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Original Article

Relationship between obesity and musculoskeletal system findings among children and adolescents

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ABSTRACT

Objectives: This study aims to demonstrate the relationship between obesity and musculoskeletal system examination findings and functionality among 5-16 years old population-based sample.

Patients and methods: This is a cross-sectional field study. Sample of this study was selected from 4,246 participants of a study, which assessed the prevalence of obesity among school children aged between 6-15 in Pendik, Istanbul, in 2013-2014 school year. Physical examination included inspection, gait, balance, muscle strength and range of motion (ROM) assessment. Turkish version of Pediatric Outcomes Data Collection Instrument (PODCI) was used. Physical examination findings and PODCI scores of "normal weight" and "overweight/obese" groups were compared. Correlation between body mass index (BMI), ROM and PODCI subscale scores were also evaluated.

Results: A total of 318 children were included in the study. 39.3% (n=125) were normal weight, 61.7% (n=193) were overweight/obese. Pes planus was the most common musculoskeletal problem with a rate of 23.9%. We found that pes planus was more common (p=0.000), standing time on one leg was shorter (p=0.002), time to complete timed up and go test (TUG) was longer (p=0.004) and "happiness" subscale scores of PODCI were lower (p=0.000) in overweight/obese children compared to their normal weight peers. Range of motion values were decreased, especially on the lower limbs, in overweight/obese children (p<0.05) compared to normal weight children. Body mass index values showed a negative correlation with ROM and PODCI "happiness" subscale scores (p<0.05).

Conclusion: Musculoskeletal problems are more common in overweight/obese children than in their normal weight peers. Increase in BMI correlates with decrease in balance, emotional functionality and ROM values. It may be possible to protect overweight/obese children from serious musculoskeletal disorders by interventions that reduce BMI.

Keywords: Balance; childhood; functionality; musculoskeletal; obesity.

The World Heath Organization (WHO) defines people who are overweight and obese as having "abnormal or excessive fat accumulation that presents a risk to health".[1] According to International Obesity Taskforce (IOTF) data, 200 million school children are overweight or obese.[1]

It has been suggested that childhood obesity effects the development and function of many body systems including the musculoskeletal system.[2] Childhood obesity is related to emerging non-communicable diseases in short term and increased morbidity and mortality risk in adulthood. Childhood obesity effects budget, global health and quality of life status of the individual and the community as a whole, which makes it one of the most serious public health challenges of the 21st century.[3]

The patient's general practitioner (GP) is normally the point of first medical contact within the health care system. General practitioners manage illnesses which present in an undifferentiated way at an early stage in

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development, use a specific decision making process determined by the prevalence and incidence of illness in the community and have a specific responsibility for the health of the community.[4,5] General practitioners need evidence-based guidelines for the management of childhood obesity and musculoskeletal comorbidities during primary care. Published studies about childhood obesity and its musculoskeletal complications were mostly completed in secondary and tertiary care settings and population-based studies on this subject are scarce which makes it difficult to develop evidence-based guidelines for primary care. Furthermore, there are not any published studies about the subject in Turkish literature.

The aim of this study was to demonstrate the relationship between obesity and the musculoskeletal system examination findings and functionality among 5-16 year olds in a community based sample. The research questions were; Are there any differences between overweight/obese children and their normal weight peers in the musculoskeletal examination findings and functionality scores? Is there a correlation between body mass index (BMI) and the musculoskeletal examination findings and/or the Turkish version of Pediatric Outcomes Data Collection Instrument (PODCI) subscale scores?

PATIENTS AND METHODS

This was an observational, cross-sectional, community based study. The study was conducted between June 2014 and November 2014 in the Pendik neighborhood of Istanbul.

The power analysis was conducted using G*Power (v3.1.7) program to determine sample size. Study power is expressed as 1-β (β=II. type error probability) and is generally required to be 95%. According to Cohen's effect size coefficient; assuming that effect size would be large (d=0.5) between two independent groups within physical examination (PE) findings and PODCI scores in two-tailed analysis, the sample account was determined to be at least 105 in each group. Considering the possibility that people would drop out of the study before it was completed, the researchers decided to include at least 125 patients in each group.

