South African Journal for Research in Sport, Physical Education and Recreation, 2022, 44(1): 69 - 81.
ISBN: 0379-9069

WHICH TYPE OF PHYSICAL ACTIVITY SHOULD BE RECOMMENDED IN CHILDHOOD OBESITY CONSIDERING VERTEBRAL CURVES AND MOTOR SKILLS? EXERCISE OR SPORTS?

Zehra Güçhan TOPCU[1] and Özlem ÜLGER[2]
[1] *Department of Physiotherapy and Rehabilitation, Faculty of Health Sciences, Eastern Mediterranean University, Famagusta, Cyprus*
[2] *Department of Physiotherapy and Rehabilitation, Faculty of Health Sciences, Hacettepe University, Ankara, Turkey*

ABSTRACT

This paper aims to compare the effects of functional exercises and basketball training on forward head posture, lumbar hyperlordosis, and motor skills of 45 obese children aged 10 years with forward head posture and hyperlordosis. The children were randomly included to the functional exercise, basketball and control groups for 12 weeks. The angles of lumbar lordosis and craniovertebral were recorded as biomechanical variables. Bruininks-Oseretsky Test of Motor Proficiency - Brief Form (BOTMP-BF) was used to determine motor skills of the children. Forty-two children completed the study. All groups had similar angles for lumbar lordosis after 12 weeks (p>0.05), whereas craniovertebral angle significantly decreased in the control group only (p<0.05). Both functional exercise and basketball were effective in improving speed and agility. There was a statistically significant increase in the total BOTMP-BF score of the functional exercise group (p<0.001). Both types of physical activity may be a way of managing the progression of forward head posture, whereas they did not affect lumbar posture. Functional exercises and basketball affected different aspects of motor skills.

Keywords: Childhood obesity; Basketball; Exercise.

INTRODUCTION

Obesity is one of the most important health problems in both developing and developed countries (Jiménez-Ormeño *et al*., 2013). Prevalence of obesity, particularly in children and adolescents, has gradually increased in recent years (Skinner *et al*., 2018). A term called "Exercise-Deficit Disorder" is identified to emphasise the importance of an active lifestyle (Stracciolini *et al*., 2013). Although it is well demonstrated that increasing the level of physical activity supports weight loss and decreases cardiovascular risk in the presence of obesity (Byun *et al*., 2012; Hansen *et al*., 2013), there is no clear evidence about the effects of any kind of physical activity on the postural problems and motor skills of obese children

Inadequate physical activity and excess weight of overweight/obese children result in postural deformities like cervical/lumbar hyperlordosis and pes planovalgus, as well as musculoskeletal pain in this population (Pomerantz *et al*., 2010; Kuni *et al*., 2015). Excess weight causes repositioning of musculoskeletal structures and postural alterations in order to support and carry heavier body mass (Molina-Garcia, Plaza-Florido *et al*., 2020). These postural changes with inadequate biomechanical array results in musculoskeletal pain in obese children more frequently than non-obese children (Silva *et al*., 2011; Molina-Garcia, Plaza-Florido *et al*., 2020). When spinal curves of obese children were investigated, it was stated that biomechanics of their spine swayed from normal (De Sá Pinto *et al*., 2006; Silva *et al*., 2011).

Moreover, obese children have lower level of physical activity and weaker motor skills according to their peers (Vameghi *et al*., 2013; Ahn *et al*., 2019). According to the spiral disengagement model, there is a vicious cycle between physical activity and motor skills. When children's physical activity level is low, their motor skills do not develop adequately so they feel unsuccessful in different types of physical activities, so the skilfulness in sports they perceive to be low, so their motivation for physical activity decreases. These children are probably overweight/obese according to this model (Goodway *et al*., 2014).

When the roles of physiotherapists in the management of childhood obesity are investigated, they treat pain developing from musculoskeletal system problems of obese children and plan exercise programmes to prevent their postural problems, as well as improve their motor skills (You *et al*., 2012). Physiotherapists use the International Classification of Functioning, Disability and Health (ICF) model and have focused on biomechanical variables of many populations as the parameters of 'body structure and functions' component while making goals about activity and the participation components of the ICF (Logerstedt *et al*., 2010).

Furthermore, sports is a good choice to increase physical activity in this population and popularly recommended by health professionals as a method of managing obesity (Nelson *et al*., 2011; Conroy *et al*., 2021). However, as is the same as exercise, no study has investigated the effects of a sport code on their posture (Conroy *et al*., 2021). Although sport is very beneficial for health, some adverse effects may be seen on posture (Witvrouw *et al*., 2009; Muyor *et al*., 2011; Elsayed 2014). For example, cyclists have higher thoracic kyphosis (Muyor *et al*., 2011) and children who play soccer have genu varum (Witvrouw *et al*., 2009). In this way, effects of sport codes should be investigated among the individuals who have a health issue.

