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Research paper

Evaluation of postural stability in children depending on the body mass index

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Abstract

Introduction: Obesity is a common health issue among children and adolescents leading to serious consequences later in life. There are reports on postural stability in children in relation to their nutritional status, but there are few studies involving a stabilometric platform.

Aim: A comparison of postural stability in children with normal body mass and obese children.

Material and methods: The stabilometric study involved 166 subjects. The postural stability evaluation was performed with the use of the Biodex Balance System platform. The following four postural stability tests were carried out: (1) eyes open, stable platform (SI0); (2) eyes open, level 4 unstable platform (SI4); (3) eyes open, level 4 unstable platform with the screen covered (SI4SC); (4) eyes closed, level 4 unstable platform (SI4EC), and the fall risk test (FRT).

Results and discussion: There were statistically significant differences found in the SI4, SI4SC, SI4EC, and FRT tests in all the inspected parameters. Only in the postural stability test on a stable platform (SI0) no differences were noted. The most marked differences between arithmetic means obtained for both groups were observed in the postural stability test on an unstable platform with closed eyes.

Conclusions: Children with obesity are characterised by increased instability on a moving surface compared to children of normal body mass. Obese children experience the biggest problem when regaining balance with their eyes closed. It is advisable to include training on an unstable surface in physiotherapy programmes for obese children.

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1. INTRODUCTION

Obesity is a global health issue among children and adolescents. According to the World Health Organisation (WHO) approximately 340 million of children and teenagers aged 5–19 were overweight or obese all over the world in 2016.[1] Obesity in girls in this age group increased from 5 million in 1975 to 50 million in 2016 whereas boys showed a rise from 6 million to 74 million in the respective years.[2] At present there are more obese people in the world than underweight people.[1]

In Poland a variety of classification systems for overweight and obesity are used. Depending on the definition, a percentage of children and adolescents with excess body mass in a population varies in individual reports. According to data from research project 'Blood Pressure Norms for Children and Adolescents in Poland OLAF (PL0080),' a representative study run in 416 schools between 2007 and 2009 with body mass index (BMI) cut-off points suggested by the International Obesity Task Force (IOTF), the incidence of obesity in Poland in the 7–12-years group accounted for 5.5% and 3.6% in case of boys and girls, respectively, and in the 13–18-years group it accounted for 3.4% and 2.0% in boys and girls, respectively. Compared to other European countries Poland showed moderate to high incidence of overweight and obesity among children and teenagers.[3,4]

Occurrence of overweight and obesity in childhood lead to serious consequence later in life. The risk of being overweight in adult age is at least twice as high in overweight children versus normal body mass subjects.[5] Overweight and obese children demonstrated a greater risk of diseases and disorders, e.g. type 2 diabetes, hypertension, sleep apnoea, asthma, menstrual disorders, hormonal abnormalities, decreased physical capacity or depression.[2,6,7] Additionally, people with excess body mass show undesirable consequences associated with the motor system. The possible problems include osteoarthrosis, lumbar spine pain, increased risk of fracture and other injuries, axial deviations of lower extremities, and flat foot.[7–12] Children with excess body mass typically show inferior coordination and achieve lower motor ability test scores compared to their overweight and normal BMI.[13,14] There are some reports on postural stability of children depending on their nutritional status, but studies employing stabilometric platforms are scarce.

2. AIM

The study objective was to compare postural stability in children with normal body mass and children with obesity.

3. MATERIAL AND METHODS

The stabilometric study involved 166 children aged 7–18. Apart from children with normal body mass they were patients of the Department of Paediatric Neurology, Epileptology, and Rehabilitation in the Children's Memorial Health Institute in Warsaw coming for rehabilitation stays dedicated to overweight and obese patients. The study was conducted within Research Project No. 220/12 titled Developing Standards for Adipose Tissue Distribution in Overweight, Obese and Normal Body Mass Children from Warsaw in a Wide Age Range (5–18). Informed written consent was obtained from all participants' parents or legal guardians. Children who participated at the study wasn't training any sports and was attending Physical Education classes at school. Exclusion criteria covered chronic diseases, injury or surgery within a year before the study as well as underweight and overweight without obesity. Children were divided into two groups according to BMI compared to the centile grid (for boys and for girls) developed by Kulaga with cut-off points suggested by Cole.[3,15] Group 1 comprised normal BMI subjects and group 2 – obese children (Table 1).

Table 1. Group characteristics.