The population of this study was recruited from a previous observational cross-sectional community-based study in which obesity prevalence among 6-15 year old school children was studied during the 2013-2014 school year in the Pendik district of Istanbul. In that study, sample size was calculated using the Epi-info program, taking into consideration the 6-15 year old population in the Pendik district of Istanbul. Participating schools and classrooms were selected randomly. A total of 4,246 children were included in the study and according to its results, 2,361 children were of normal weight, 993 were overweight and 580 were obese. Parents of the participating children were informed about their child's anthropometric measurements.[6] Until we reached the minimum sample size, participants of the previous study were selected through randomization and invited to the hospital by phone call for a detailed musculoskeletal assessment. Children were included after written informed consent was obtained from the parents.

Inclusion criteria were to have a signed written informed consent, to not be given any treatment for obesity and/or musculoskeletal conditions and to not have any disability which may prevent a physical examination.

A detailed examination of the musculoskeletal system was developed by researchers taking into consideration previous studies from the literature and suitability of primary care. This examination combines the maneuvers of a screening method called pediatric Gait, Arms, Leg, Spine (pGALS)[7] and a further evaluation method called pediatric Regional Examination of Musculoskeletal System (pREMS)[8] for musculoskeletal conditions in children, range of motion (ROM) assessment, the manual muscle test

Table 1. Comparison of weight groups within sex and mean age (n=318)

	Weight groups						
	Normal weight			Overweight/obese			
	n	%	Mean±SD	n	%	Mean±SD	*p**
Sex							
Female	67	21.1		91	28.6		0.302‖
Male	58	18.2		102	32.1		0.302‖
Mean age (year)			10.2±2.3			10.2±2.3	0.816‡

SD: Standard deviation; *p<0.05: Statistical significant; ‖ Chi-square; ‡ Independent t-test.

Table 2. Inspection and gait assessment results (n=318)

	Yes		No		Total	
	n	%	n	%	n	%
Pes planus	76	23.9	242	76.1	318	100.0
Increased thoracic kyphosis	43	13.5	275	86.5	318	100.0
Shoulder asymmetry	33	10.4	285	89.6	318	100.0
Plano valgus	29	9.1	289	90.9	318	100.0
Scapular wing	8	2.5	310	97.5	318	100.0
Antalgic gait	5	1.6	313	98.4	318	100.0
Genu valgum	4	1.3	314	98.7	318	100.0
Genu varum	3	0.9	315	99.1	318	100.0
Pelvic asymmetry	3	0.9	315	99.1	318	100.0
Increased cervical lordosis	2	0.6	316	99.4	318	100.0
Persistent femoral anteversion	2	0.6	316	99.4	318	100.0
Circumduction gait	1	0.3	317	99.7	318	100.0
Recurvatum	0	0.0	318	100.0	318	100.0
Toe walking	0	0.0	318	100.0	318	100.0
Trendelenburg	0	0.0	318	100.0	318	100.0

(MMT), the timed up and go test (TUG), hopping on one leg and standing time on one leg (STOOL) tests together. Muscle strength was assessed using MMT scores ranging from 0 to 5. 0 referred to no visible or palpable contraction and 5 referred to maximal muscle strength. The ROM was measured using a goniometer. Physical examination forms were inspected, gait, balance, muscle strength and ROM parts. Participants with musculoskeletal problems identified during the examination were referred to physical medicine and rehabilitation clinics for further evaluation and treatment.

Physical function was assessed using the PODCI. This instrument was translated into Turkish and a reliability study was conducted by Merder-Coskun et al.[9] Cronbach's alpha values of the subscales for PODCI were found to be 0.96 for "global functioning", 0.95 for "transfer and basic mobility", 0.93 for "sports and physical functioning", 0.90 for "upper extremity and physical function"; 0.77 for "happiness" and 0.38 for pain/comfort. The instrument was originally developed to determine the need for treatment and response to treatment in children with musculoskeletal problems. The instrument has 86 items and "upper extremity", "transfer and basic mobility", "physical function and sport", "comfort", "happiness" and "general health" subscales. The standardized score was calculated for each subscale and ranged from 0-100. Zero (0) referred to the lowest physical functionality and 100 referred to the highest functionality. The instrument can be applied to children between 2-18 years of age. There are two versions that can be used for children and parents. The parent forms were used in our study.

