design

The intervention program was carried out over a period of 6 months and consisted of 3 volleyball trainings per week, in which only the girls from the intervention group participated. Each training session lasted 1 hour and 30 minutes, consisting of 15 minutes warm up, 50 minutes volleyball skills training, 10 minutes Physical Education (PE) games, 15 minutes strength and flexibility activities. In volleyball skills training and PE games, the main goal was to find the best exercises and organize them in order to build up the endurance.

Therefore the subjects were required to perform the exercises at a pulse rate of about 70% of the maximum potential of the girls (about a heart rate of 145-150 beats per minute – monitored using a heart rate monitor), over a prolonged time interval. In addition to these 3 workouts, both intervention and control groups participated in 2 hours of PE / week at school. For the control group, the PE classes at school were the only physical activity they participated.

Results

All the results obtained in this study were analyzed using GraphPad Prism 6 software.

Anthropometric measurements and body composition of both intervention and control group are presented in Table 1.

Table 1 – Trend of anthropometric measurements and body composition of intervention and control groups

Variables	Intervention group				Control group			
	T1	T2	Df	p value	T1	T2	Df	p value
Height (cm)	141.6 ± 8.4	145.3 ± 9.4	3.7	< 0.001	138.7 ± 7.2	141.1 ± 7.37	2.35	< 0.001
Weight (kg)	46.14 ± 8.9	46.39 ± 9.15	0.25	0.747	43.71 ± 8.78	47.46 ± 8.42	3.75	< 0.001
BMI (kg/m^2)	22.79 ± 2.4	21.81 ± 2.6	0.98	0.027	22.48 ± 2.67	23.69 ± 2.62	1.20	0.004
BMI Percentiles	95 ± 2.8	89.29 ± 10.7	5.92	0.039	94.21 ± 4.42	96.14 ± 2.87	1.92	0.029
Body Fat Percentage (%)	37.19 ± 5.4	31.89 ± 6.7	5.3	< 0.001	36.42 ± 4.43	38.86 ± 3.98	2.43	0.005
Skeletal Muscle Percentage (%)	32.69 ± 2.8	35.76 ± 3.7	3.07	< 0.001	32.85 ± 2.10	31.8 ± 2.08	1.05	0.021

Values are presented as mean ± standard deviation.

T1 – baseline evaluation; T2 – evaluation after 6 months; Df – The difference between T1 and T2; BMI: Body Mass Index

At the end of the study we noticed an improvement of body composition in the intervention group, with a significant decrease in fat percent (5.3%, $p < 0.001$) and a significant increase in skeletal muscle percent (3.07%, $p < 0.001$). In contrast, for the control group, body mean fat percent increased (2.43%, $p = 0.005$), leading to a significant increase in body mass index (BMI) ($p = 0.004$).

Improvement on the body composition of the subjects included in the intervention group was associated with a significant decrease in BMI (Figure 1), from an average of 95% BMI Percentiles, corresponding to the status of obese (according to the definition of childhood obesity proposed by the Centers for Disease Control - CDC), the intervention group reached BMI Percentiles 89.29% being thus slightly below half of the overweight category. In contrast, the control group went from overweight category (mean BMI Percentiles 94.21) to obese category (mean BMI Percentiles 96.14) (Figure 2).