	Normal BMI	Obese
N	74	92
females	38	58
males	36	34
Age, years	11.2 ± 2.7	12.3 ± 2.9
Body mass, kg	39.5 ± 11.4	70.2 ± 21.0
Height, m	148.2 ± 15.0	155.4 ±14.4
BMI, kg/m^2	17.6 ± 2.1	28.3 ± 4.4

Postural stability evaluation was performed based on the Biodex Balance System (Biodex, Shirley, NY, USA). During examination patients were standing barefoot with legs apart at the width of their hips and arms hanging freely down the trunk. Patients' personal data, their height, and coordinates of the feet position on the platform were entered in the system. The following four postural stability tests were carried out:

(1) Eyes open, stable platform (SI0);
(2) Eyes open, level 4 unstable platform (SI4);
(3) Eyes open, level 4 unstable platform with the screen covered (SI4SC);
(4) Eyes closed, level 4 unstable platform (SI4EC), and the fall risk test (FRT), where platform instability varied from 6 to 2.

The FRT was conducted with patients' eyes open. Each test consisted of three 20-s trials with 10-s intervals. During the open eyes tests with the screen uncovered, patients followed a dot on the screen corresponding to the centre of pressure (COP) exerted by feet on the supporting surface. Their task was to keep the dot in the centre of the circle by subtle body shifting. Detaching or moving feet was not allowed, neither was grabbing the barrier. Patients were assisted by the physiotherapist during the tests. Patients rested before each stability test.

The four postural stability tests evaluated the overall stability index (O), anteroposterior stability index (A-P), mediolateral stability index (M-L), and the fall risk index (FRI) in the FRT. A higher index value was indicative of more marked body sway associated with inferior postural stability.

Statistica v. 13 software was used for the statistical analysis. The normality of distribution of the investigated parameters was verified with the Kolmogorov–Smirnov test. The statistical analysis was performed with the Student's *t* test. The confidentiality interval was set at $\alpha = 0.05$.

4. RESULTS

Statistically significant differences between the groups were observed in all the parameters investigated in the following tests: SI4, SI4SC, SI4EC, and FRT. Only in the SI0 test the groups showed no differences (Table 2). The largest differences between arithmetic means obtained in both groups were noted in the postural stability test on an unstable platform with eyes closed.

5. DISCUSSION

Stability defined as resistance to disturbances coming from the body but also those resulting from changeability of the environment is very important in everyday functioning. Stable platform tests are useful for postural stability evaluation, but unstable platform trials are particularly important.[16] Maintaining the posture on an unstable supporting surface requires greater motor control; therefore, unstable platform tests may be more sensitive.[17,18]

Studies demonstrated, that in all the postural stability tests on an unstable platform, obese children had significantly worse results compared to their healthy-bodied peers. Similar differences were noted in the FRT, where platform's instability was changing. Different results were obtained by Goulding et al., who with a test on a stabilometric platform, demonstrated that on a static as well as unstable surface obese boys had similar scores to boys of normal body mass.[19]

In the discussed research significant differences in O, A-P, and M-L mean indices between the groups were observed in the postural stability test on an unstable platform with eyes closed. Similar outcomes were obtained by other researchers. Closing eyes led to longer path of the centre of pressure (COP) in obese subjects compared to participants of normal body mass and overweight in the test on hard and soft supporting surface.[20] Stability in obese boys was dem-

Table 2. Results of postural stability tests.

Test	Postural stability indices	Group	Mean	SD	SE	*T*	d*f*	*P*
SI0	O	Normal BMI	0.830	0.5236	0.0609	0.210	164	0.834
		Obese	2.492	1.8637	0.1943			
	A-P	Normal BMI	0.691	0.5232	0.0608	0.898	164	0.371
		Obese	0.671	0.6675	0.0696			
	M-L	Normal BMI	0.559	0.4554	0.0529	–0.676	164	0.500
		Obese	0.498	0.4266	0.0445			
SI4	O	Normal BMI	0.303	0.2054	0.0239	–8.337	164	0.000
		Obese	0.341	0.4553	0.0475			
	A-P	Normal BMI	0.759	0.3256	0.0378	–7.484	164	0.000
		Obese	1.907	1.1463	0.1195			
	M-L	Normal BMI	0.511	0.2557	0.0297	–8.304	164	0.000
		Obese	1.251	0.8189	0.0854			
SI4SC	O	Normal BMI	0.432	0.2146	0.0249	–8.663	164	0.000
		Obese	1.149	0.7164	0.0747			
	A-P	Normal BMI	1.215	0.4956	0.0576	–6.942	164	0.000
		Obese	2.863	1.5743	0.1641			
	M-L SI	Normal BMI	0.843	0.4092	0.0476	–9.056	164	0.000
		Obese	1.996	1.3794	0.1438			
SI4EC	O SI	Normal BMI	0.705	0.2838	0.0330	–9.449	164	0.000
		Obese	1.633	0.8427	0.0879			
	A-P SI	Normal BMI	3.308	2.1614	0.2513	–8.873	163	0.000
		Obese	7.715	3.5116	0.3661			
	M-L SI	Normal BMI	2.270	1.7530	0.2050	–9.449	164	0.000
		Obese	5.540	2.7300	0.2850			
FRT	FRI	Normal BMI	0.830	0.5236	0.0609	–7.438	164	0.000
		Obese	2.492	1.8637	0.1943			