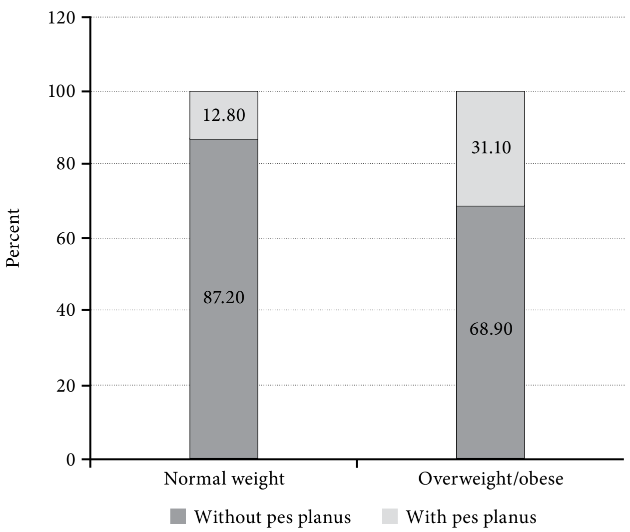

Figure 1. Comparison of weight groups within pes planus.

Analysis was performed with the SPSS version 16.0 (SPSS Inc., Chicago, IL, USA). Descriptive statistics were computed and summarized; continuous variables were summarized using means and standard deviations (SD) and categorical variables using proportions. Continuous variables were tested using the Shapiro-Wilk for normality. Continuous variables with a p value of >0.05 were considered normally distributed. Since the test is biased by sample size, Q-Q plot was used for verification in addition to the test. Chi-square was used for comparison of discrete variables. Student's t-test and Mann-Whitney U tests were used for comparison of continuous variables. Pearson's correlation

Table 3. Comparison of weight groups within standing time on one leg test, timed up and go test and hopping on one leg test (n=318)

	Normal weight			Overweight/obese			
	Mean±SD	Median	Min-Max	Mean±SD	Median	Min-Max	*p*
STOLL (sec)							
Right	140.0±111.3	140.0	9-300	90.0±105.5	90.0	3-300	0.013†*
Left	162.0±114.1	162.0	4-300	90.0±106.2	90.0	3-300	0.002†*
Hopping on one leg (times)							
Right		∞	3-∞		∞	1-∞	0.829†
Left		∞	∞		∞	1-∞	0.421†
TUG (sec)	7.4±1.2			8.1±3.9			0.004‡*

SD: Standard deviation; Min: Minimum; Max: Maximum; * p<0.05: Statistical significant; STOOL: Standing time on one leg; † Mann-Whitney U test; TUG: Timed up and go test; ‡ Independent t-test.

analysis method was used for the evaluation of the relationship between continuous variables. Confidence intervals were set at 95% and values were considered statistically significant if p<0.05. Reliability of the instrument was tested in our study. Cronbach's alpha was used to determine the internal consistency of the instrument. An alpha (α) value of 0.8> α ≥0.7 is considered to be "acceptable", 0.9> α ≥0.8 is considered to be "good" and α ≥0.9 indicates "excellent" internal consistency.

The Ethics Committee approval was obtained from Marmara University Faculty of Medicine Ethics Committee (70737436-050-06.04-1300241517 numbered, dated 12.06.2013 Ethics Committee approval). Permission to conduct research in schools was taken from the Istanbul Directorate of National Education. The study was conducted in accordance with the principles of the Declaration of Helsinki.