The role of exercises and sport programmes on the management of the problems arising from childhood obesity should be determined. Although the effects of exercise and various sport codes were shown on the management of obesity and obesity related motor problems separately, group exercises managed by physiotherapists and team sports on postural deformities and motor skills of obese children are not clear. This study aimed to investigate and compare the effects of group exercise and a basketball programme on the angles of the cervical and lumbar regions and motor skills of obese children.

METHODOLOGY

Study design

This study was a randomised controlled prospective design.

Sample

According to the power analysis which was performed using G*Power.software (3.1.), the prevalence of childhood obesity was taken based on a previous study (Skelton *et al*., 2009) as $p=0.18$ ($0.13 \leq p \leq 0.23$). The sample of 42 (at least 13 children in each group) was found with a Power=0.99 and d=0.83.

The inclusion criteria were as follows: (1) children who were 10 years old; (2) children whose BMI values were ≥95 Percentiles; (3) children who were reported as obese by a physician; (4) a report which was given by a doctor to state that the child could participate in aerobic exercise; (5) children who had a score ranging from 1 to 3 for neck and lumbar regions according to New York Posture Rating Chart; (6) children who had not continued to a diet programme for three months; and (7) children who had not participated regularly in any sport or exercise for six months. The children who had any disease requiring use of medicine, had any pain which could prevent them from doing exercise or sport, and had any neuromuscular disease were excluded from the study. Among a total of 465 children, 45 children were included in the study. The flowchart is presented in Figure 1.

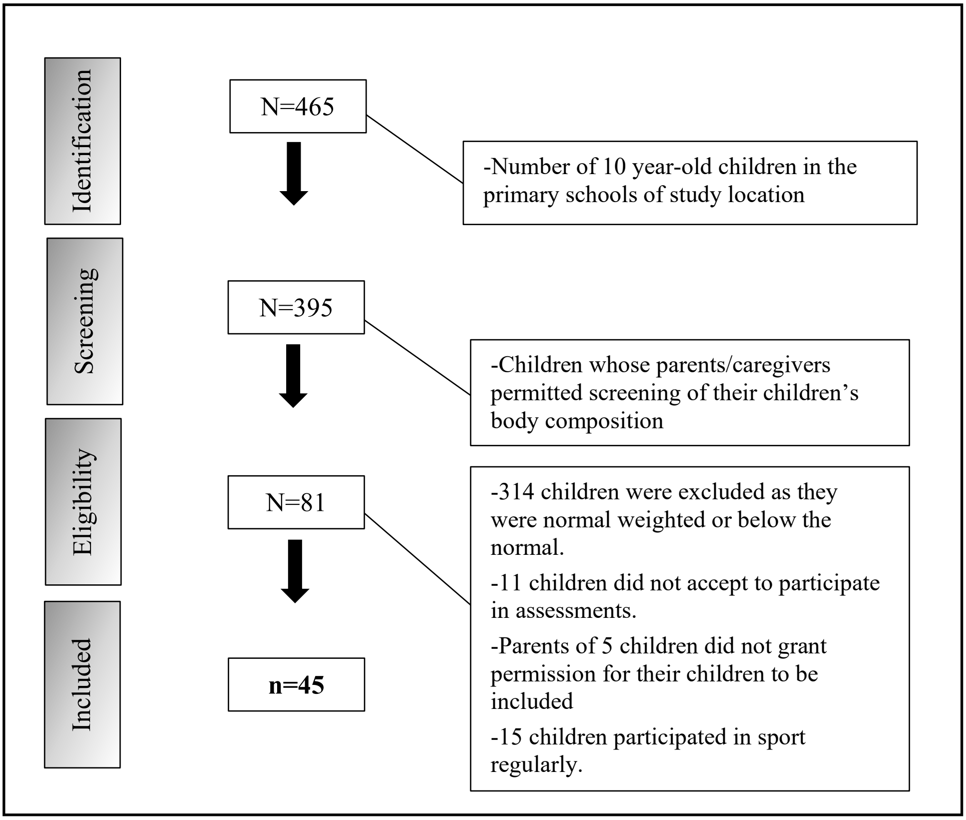

Figure 1. **FLOWCHART OF CHILDREN'S PARTICIPATION**

Informed consent approved by the Hacettepe University Ethical Committee (registration number GO 16/53) was obtained from the parents of the children. A random number generator was used for randomisation. Only one child, after randomisation, was moved to the control group due to a transportation problem. Following the first assessments, children were assigned to the functional exercise group (FEG=14), basketball group (BG=15), and control group (CG=16).

The children who were in the intervention groups were asked to participate in their physical activity programmes for 60 minutes, three times a week. "Participation Certificates" were presented to the children on random days and medals were awarded to the children at the end of 12 weeks in order to motivate and encourage regular participation. Only three children could not take medals so participation rates in the intervention groups were high. Nevertheless, extra sessions were arranged for these three children who missed their days so all of the 26 children completed three times a week participation at the end of 12-week programmes.

During the 12-week intervention, one child from the functional exercise group and two children from the basketball group left the programmes because of their intensive school programme. Therefore, 13 children in each study group completed the intervention while 16 children remained in the control group. At the end of 12 weeks, 42 children were reassessed.