Comments: SD – standard deviation, SE – standard error, *T* – Student's *t* test, d*f* – degrees of freedom, *P* – statistical significance.

onstrated to depend on changing the visual conditions to a greater extent than in boys with no obesity.[21]

The results showed no differences in postural stability testing in obese and normal body mass children when using the static platform with eyes open. Niederer et al. demonstrated that obese children aged 4–6 achieved better results in the static balance test on a stable platform compared to their peers of normal body mass.[22] Nevertheless, research by Colne et al. found greater COP sway in obese teenagers in a test on a stable platform compared to subjects of normal body mass, which may be indicative of inferior stability in obese patients.[23] Static tests do not entirely reflect the problem of balance sustaining mechanism, because they do not provide for disturbances caused by changeability of the environment affecting people's stability.

Unfortunately, few studies have been conducted so far with the use of specialist devices for stability evaluation in children with excess body mass and conclusions on the ability to maintain and regain balance are mainly drawn based on studies employing different batteries of motor ability tests. In simple balance tests with no specialist devices obese and overweight children had worse results compared to healthy bodied peers.[22,24] Obese and overweight children also performed less well in stability trials comprising Bruininks–Oseretsky Test of Motor Proficiency, 2nd edition (BOT-2) as well as Movement Assessment Battery for Children (MAB-C).[13,19,25]

There are many more publications on postural stability in adults. Some researchers indicated lack of differences in balance tests between groups of obese subjects and normal body mass subjects.[26,27] Other reported that worse score in different postural stability tests strongly correlated with the increase of BMI.[17,28,29] In obese adults more frequent falls were noted.[26] This was also confirmed by a mathematical model developed by Corbail et al., according to which the fall risk increased as BMI rose and reduction of the body mass improved postural stability.[30]

Maintaining balance depends on analysis of stimuli from three systems of senses: visual, proprioceptive, and vestibular.[31] With disturbances from the environment obese subjects probably rely on their vision to a larger extent. It may be caused by decreased sensitivity of mechanoreceptors in their feet.[32,33] It was proven, that subjects with greater body mass have larger foot-surface contact area, suffer from flat foot more often, and additionally, due to high body mass, more pressure is exerted on their feet at the area of the heel and metatarsus. Higher values of blood pressure and larger contact areas in obese patients may reduce the receptor sensitivity and affect the process of maintaining balance.[11,28,34,35] The problem with controlling a stable position in children with excess body mass may also be caused by less well-developed musculoskeletal system or differences in balance regaining strategies.[19,21,32]

The authors are aware, that there are more accurate tools to analyse the body composition, which define the nutritional level better than BMI. BMI does not provide for the body built and structure. However, it is commonly used. It defines the nutritional status in adults and is employed to classify them into groups. In people of over 20 years of age consistent BMI ranges are used, which indicate underweight, normal body mass, overweight, and obesity. In childhood and adolescence the weight to height ratio changes depending on gender and age.[36,37] Therefore, it is necessary to compare the calculated BMI value with centile grids developed by Kulaga.[3,15]

In view of the results from this study it seems advisable to introduce unstable surface training in treatment and physiotherapy programme for obese children. Fall prevention in this group of patients is of crucial importance.

6. CONCLUSIONS

Children with obesity were characterised by higher instability on a moving surface compared to children of normal body mass and performed much worse in regaining balance with their eyes closed. It is advisable to introduce unstable surface training in the physiotherapy programme for obese children and modify it e.g. by instructing the patient to carry out tasks with their eyes closed.

Conflict of interest

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