RESULTS

A total of 318 children, who fulfilled the inclusion criteria, were included in this study. 39.3% (n=125) were normal weight, 16.4% (n=52) were overweight and 44.3% (n=141) were obese. Participants were divided into two groups; "normal weight group" and "overweight/obese group". Demographic data is shown in Table 1. Age was normally distributed in both groups and there was no statistically significant

Table 4. Comparison of weight groups within range of motion (n=318)

	Right			Left		
	Normal	OW/Obese		Normal	OW/Obese	
	Mean±SD	Mean±SD	*p**	Mean±SD	Mean±SD	*p*
Neck (degree)						
Flexion				59.4±8.8	56.6±7.7	0.002‡*
Shoulder (degree)						
Flexion	179.9±0.7	180.0±0.0	0.036‡	179.9±0.8	180.0±0.0	0.031‡*
Elbow (degree)						
Flexion	144.4±6.2	139.0±6.4	0.000‡	144.4±6.2	139.0±6.4	0.000‡*
Wrist (degree)						
Flexion	82.5±4.0	80.6±4.7	0.000‡	82.2±4.8	81.6±4.7	0.000‡*
Hip (degree)						
Felxion	133.6±11.4	121.7±10.4	0.000‡	133.8±11.0	121.9±10.3	0.000‡*
Extension	42.6±5.8	38.0±7.7	0.000‡	42.6±5.8	38.0±7.7	0.000‡*
Abduction	67.5±9.1	60.9±10.9	0.000‡	67.4±9.1	60.9±11.0	0.000‡*
Adduction	48.2±9.3	41.3±8.7	0.000‡	48.2±9.3	41.5±8.6	0.000‡*
External rotation	57.4±10.3	45.7±10.1	0.000‡	57.4±10.3	45.6±10.1	0.000‡*
Internal raotation	48.9±9.6	36.2±10.7	0.000‡	48.9±9.6	48.9±10.7	0.000‡*
Knee (degree)						
Flexion	142.3±5.4	134.6±7.2	0.000‡	142.3±5.4	134.7±7.0	0.000‡*
Foot (degree)						
Flexion	51.5±6.6	48.2±5.9	0.000‡	51.5±6.6	48.2±6.1	0.000‡*
Extension	27.5±3.9	23.5±3.6	0.000‡	27.6±4.0	23.6±3.6	0.000‡*
Pronation	21.9±3.5	19.3±4.9	0.000‡	21.8±3.4	19.1±5.0	0.000‡*

OW: Overweight; SD: Standard deviation; * p<0.05: Statistical significant; ‡ Independent t-test.

Table 5. Comparison of weight groups within Turkish version of Pediatric Outcomes Data Collection Instrument subscale scores (n=318)

		Normal	Overweight/Obese	
	n	Mean±SD	Mean±SD	*p*
Upper extremity	318	93.0±8.7	92.4±9.7	0.600‡
Transfer and mobility	318	98.6±3.4	97.8±4.1	0.073‡
Sports	318	90.8±10.6	88.8±11.9	0.121‡
Pain/comfort	318	77.5±19.4	80.9±20.4	0.142‡
Happiness	318	90.3±14.4	81.4±22.2	0.000‡*
Global functionality	318	89.9±7.8	89.9±8.6	0.976‡

SD: Standard deviation; * p<0.05: Statistical significant; ‡ Independent t-test.

difference between the two groups in terms of sex or average age (p>0.05).

Pes planus was the most common musculoskeletal problem which was identified during the physical examination with a rate of 23.9%. Inspection and gait assessment results are shown in Table 2. Group comparison in terms of the presence of pes planus is shown in Figure 1. Pes planus was more common in overweight/obese children than their normal weight peers (p=0.000).

Time to complete TUG test results were normally distributed (p>0.05) but standing time on one leg (STOOL) or hopping on one leg test results were not (p<0.05). A statistically significant difference was found between two groups within STOOL and TUG results but not in hopping on one leg test results. Group comparisons in terms of balance test results are shown in Table 3. The STOOL was shorter (p=0.013 for right and p=0.02 for left) and time to complete TUG test was longer (p=0.004) in overweight/obese children than in normal weight children. There was no difference between the hopping on one leg test results of the two groups (p=0.829 for right and p=0.421 for left).