Assessments

Gender, height and weight of the children were recorded. The children were then assessed as follows:

- *Lumbar lordosis*: 50cm flexi-ruler was used. This method was reliable and valid for the lumbar region (De Oliveira *et al*., 2012). The spinosus process of the L1 and S2 vertebras were the reference points for lumbar region. The angles were then calculated (De Oliveira *et al*., 2012).
- *Forward head posture*: Craniovertebral angle was measured to determine the head posture (Singla & Veqar, 2015). High intrarater reliability was shown for this assessment (Kerry, 2003). The children were asked to stand vertical and a photograph was taken from their right side. Adhesive reflective photo markers were placed on the landmarks, which were tragus and the processus spinosus of C7. The angle between the line through these landmarks and horizontal line was then recorded as craniovertebral angle (Singla & Veqar, 2015). A smaller angle shows more forward head posture (Kerry, 2003; Singla & Veqar, 2015).
- Bruininks-Oseretsky Test of Motor Proficiency-Brief Form (BOTMP-BF) was used to determine the motor skills of the children (Bruininks, 2010). Its reliability and validity were have been reported (Bruininks, 2010). Bilateral coordination, balance, strength and speed-agility were measured to specify gross motor skills, while fine motor precision, fine motor integration, manual dexterity and upper limb coordination were measured for fine motor skills. Total BOTMP-BF score shows “very good” as ≥70, “above average” as 60-69, “average” as 41-59, “below average” as 31-40 and “very poor” as ≤40 (Bruininks, 2010).

Interventions

FEG: Functional Exercise Group accompanied by physiotherapist

Functional exercises planned and conducted by physiotherapist were used to address the postural problems and support motor skills of the children. The children were included in the Cardiopulmonary Laboratory of Eastern Mediterranean University. Elastic bands and exercise mats were used as equipment for the exercises. The colours of the bands were changed according to the child’s strength ranging as yellow, red and green. Repetition numbers of new taught exercises were 8-10 and increased to 12-15 in further sessions. Exercises were conducted accompanied by music provided by the first author. Exercises were introduced with a movement of an animal or any daily movement to generate a code for facilitating the children’s learning so they imagined the movements and learnt the exercises more easily. Table 1 presents an outline of the group exercises for a session.

Table 1. **SESSION OUTLINE OF FUNCTIONAL EXERCISE GROUP**

Aim	Duration	Music	Exercise examples
Warming	15 min	100-120 bpm	Jogging Mobilisation of all body joints
Strengthening-balance-agility exercises	35 min	80 bpm	Sit-ups to strengthen abdominal muscles Strengthening of neck muscles (especially neck flexors such as chin tuck exercises) Elastic band exercises for shoulder and hip muscles Use of body weight to strengthen quadriceps femoris muscle Balance exercises such as Single leg / Tandem standing Agility exercises which include sudden position or location changes while doing a movement
Cooling	10 min	60 bpm	Stretching lumbar extensors Stretching neck extensors Breathing exercises

BG: Basketball Group

Basketball education was presented to the children by a specialist trainer. The basketball trainer created his own programme independently. He stated that he also benefited from a programme found in the literature related to obese children (Elsayed, 2014). The schedule is shown in Table 2. The children in this group were allowed in the MAGEM Stadium of Gazimağusa Municipality. Ten minutes running and stretching were conducted for both warming and cooling at the start and end of every session.

Table 2. **SCHEDULE FOR BASKETBALL GROUP**

Week	Activities
1	Pass Exercises, Dribble exercises, Defence, Game
2	Pass Exercises, Dribble exercises, Defence, Stopping exercises, Shot exercises
3	Pass Exercises, Dribble exercises, Defence, Stopping exercises, Shot exercises, Game
4	Pass Exercises, Dribble exercises, Defence, Stopping exercises, Shot exercises, Game
5	Pass Exercises, Dribble exercises, Defence, Stopping exercises, Shot exercises, Game
6	Pass Exercises, Dribble exercises, Weave, Shot exercises, Game
7	Pass Exercises, Dribble exercises, Drill, Shot exercises, Game
8	Pass Exercises, Dribble exercises, Shot exercises, Game
9-12	Dribble exercises, Fast Break, Attack exercises, Game

CG: Control Group

Sixteen obese children who did not participate in any physical activity during the 12 weeks were included in the control group and assessed before and after 12 weeks.

Statistical analysis

SPSS 19 statistical software package (IBM SPSS Statistics 19, SPSS Inc., an IBM Co., Somers, NY) was used for statistical analysis. Difference at $p<0.05$ level was considered to be statistically significant. Mean±Standard Deviation (X±SD) was used to indicate the continuous variables acquired by the measurements. Chi-square test was used to compare the qualitative findings. For the normally distributed data, the One Way Analysis of Variance was used to compare the variables among groups. The dependent t test was also applied to compare the results within the groups over time. When there was not a normal distribution in the group Kruskal Wallis Variance Analysis was conducted and groups were then compared using the Mann Whitney Y-test.