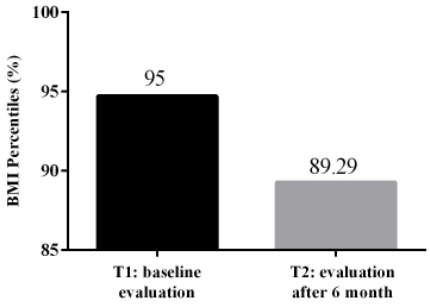

Fig. 1 – BMI Percentiles difference between T1 and T2 for intervention group

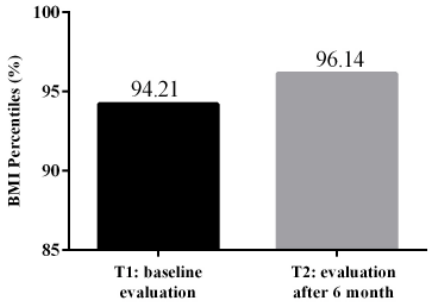

Fig. 2 – BMI Percentiles difference between T1 and T2 for control group

In Table 2 we presented the evolution of the fitness level, from the initial test (T1) to the final one (T2). While significant differences can be seen in the intervention group for all physical tests applied ($p < 0.001$), for the control group, the results obtained for the initial and final testing were very similar, with the only difference observed for the plate tapping test, were we recorded an improvement of 2.45 seconds ($p < 0.001$).

Table 2 - Physical performance parameters of intervention and control groups

Tests	Intervention group				Control group			
	T1	T2	Df	p	T1	T2	Df	p
Flamingo balance (fails)	9 ± 1.56	6.85 ± 1.74	2.14	< 0.001	8.57 ± 1.39	8 ± 1.3	0.57	0.102
Shuttle run: 10 x 5 metres (s)	26.28 ± 1.1	24.43 ± 1.16	1.84	< 0.001	26.28 ± 1.1	25.9 ± 0.96	0.37	0.070
Plate tapping (s)	27.8 ± 4.8	21.84 ± 4.2	5.96	< 0.001	27.8 ± 4.85	25.33 ± 4.14	2.47	< 0.001
Sit-ups (rep)	8.71 ± 1.38	13.43 ± 2.06	4.71	< 0.001	8.71 ± 1.38	9.14 ± 1.09	0.42	0.082
Standing broad jump (cm)	95.5 ± 10.64	110.6 ± 14.01	15.14	< 0.001	95.5 ± 10.64	96.79 ± 15.06	1.28	0.560

T1 – baseline evaluation; T2 – evaluation after 6 months; Df – The difference between T1 and T2; p – value for significantly different

The results obtained from the questionnaire applied (Table 3), shows positive changes in the intervention group, the level of physical activity obtaining a better value than the initial one ($p < 0.001$). While the value obtained for stimulus exposure also decreased ($p < 0.001$) we did not observe the same for the control group, where stimulus exposure increased ($p = 0.002$). A change in the level of physical activity also occurred in the control group, to a lesser extent but still statistically significant, due to an increase in the number of hours of outdoor walking per week. Participation in physical activities in an organized setting remained unchanged for the control group.

Table 3. Questionnaire scores for intervention and control groups

Scale	Intervention group			Control group		
	T1	T2	p	T1	T2	p
*Activity level**	6.86	2.8	< 0.001	6.93	6.23	0.020
Stimulus exposure	16.70	12.76	< 0.001	17.3	17.96	0.002
Eating related to hunger	1.80	1.66	0.160	2.07	1.93	0.160
Eating style	17	18	0.540	18	16	0.010

T1 – baseline evaluation; T2 – evaluation after 6 months; Df – The difference between T1 and T2; p – value for significantly different

* The level of physical activity is inversely proportional to the recorded value. The lower the score, the higher the level of physical activity

Discussion

The purpose of this study was to evaluate the impact of a 6-month volleyball-training program on body composition and fitness. The results obtained by the intervention group, at the end of the study, indicate a significant improvement in fitness and body composition (BMI, Skeletal Muscle Percentage and Body Fat Percentage).

In order to be able to formulate a conclusion as close as possible to reality, and to highlight the effectiveness of volleyball training, we monitored and analyzed separately the level of physical activity and some of the eating habits, to verify the role of each in body composition and fitness changes. In this regard, at the beginning of the study we correlated Body Fat Percentage (BFP) with the data obtained from the applied questionnaire. Following the statistical analysis, we identified two positive correlations: the first reasonable, positive correlation between BFP and physical activity level ($r = 0.55$, $p=0.041$), the second weak correlation between BFP and stimulus exposure ($r = 0.38$ $p=0.173$). Therefore, based on these correlations, we can say that for the intervention group, there is a moderate correlation between PBF and the time spent in a sedentary / physically active way compared to the correlation between PBF and stimulus exposure (quantity and types of food consumed).