The ROM values were distributed normally (p>0.05). Group comparisons in terms of ROM values are shown in Table 4. There was a statistically significant difference between the two groups in terms of ROM values. ROM values of overweight/obese group were measured to be lower than the normal weight group (p<0.05).

The PODCI subscale score was distributed normally (p>0.05). The PODCI subscale scores are shown in Table 5. A statistical difference was found between

Table 6. Correlation between range of motion and body mass index (n=318)

	Right		Left	
	Pearson correlation (r)	*p**	Pearson correlation (r)	*p*
Neck				
Flexion	-0.130	0.021‡		
Elbow				
Flexion	-0.327	0.000‡	-0.338	0.000§*
Wrist				
Flexion	-0.186	0.001‡	-0.182	0.001§*
Hip				
Flexion	-0.488	0.000‡	-0.508	0.000§*
Extension	-0.333	0.000‡	-0.337	0.000§*
Abduction	-0.318	0.000‡	-0.318	0.000§*
Adduction	-0.359	0.000‡	-0.358	0.000§*
External rotation	-0.407	0.000‡	-0.409	0.000§*
Internal rotation	-0.464	0.000‡	-0.457	0.000§*
Knee				
Flexion	-0.505	0.000‡	-0.509	0.000§*
Foot				
Flexion	-0.235	0.000‡	-0.236	0.000§*
Extension	-0.442	0.000‡	-0.449	0.000§*
Pronation	-0.237	0.000‡	-0.344	0.000§*

* p<0.05: Statistical significant; § Pearson correlation.

Table 7. Correlation between Turkish version of Pediatric Outcomes Data Collection Instrument "Happiness" subscale score and body mass index

	Pearson Correlation (r)	*p*
PODCI "Happiness" subscale score	-0.344	0.000§*

* p<0.05: Statistical significant; § Pearson correlation; PODCI Turkish version of Pediatric Outcomes Data Collection Instrument.

Table 8. Reliability of Turkish version of Pediatric Outcomes Data Collection Instrument subscales in normal, overweight/obese groups and in total

	Normal (n=125)	Overweight/Obese (n=193)	*Total* (n=318)
Upper extremity¶	0.454	0.674	0.614
Transfer and mobility¶	0.898	0.497	0.792
Sports¶	0.725	0.715	0.719
Pain/comfort¶	-0.125	-0.212	-0.185
Happiness¶	0.822	0.854	0.851
Global functionality¶	0.825	0.792	0.805

¶ Cronbach alpha.

groups within PODCI "Happiness" subscale scores. The PODCI "Happiness" subscores for the overweight/obese group were lower, compared to the scores of normal weight group (p=0.000).

Manuel muscle test results ranged from 3 to 5. Only six of the participants had a muscle strength value of 4 and only two of the participants had a muscle strength value of 3 in any muscle. There was no statistically significant difference between the two groups in terms of muscle strength mean ± standard deviation (SD) values.

The correlation of BMI values with ROM values is shown in Table 6. A statistically significant weak to moderate inverse correlation was found between BMI and ROM (p<0.05).

The correlation between BMI values and PODCI "happiness" subscale score values is shown in Table 7. There was a statistically significant weak inverse correlation between BMI and PODCI "happiness" subscale score (r= -0.344, p=0.001).

Reliability of the instrument was tested in our study. Reliability of PODCI subscales in two groups and in total are listed in Table 8. The scale was found to be acceptable to good reliable on "sports", "happiness" and "global functioning" subscales in total and between the two groups.

DISCUSSION

The relationship between childhood obesity and some orthopedic diseases has been demonstrated by several studies.[10,11] In these studies, children with obesity and/or musculoskeletal complaints in secondary or tertiary care were included, inappropriate diagnostic methods for a primary care setting were used and the aim was generally to target the diagnosis or treatment of specific diseases in those studies. However, both obesity and musculoskeletal complaints are presented to primary care providers in the community in a very different way from the presentations in secondary care. In our study, overweight/obese children and their normal weight peers in a community based non-treatment seeking sample were included and we attempted to establish which most detailed musculoskeletal examination method can be applied in primary care setting.