RESULTS

Out of the 45 participants, 25 were girls and 20 boys. The gender distribution within the groups (FEG: 11 girls, 3 boys; BG: 4 girls, 11 boys; CG: 10 girls, 6 boys) was not homogenous ($p=0.013$). The results of the BMI values demonstrated that all groups were similar ($p>0.05$). The BMI value of the FEG was 25. 83±2.76 kg/m^2, the BG was 25.05±2.77 kg/m^2, and the CG was 25.12±2.79 kg/m^2. There was no significant differences in biomechanical variables among groups before 12-week study period ($p>0.05$). The children had an average BOTMP-BF score with 48.31 in the beginning. Except fine motor integration, motor skills of all groups were similar in the beginning ($p>0.05$). Fine motor integration was significantly better in the FEG than the CG ($p<0.05$), while the starting values of this skill were similar in the FEG and BG.

The changes of biomechanical variables within the groups after 12 weeks indicates no significant improvement in both intervention groups, whereas craniovertebral angle of the CG decreased significantly ($p<0.05$) (Table 3). However, the changes of motor skills of the FEG show significant improvements in fine motor precision ($p<0.05$), manual dexterity ($p<0.05$), speed and agility ($p<0.001$), strength ($p<0.001$), and total BOTMP-BF score ($p<0.001$). Fine motor integration and upper limb coordination did not change in the FEG ($p>0.05$), while they significantly improved in the BG ($p<0.05$). There was no significant change in the motor skills of the CG during 12 weeks ($p>0.05$) (Table 4). The results among the groups after 12-week intervention is presented in Table 5.

Table 3. **CHANGES IN BIOMECHANICAL VARIABLE AVERAGES WITHIN FEG, BG, CG DURING 12 WEEKS**

Group and variable	Before	After	t	p
Functional Exercise (n=13)				
Lumbar lordosis angle (°)	59.30±11.93	59.41±13.74	0.054	0.957
Craniovertebral angle (°)	46.62±4.57	46.85±4.38	0.314	0.759
Basketball (n=13)				
Lumbar lordosis angle (°)	62.11±11.15	63.89±11.68	0.563	0.584
Craniovertebral angle (°)	48.62±5.85	46.23±4.13	1.431	0.178
Control (n=16)				
Lumbar lordosis angle (°)	58.07±9.24	60.71±10.62	1.077	0.299
Craniovertebral angle (°)	47.06±3.75	44.69±4.14	2.132	**0.049***

FEG=Functional Exercise Group BG=Basketball Group CG=Control Group $p<0.05$ significant

Table 4. **CHANGES IN MOTOR SKILL AVERAGES WITHIN FEG, BG, AND CG DURING 12 WEEKS**

Motor skill variables	**Before**	**After**	**t**	**p**
***Functional exercise* (n=13)**				
Fine motor precision	8.54±1.45	9.15±1.07	3.411	**0.005***
Fine motor integration	9.38±0.87	9.62±1.12	1.000	0.337
Manual dexterity	5.46±0.97	6.31±1.03	4.430	**0.001***
Upper limb co-ordination	11.46±1.2	11.62±0.65	0.457	0.656
Bilateral co-ordination	6.85±0.55	6.92±0.28	1.000	0.337
Balance	3.85±0.55	4.00±0	1.000	0.337
Speed and agility	2.54±1.05	4.85±1.34	9.733	**<0.001***
Strength	1.31±0.95	3.00±1.00	9.679	**<0.001***
BOTMP-BF Total	49.38±3.01	55.46±3.6	14.628	**<0.001***
***Basketball* (n=13)**				
Fine motor precision	8.08±1.04	8.62±1.39	1.203	0.252
Fine motor integration	9.00±1.08	9.92±0.86	3.207	**0.008***
Manual dexterity	5.62±0.96	5.85±0.90	1.000	0.937
Upper limb co-ordination	11.23±1.24	11.85±0.55	3.886	**0.002***
Bilateral co-ordination	6.62±1.39	6.85±0.55	1.000	0.337
Balance	3.75±0.68	3.75±0.68	1.535	0.151
Speed and agility	2.46±0.78	3.15±0.9	2.635	**0.022***
Strength	1.24±1.24	1.38±1.33	0.805	0.436
BOTMP-BF Total	48.23±3.49	51.08±2.9	0.655	0.525
***Control group* (n=16)**				
Fine motor precision	8.44±1.41	8.31±1.62	0.460	0.652
Fine motor integration	8.19±1.6	8.13±1.54	0.235	0.817
Manual dexterity	5.63±1.26	5.75±1.06	0.565	0.580
Upper limb co-ordination	11±1.67	10.63±1.5	0.312	0.759
Bilateral co-ordination	6.69±0.6	6.88±0.5	1.861	0.083
Balance	3.75±0.68	3.75±0.68	1.065	0.304
Speed and agility	2.44±1.09	2.44±1.03	0.000	1.000
Strength	1.19±0.25	1.25±1.24	0.324	0.751
BOTMP-BF Total	47.31±5.59	47.13±6.08	0.663	0.517