At the end of the study, although we noticed that for the "stimulus exposure" scale there was an improvement, the association between BFP and this scale remained unchanged ($r = 0.34$, $p=0.221$). Instead, by increasing the number of physically active hours, due to the participation in the 3 volleyball trainings per week, we noticed a substantial increase in the connection between BFP and the level of physical activity ($r = 0.90$,

p=<0.001) (Figure 3). Thus, we can assume that the progress made in the intervention group is largely due to the increase in the level of physical activity.

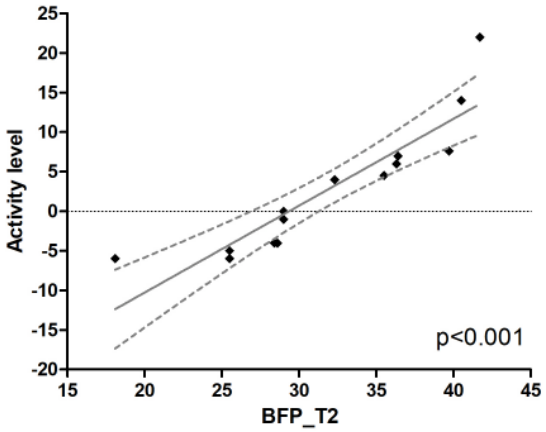

Fig. 3 Relationship Between Physical Activity Level and Body Fat Percent

Other authors who have studied the effects of certain training programs on body composition and fitness reinforce this statement.

In a study conducted in a summer camp over a period of 4 weeks, with a physical activity of 5 hours per day (5 days per week), the studied subjects obtained significant results in improving their body composition and fitness. In 2009, a study published by McGuigan et al. showed a 2.6% decrease in BFP and an improvement in strength and power after an 8-week resistance-training program, without any interventions on the nutrition habits. The study by López-Sánchez et al. (2017), over a period of 12 weeks, showed significant improvements on the body composition of the subjects (10 to 11 years old, girls and boys) after participating in 3 training sessions per week (15 minutes / intense physical activity), throughout the study.

Improved results for the intervention group can also be found in the study of Seo et al. (2019), where after 16 weeks of having applied a complex program of medical advice, nutrition and physical training, the experimental group obtained a lower percentage of body fat with superior results on the muscle strength.

Another intervention program based on nutrition, physical activity and psychological support, carried out over a period of 10 months, brought improvement on body composition in the fight against severe obesity in children and adolescents (Deforche, et al., 2003).

It is known that an overweight or obese status often leads to a decrease in fitness and the number of hours spent in various activities. In order to overcome this sedentary behavior and improve not only fitness level, but also the general health altogether in children, lifestyle changes must be adopted. This is also demonstrated by the study of Bovet et al. (2007) highlighting the strong correlation between BMI and physical activity level.

As shown by the studies presented above, significant results can be obtained both through intervention programs carried out over a shorter period, but with the addition of dietary changes, and on longer programs in which there was only an increase in the level of physical activity, as seen in our study. However, a much more attention should be given to intervention programs lasting more than 6 months. A longer application period does not guarantee a significant difference between the results of a 6-month program and a 12-month program. Moreover, a long intervention program may be less accepted by participants (Makkes, et al., 2016).

Conclusions

Our study shows that by participating in 3 volleyball workouts per week, for 6 months, significant results can be obtained in preventing weight gain and improving body composition and fitness in overweight and obese children, without a substantial dietary interventions.

While at the beginning of the study, the intervention group was classified as obese, according to BMI percentiles, at the end of the study, the subjects in this group significantly improved their body composition parameters, with a Body Fat Percentage below the initial value, an increase in Skeletal Muscle Percentageand thus a BMI that ranked them below the middle percentile of the overweight category.