We found that TUG test scores were significantly higher in overweight/obese children than in normal weight children. Tsiros et al.[12] compared TUG scores of overweight/obese children with normal weight children and they observed similar findings with our study. We found that standing time on one leg was shorter in overweight/obese children, compared to normal weight peers. On the other hand, there were no differences between hopping on one leg test results between groups. This result was compatible with other studies. Roberts et al.[13] reported that odds ratios between obese and healthy weight children showed that obese children were less likely to pass hopping and standing one foot tests than their healthy weight peers. Pathare et al.[14] suggested that being overweight/obese resulted in poorer performance on standing on one leg test. A decrease in balance performance in overweight/obese children might increase the risk of falling and injuries in these children, compared to their normal weight peers.

There were no statistically significant differences between MMT results of overweight/obese children and normal weight children in our study. On the other hand, some differences have been reported between overweight/obese children and normal weight children in several studies. Lambertz et al.[15] measured strength of triceps surae muscle using electromyography and reported an increased strength in obese children compared to normal weight children. Ervin et al.[16] assessed muscle strength by observing children during a structured exercise program and they reported decreased performance in obese children in weight-bearing movements. Electromyography and active performance assessment methods are more sensitive than manual muscle test. The difference between assessment methods in those studies might be the reason for the difference in the results with our study.

In our study, ROM values of overweight/obese group were measured to be lower than the normal weight group, especially those in the lower limbs. The ROM values of lower limbs were found to be negatively correlated with BMI in our study. These results were supported by the study of O'Malley et al.[17] In the study of Bell et al.[18] no difference was reported between lower limb ROM values of overweight/obese children and normal weight children but the assessment method was not described. Decreased ROM values might restrict mobility and daily living activities in overweight/obese children.

We compared PODCI subscale mean±SD scores in our study and found a difference only in "Happiness" subscale scores between the two groups. Scores of overweight/obese group were lower, compared to the scores of the normal weight group. The PODCI "Happiness" subscale scores were found to be negatively correlated with BMI in our study. Podeszwa et al.[19] compared the PODCI subscale scores of obese children with normative data in their study. They reported no difference in "Happiness" subscale scores between the two groups however they reported significant impairment in "Sports and Physical Function", "Comfort" and "Global Function" subscale scores of obese children, compared to the normative data. In our study, obese and overweight children were combined into one group, but in the other study, overweight children were not included. Therefore this might affect the results.

Our study showed that pes planus was significantly more frequent in overweight/obese children than in normal weight children. This result was supported by previous studies. Riddiford-Harland et al.[20] and Dowling et al.[21] demonstrated that medial longitudinal arches of the foot of overweight/obese children were flatter and Chippaux-Smirak Index of their footprints were higher than in normal weight children. Krul et al.[22] reported that lower limb musculoskeletal complaints and problems were more frequent in overweight/obese children compared to normal weight children seen in primary care clinics.

Myers et al.[23] reported that musculoskeletal assessment was rarely documented in routine general pediatric medical in-patient clerking and throughout admission, even in cases with musculoskeletal complaints. Moreover, self-rated confidence among healthcare providers in musculoskeletal assessment was low, compared to other systems. The study by Jandial et al.[24] has suggested that self-rated confidence in pediatric musculoskeletal assessment was the lowest, compared to other bodily systems among trainees and experienced doctors in primary and secondary care specialties to whom children with musculoskeletal complaints are likely to present. There is need for further methodological or interventional studies to improve the knowledge and skills on pediatric musculoskeletal assessment among healthcare providers. We believe that this study adds to the literature about obesity and musculoskeletal problems in children and adolescents in a population based sample. This will contribute to the clinical practice by providing evidence to healthcare providers.

In conclusion, our study showed that musculoskeletal problems are more common in overweight/obese children than in normal weight children. An increase in BMI correlates with a decrease in balance test scores, emotional functionality scores and ROM values. This result highlights the importance of musculoskeletal assessment especially in overweight and obese children in each visit in primary care even if they do not have any complaints. Interventions to decrease BMI can protect overweight/obese children from severe musculoskeletal diseases.

Declaration of conflicting interests

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