FEG=Functional Exercise Group BG=Basketball Group CG=Control Group $p<0.05$ significant

Table 5. **COMPARISON OF BIOMECHANICAL VARIABLES AND MOTOR SKILLS OF AFTER 12 WEEKS AMONG GROUPS**

Variables	**FEG** (n=13) M±SD	**BG** (n=13) M±SD	**CG** (n=16) M±SD	F	p
Lumbar lordosis angle (°)	59.41±13.74	63.89±11.68	60.71±10.62	0.485	0.619
Craniovertebral angle (°)	46.85±4.38	46.23±4.13	44.69±4.14	1.026	0.368
Fine motor precision	9.15±1.07	8.62±1.39	8.31±1.62	1.312	0.281
Fine motor integration	9.62±1.12 [(a)]	9.92±0.86 [(a)]	8.13±1.54[(b)]	8.940	**0.001***
Manual dexterity	6.31±1.03	5.85±0.90	5.75±1.06	1.207	0.310
Upper limb co-ordination	11.62±0.65 [(a)]	11.85±0.55 [(a)]	10.63±1.5 [(b)]	5.713	**0.007***
Bilateral co-ordination	6.92±0.28	6.85±0.55	6.88±0.5	0.092	0.912
Balance	4.00±0	4.00±0	3.75±0.68	1.724	0.192
Speed and agility	4.85±1.00[(a)]	3.15±0.9[(a)]	2.44±1.03[(b)]	19.866	**<0.001***
Strength	3.00±1.00[(a)]	1.38±1.33[(b)]	1.25±1.24[(b)]	8.956	**<0.001***
BOTMP-BF Total	55.46±3.60[(a)]	51.08±2.9 [(b)]	47.13±6.08 [(b)]	12.012	**<0.001***

FEG=Functional Exercise Group BG=Basketball Group CG=Control Group p<0.05 significant

DISCUSSION

The parents of overweight and obese children were asked to improve strategies in order to make their children more physically active, but information on the most appropriate physical activity was presented to them was inadequate. We tried to present some results about more effective type of physical activity on biomechanical variables of columna vertebralis and motor problems among obese children. Although both intervention groups were not effective in decreasing hyperlordosis, both of them improved different aspects of motor skills when compared to the control group. However, forward head posture worsened in the control group.

Obese children are included in exercise to decrease body mass index according to many papers reviewed in literature (Kelley *et al*., 2015), whereas very few authors have recently focussed on the biomechanical problems of this population (Batistão *et al*., 2014; Molina-Garcia, Mora-Gonzalez *et al*., 2020; Molina-Garcia, Plaza-Florido *et al*., 2020, Spech *et al*., 2022). The number of obese children increase every day, especially after the Covid pandemic, so it is important to develop more solutions to manage with this health issue. These children have problems to continue a type of physical activity as they feel themselves inadequate in both appearance and physical fitness so the low levels of physical activity results in more obesity (Spech *et al*., 2022; Bray *et al*., 2018).

The obese population is usually motivated to participate in aerobic exercises to break this vicious cycle between obesity and physical activity rather than sport branches or group exercises for more recreation (Rey *et al*., 2018). Furthermore, many papers reviewed in the study by Spech *et al*. (2022) showed that not only deformities but kinetic and kinematic variables of obese adolescents are also different during the movements like running and jumping, which are important skills in many sport codes from the healthy population. Thus, this population should be taken into account differently from their peers who have healthy weight. From this perspective in this paper, obese children were grouped for their recreational motivation and included in physical activities.

The reason for lumbar hyperlordosis commonly seen in obesity was explained, as obese children improved these postural sways in order to provide normal function and appearance (Batistão *et al*., 2014; Molina-Garcia, Mora-Gonzalez *et al*., 2020). There was no effect and change on this angle in either of the intervention groups. There have been studies reporting positive effects of individual or group exercises accompanied by a physiotherapist on lumbar hyperlordosis of adults (Angin & Erden, 2008; Cho *et al*., 2015). However, the results of the adults compared with children are not appropriate as children are still in a growth and maturing stage. Similarly, Kilinç *et al*. (2009) indicated that the angle of lumbar lordosis of children did not change after playing basketball for 10 weeks. Currently there is a lingering debate as to whether this deformity should be prevented/decreased without considering weight loss. Further studies are required to investigate the effects of exercise or different physical activities on the lumbar curve.

Craniovertebral angle was similar before and after 12 weeks in the intervention groups, FEG and BG. Similarly, a recent paper by Molina-Garcia, Mora-Gonzalez, *et al*. (2020) used a different exercise approach in overweight/obese children and measured two variables for forward head posture, craniocervical angle and plumb-tragus distance. They showed that craniocervical angle did not change, whereas plumb-tragus angle decreased with low effect. Singla and Veqar (2015) compared this angle between college students who play and do not play basketball and found no difference, however, they included children with normal weight.