The results of the physical tests at the end of the intervention program showed a significant improvement for the body balance tests, running speed - agility, speed of limb movement, trunk strength, explosive power of legs. Although the final BMI decreased in most subjects, thus leading to a new weight category clasification for the intervention group, it is possible that in reality the benefits of the intervention program to be even higher. The results obtained by the intervention group indicated a decrease in BFP but also an increase in muscle mass, which led to a quite constant body weight.

In this situation, we believe that BMI and BMI percentiles may not be a reliable parameter for diagnosing and assessing childhood obesity. Therefore, we believe that further studies are needed to identify more accurate criteria, based on BFP, in diagnosing childhood obesity.

References:

Abarca-Gómez, L., Abdeen, Z. A., Hamid, Z. A., Abu-Rmeileh, N. M., Acosta-Cazares, B., Acuin, C., & al, e. (2017). 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. *The lancet, 390*(10113), 2627-2642.

Bielik, V., Hamar, D., Penesová, A., Babjaková, J., Antala, B., Labudová, J., & Kovács, L. (2017). Odporúčania pre pohybovú aktivitu detí a mládeže na Slovensku (6–18 rokov) (Recommendations for the movement of children and youth in Slovakia (6 – 18 years). *Česko-Slovenská Pediatrie, 72*(6), 377-381.

Bovet, P., Auguste, R., & Burdette, H. (2007). Strong inverse association between physical fitness and overweight in adolescents: a large school-based survey. *Bovet, P., Auguste, R., & Burdette, H. (2007). Strong inverse association between physicInternational Journal of Behavioral Nutrition and Physical Activity, 4*(1), 1-8.

Centers for Disease Control and Prevention. (2022, 1 5). *BMI Percentile Calculator for Child and Teen*. Retrieved from https://www.cdc.gov/healthyweight/bmi/calculator.html

Chirita-Emandi, A., Barbu, C. G., Cinteza, E. E., Chesaru, B. I., Gafencu, M., Mocanu, V., & ... Puiu, M. (2016). Overweight and underweight prevalence trends in children from Romania-pooled analysis of cross-sectional studies between 2006 and 2015. *Obesity facts, 9*(3), 206-220.

De La O, A., Jordan, K. C., Ortiz, K., Moyer-Mileur, L. J., Stoddard, G., Friedrichs, M., & Mihalopoulos, N. L. (2009). Do parents accurately perceive their child's weight status? *Journal of Pediatric Health Care, 23*(4), 216-221.

Deforche, B., De Bourdeaudhuij, I., Debode, P., Vinaimont, F., Hills, A. P., Verstraete, S., & Bouckaert, J. (2003). Changes in fat mass, fat-free mass and aerobic fitness in severely obese children and adolescents following a residential treatment programme. *European journal of pediatrics, 162(9), 616-622, 162*(9), 616-622.

Eurofit, C. O. (1993). *Handbook for the Eurofit test on physical fitness.* Strasbourg: Council of Europe.

Gadde, K. M., Martin, C. K., Berthoud, H. R., & Heymsfield, S. B. (2018). Obesity: pathophysiology and management. *Journal of the American College of Cardiology, 71*(1), 69-84.

Golan, M., & Weizman, A. (1998). Reliability and validity of the family eating and activity habits questionnaire. *European Journal of Clinical Nutrition, 52*(10), 771-777.

Jiménez-Pavón, D. A., Kelly, J., & Reilly, J. J. (2010). Associations between objectively measured habitual physical activity and adiposity in children and adolescents: Systematic review. *International Journal of Pediatric Obesity, 5*(1), 3-18.

Jurat, V., Potop, L., Timnea, O. C., & Potop, V. (2018). Physiological features of obesity in children and adolescents. *Journal of Physical Education and Sport, 18*(5), 2199-2206. doi:DOI:10.7752/jpes.2018.s5332

Kumar, S., & Kelly, A. S. (2017). Review of childhood obesity: from epidemiology, etiology, and comorbidities to clinical assessment and treatment. *Mayo Clinic Proceedings, 92*(2), 251-265.