Although there was no improvement in the intervention groups, the present study showed a different finding to that of the study by Molina-Garcia, Mora-Gonzalez *et al*. (2020) where the angle decreased significantly in the CG. The children with forward head posture were included in this study, whereas Molina-Garcia, Mora-Gonzalez *et al*. (2020) included their participants without assessing their deformities. This change in the control group can be explained as the exercise and playing basketball may prevent deterioration of this deformity in this population. Moreover, the negative progression of forward head posture indicates that childhood obesity should not be considered as a condition with only an excess body mass index.

The results of motor skills of both FEG and BG had a significant increase in total BOTMP-BF score. The level of motor skills of the children included in our study was still "average" in all groups. Both FEG and BG were effective in speed-agility dimension, whereas other dimensions were differently affected by these two different kinds of physical activity. Since Molina-Garcia, Plaza-Florido *et al*. (2020) presented an association between the sways of columna vertebralis and physical fitness parameters in obese/overweight children, it might be that better physical fitness parameters may result in healthier sways of spine. Nevertheless, our results showed improvements in motor skills as the parameters of physical fitness, whereas the angles of columna vertebralis did not change so further research is needed to determine this association as it reflects in clinical practice.

No obesity-centred content has been planned in the physiotherapy discipline or any sports branches presented in this paediatric population (Byun et al., 2012). Thus, the current study has taken a leading initiative to reveal variables to be considered in this area. Nevertheless, there are several limitations of the current investigation. Firstly, sample size was calculated with a large effect size due to the small population of Cyprus and limited transportation services to the research centre. Secondly, gender was not homogenous among the groups so the difference for gender could affect the results in the improvements of the outcome measures. Lastly, the measurement method of balance under the BOTMP-BF was inappropriate for this population as it was easy for these children. Thus, the scores were all high, but the children in the functional exercise group had challenges in the exercises while standing on one leg. Thus, a different method could be selected to show the changes in balance in all groups.

CLINICAL IMPLICATIONS

Both doing functional exercises and playing basketball were not found to be beneficial for the excessive angles in the vertebral curves. However, the findings showed that these activities are probably important to prevent more increase in these angles and protect the condition of the deformities. Motor skills of obese children were improved by both activities so weak motor skills of this population should be supported by a physical activity, but it is essential to determine which skill needs support and which activity will be more beneficial for this weakness. Since this population has differences from their peers with healthy weight, their needs should be investigated in more detail, especially while their numbers are increasing and they avoided physical activities due to the pandemic and its quarantine conditions.

CONCLUSION

Functional exercises and basketball may be beneficial to prevent progression of postural problems, but more research is required to achieve a better improvement in biomechanical variables. Particularly, the results in motor skills showed that either type of physical activity improved the motor skills of these children. A combination of basketball and functional exercises could reveal a better improvement. Therefore, physiotherapists should be more cognisant of these variables when designing studies involving this population by choosing an appropriate sports code. Integrating functional exercises with these sports codes is strongly recommended.

Conflict of interest

The authors reported no conflict of interest.

REFERENCES

AHN, S.; ZHANG, H.; BERLIN, K. S.; LEVY, M. & KABRA, R. (2020). Adverse childhood experiences and childhood obesity: A path analysis approach. *Children's Health Care*, 49(3): 247-266. [doi.org/10.1080/02739615.2019.1697928].

ANGIN, E. & ERDEN, Z. (2008). The effect of group exercise on postmenopausal osteoporosis and osteopenia. *Acta Orthopaedica et Traumatologica Turcica* (trans.: *Turkish Orthopedic and Traumatologica Journal*), 43(4): 343-350. [doi.org/10.3944/AOTT.2009.343].

BATISTÃO, M.V.; CARNAZ, L.; BARBOSA, L.F.; MOTTA, G.C.D. & SATO, T.D.O. (2014). Posture and musculoskeletal pain in eutrophic, overweighed, and obese students. A cross-sectional study. *Motriz: Revista de Educação Física* (trans.: *Motive: Physical Education Journal)*. 20(2): 192-199. [doi.org/10.1590/S1980-65742014000200009].

BRAY, I.; SLATER, A.; LEWIS-SMITH, H.; BIRD, E. & SABEY, A. (2018). Promoting positive body image and tackling overweight/obesity in children and adolescents: A combined health psychology and public health approach. *Preventive Medicine*, 116(November): 219-221. [doi.org/10.1016/j.ypmed.2018.08.011].

BRUININKS, R.H. (2010). *Bruininks-Oseretsky test of motor proficiency*. Brief form, 2nd edition. Bloomington MN: PsychCorp.

BYUN, J.G.; CHO, H.C.; LEE, P.Y. & KIM, S.Y. (2012). Effects of group exercise program on neuroplacidity and metabolic risk factors in obesity children. *International Journal Human Movement Science,* 6(2): 153-165.

CONFROY, K.; MİLES, C.; KAPLAN, S. & SKELTON, J.A. (2021). Pediatric obesity and sports medicine: A narrative review and clinical recommendations. *Clinical Journal of Sport Medicine*, 31(6): e484-e498. [doi: 10.1097/JSM.0000000000000839].

CHO, I.; JEON, C.; LEE, S.; LEE, D. & HWANGBO, G. (2015). Effects of lumbar stabilization exercise on functional disability and lumbar lordosis angle in patients with chronic low back pain. *Journal of Physical Therapy Science*, 27(6): 1983-1985. [doi.org/10.1589/jpts.27.1983].

DE OLIVEIRA, T.S.; CANDOTTI, C.T.; LA TORRE, M.; PELINSON, P.P.T.; FURLANETTO, T.S.; KUTCHAK, F.M. & LOSS, J.F. (2012). Validity and reproducibility of the measurements obtained using the flexicurve instrument to evaluate the angles of thoracic and lumbar curvatures of the spine in the sagittal plane. *Rehabilitation Research and Practice*, Online, 24 April 2012, Article ID 186156 (9 pages). [doi.org/10.1155/2012/186156].

DE SÁ PINTO, A.L.; DE BARROS HOLANDA, P.M.; RADU, A.S.; VILLARES, S.M.F. & LIMA, F.R. (2006). Musculoskeletal findings in obese children. *Journal of Paediatric Child Health*, 42(6): 341-344. [doi.org/10.1111/j.1440-1754.2006.00869.x].

ELSAYED, T.A. (2014). Eight weeks of basketball practice can significantly alter body composition and motor proficiency in primary school children who are overweight. *Journal of American Science,* 10(6): 212-220. [doi: 10.7537/marsjas100614.26].

GOODWAY, J.D.; FAMELIA, R. & BAKHTIAR, S. (2014). Future directions in physical education & sport: Developing fundamental motor competence in the early years is paramount to lifelong physical activity. *Asian Social Science*, 10(5), 44-54. [doi.org/10.5539/ass.v10n5p44].

HANSEN, P.R.; ANDERSEN, L.J.; REBELO, A.N.; BRITO, J.; HORNSTRUP, T.; SCHMIDT, J.F.; JACKMAN, S.R.; MOTA, J.; REGO, C.; OLIVEIRA, J.; SEABRA, A. & KRUSTRUP, P. (2013). Cardiovascular effects of 3 months of football training in overweight children examined by comprehensive echocardiography: A pilot study. *Journal of Sports Science*, 31(13), 1432-1440. [doi.org/10.1080/02640414.2013.792951].

JIMÉNEZ-ORMEÑO, E.; AGUADO, X.; DELGADO-ABELLÁN, L.; MECERREYES, L. & ALEGRE, L.M. (2013). Foot morphology in normal-weight, overweight, and obese schoolchildren. *European Journal of Pediatrics,* 172(5), 645-652. [doi.org/10.1007/s00431-013-1944-4].

KELLEY, G.A.; KELLEY, K.S. & PATE, R.R. (2015). Exercise and BMI in overweight and obese children and adolescents: A systematic review and trial sequential meta-analysis. *Biomedical Research International*, Online, 22 October 2015, Article ID 704539 (17 pages). [doi.org/10.1 155/2015/704539].

KERRY, C. (2003). Reliability of measuring natural head posture using the craniovertebral angle. *Irish Ergonomics Review*, 37-41.

KILINÇ, F.; YAMAN, H. & ATAY, E. (2009). Investigation of the effects of intensive one-sided and double-sided training drills on the postures of basketball playing children. *Journal of Physical Therapy Science,* 21(1): 23-28. [doi.org/10.1589/jpts.21.23].

KUNI, B.; RUHLING, N.E.; HEGAR, U.; ROTH, C. & SCHMITT, H. (2015). Ball games and nutrition counseling improve postural control in overweight children. *BMC Pediatrics,* 15(1), no. 205. [doi.org/10.1186/s12887-015-0523-4].

LOGERSTEDT, D.S., SNYDER-MACKLER, L.; RİTTER, R.C. & AXE, M.J. (2010). Knee pain and mobility impairments: meniscal and articular cartilage lesions: clinical practice guidelines linked to the international classification of functioning, disability, and health from the orthopaedic section of the American Physical Therapy Association. *Journal of Orthopaedic Sports Physical Therapy*, 40(6): A1-A35. [doi.org/10.2519/jospt.2010.0304].

MOLINA-GARCIA, P.; MORA-GONZALEZ, J.; MIGUELES, J.H.; RODRIGUEZ-AYLLON, M.; ESTEBAN-CORNEJO, I.; CADENAS-SANCHEZ, C.; PLAZA-FLORIDO, A.; GIL-COSANO, J.J.; PELAEZ-PEREZ, M.A.; GARCIA-DELGADO, G. & VANRENTERGHEM, J. (2020). Effects of exercise on body posture, functional movement, and physical fitness in children with overweight/obesity. *Journal of Strength and Conditioning Research*, 34(8): 2146-2155. [doi.org/ 10.1519/JSC.0000000000003655].