López-Sánchez, G. F., Díaz-Suárez, A., Radzimiński, Ł., & Jastrzębski, Z. (2017). Effects of a 12-week-long program of vigorous-intensity physical activity on the body composition of 10-and 11-year-old children. *Journal of Human Sport and Exercise, 12*(1), 236-245.

Makkes, S., Renders, C. M., Bosmans, J. E., van der Baan-Slootweg, O. H., Hoekstra, T., & Seidell, J. C. (2016). One-year effects of two intensive inpatient treatments for severely obese children and adolescents. *BMC pediatrics, 16*(1), 1-13.

McGuigan, M. R., Tatasciore, M., Newton, R. U., & Pettigrew, S. (2009). Eight weeks of resistance training can significantly alter body composition in children who are overweight or obese. *The Journal of Strength & Conditioning Research, 23*(1), 80-85.

Morano, M., Colella, D., Rutigliano, I., Fiore, P., Pettoello-Mantovani, M., & Campanozzi, A. (2012). Changes in actual and perceived physical abilities in clinically obese children: a 9-month multi-component intervention study. *PloS one, 7*(12).

Morano, M., Colella, D., Rutigliano, I., Fiore, P., Pettoello-Mantovani, M., & Campanozzi, A. (2014). A multi-modal training programme to improve physical activity, physical fitness and perceived physical ability in obese children. *Journal of sports sciences, 32*(4), 345-353.

Morano, M., Rago, A., & Raiola, G. (2019). Multimodal-lifestyle interventions for overweight and obese children: A summary of results. *Journal of Physical Education and Sport, 19*, 1933-1936. doi:DOI:10.7752/jpes.2019.s5287

Morano, M., Rutigliano, I., Rago, A., Pettoello-Mantovani, M., & Campanozzi, A. (2016). A multicomponent, school-initiated obesity intervention to promote healthy lifestyles in children. *Nutrition, 32*(10), 1075-1080.

Organization, W. H. (2010). *Global recommendations of phyisical activity for health.* Geneva.

Poitras, V. J., Gray, C. E., Borghese, M. M., Carson, V., Chaput, J. P., Janssen, I., & Tremblay, M. S. (2016). Systematic review of the relationships between objectively measured physical activity and health indicators in school-aged children and youth. *Applied Physiology, Nutrition, and Metabolism, 41*(6), S197-S239.

Poston II, W. S., & Foreyt, J. P. (1999). Obesity is an environmental issue. *Atherosclerosis, 146*(2), 201-209.

Seo, Y. G., Lim, H., Kim, Y., Ju, Y. S., Lee, H. J., Jang, H. B., & Park, K. H. (2019). The effect of a multidisciplinary lifestyle intervention on obesity status, body composition, physical fitness, and cardiometabolic risk markers in children and adolescents with obesity. *Nutrients, 11(1), 137., 11*(1), 137.

Strava, C. C. (2017). Overweight between perception and reality. *Timisoara Physical Education & Rehabilitation Journal, 10*(19).

The National Institute of Public Health (ROMANIA). (2020). *Assessment of the nutrition status of primary school children according to the WHO methodology by participating in the European Childhood Obesity Surveillance Initiative (COSI) project.* Retrieved from https://insp.gov.ro/download/cnepss/stare-de-sanatate/rapoarte_si_studii_despre_starea_de_sanatate/sanatatea_copiilor/rapoarte-nationale/COSI-2019-raport-final.pdf

Verloigne, M., Van Lippevelde, W., Maes, L., Yıldırım, M., Chinapaw, M., Manios, Y., & & De Bourdeaudhuij, I. (2012). Levels of physical activity and sedentary time among 10-to 12-year-old boys and girls across 5 European countries using accelerometers: an observational study within the ENERGY-project. *International journal of behavioral nutrition and physical activity, 9*(1), 1-8.

Wittmeier, K. D., Mollard, R. C., & Kriellaars, D. J. (2008). Physical activity intensity and risk of overweight and adiposity in children. *Obesity, 16*(2), 415-420.