MOLINA-GARCIA, P.; PLAZA-FLORIDO, A.; MORA-GONZALEZ, J.; TORRES-LOPEZ, L.V.; VANRENTERGHEM, J. & ORTEGA, F.B. (2020). Role of physical fitness and functional movement in the body posture of children with overweight/obesity. *Gait & Posture*, 80(July): 331-338. [doi.org/10.1016/j.gaitpost.2020.04.001].

MUYOR, J.M.; LÓPEZ-MIÑARRO, P.A. & ALACID, F.A. (2011). Comparison of the thoracic spine in the sagittal plane between elite cyclists and non-athlete subjects. *Journal of Back Musculoskeletal Rehabilitation,* 24(3): 129-135. [doi.org/10.3233/BMR-2011-0286].

NELSON, T.F.; STOVİTZ, S.D.; THOMAS, M.; LAVOİ, N.M.; BAUER, K.W. & NEUMARK-SZTAİNER, D. (2011). Do youth sports prevent pediatric obesity? A systematic review and commentary. *Current Sports Medicine Reports*, 10(6): 360-370. [doi.org/10.1249/JSR.0b0 13e318237bf74].

POMERANTZ, W.J.; TIMM, N.L. & GITTELMAN, M.A. (2010). Injury patterns in obese versus nonobese children presenting to a pediatric emergency department. *Pediatrics*. 125(4): 681-685. [doi.org/10.1542/peds.2009-2367].

REY, O.; VALLIER, J.M.; NICOL, C.; MERCIER, C.S. & MAïANO, C. (2018). Repeated effects of vigorous interval training in basketball, running-biking, and boxing on the physical self-perceptions of obese adolescents. *Journal of Applied Sport Psychology*, 30(1): 64-82. [doi.org/10.1080/ 10413200.2017.1334159].

SILVA, L.R.D.; RODACKI, A.L.; BRANDALIZE, M.; LOPES, M.D.F.A.; BENTO, P.C.B. & LEITE, N. (2011). Postural changes in obese and non-obese children and adolescents. *Revista Brasileira de Cineantropometria & Desempenho Humano* (trans.: *Brazilian Journal of Kinanthropometry and Human Performance*), 13(6): 448-454. [doi.org/10.5007/1980-0037.2011v13n6p448].

SINGLA, D. & VEQAR, Z. (2015). Effect of playing basketball on the posture of cervical spine in healthy collegiate students. *International Journal of Biomedical and Advance Research,* 6(2): 133-136. [doi: 10.7439/ijbar.v6i2.1667].

SKELTON, J.A.; COOK, S.R.; AUINGER, P.; KLEIN, J.D. & BARLOW, S.E. (2009). Prevalence and trends of severe obesity among US children and adolescents. *Academy Pediatrics*, 9(5): 322-329. [doi: org/10.1016/j.acap.2009.04.005].

SKINNER, A.C.; RAVANBAKHT, S.N.; SKELTON, J.A.; PERRİN, E.M. & ARMSTRONG, S.C. (2018). Prevalence of obesity and severe obesity in US children, 1999–2016. *Pediatrics*, 141(3): Online, Article e20173459. [doi.org/10.1542/peds.2017-3459].

SPECH, C.; PAPONETTI, M.; MANSFIELD, C.; SCHMITT, L. & BRIGGS, M. (2022). Biomechanical variations in children who are overweight and obese during high-impact activities: A systematic review and meta-analysis. *Obesity Review*, 23(6): Article e13431. Online, 3 February. [doi: 10.1111/obr.13431].

STRACCIOLINI, A.; MYER, G.D. & FAIGENBAUM, A.D. (2013). Exercise-deficit disorder in children: are we ready to make this diagnosis? *Physical Sportsmedicine,* 41(1): 94-101. [doi: 10.3810/psm.2013.02.2003

VAMEGHI, R.; SHAMS, A. & DEHKORDI, P.S. (2013). The effect of age, sex and obesity on fundamental motor skills among 4 to 6 years-old children. *Pakistan Journal of Medical Sciences,* 29(2): 586-589. [doi: 10.12669/pjms.292.3069].

WITVROUW, E.; DANNEELS, L.; THIJS, Y.; CAMBIER, D. & BELLEMANS, J. (2009). Does soccer participation lead to genu varum? *Knee Surgery Sports Traumatology Arthroscopy,* 17(4): 422-427. [doi: 10.1007/s00167-008-0710-z].

YOU, L.; SADLER, G.; MAJUMDAR, S.; BURNETT, D. & EVANS, C. (2012). Physiotherapists' perceptions of their role in the rehabilitation management of individuals with obesity. *Physiotherapy Canada*, 64(2): 168-175. [doi: 10.3138/ptc.2011-01].

Corresponding author: Dr. Z.G. Topcu; **Email:** zehra.guchan@emu.edu.tr

(Subject editor: Prof. Maya van Gent)