Original paper

Posture defects and the speed of the centre of foot pressure in children of school age

Wady postawy a prędkość środka nacisku stóp u dzieci w wieku szkolnym

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Key words: posture defects, the centre of foot pressure, lateral speed, anteroposterior speed.

Słowa kluczowe: wady postawy, środek nacisku stóp, prędkość boczna, prędkość przednio-tylna.

Abstract

Introduction: The development of civilisation and the modern lifestyle of children and teenagers have caused an increase in the number of cases of faulty body posture.
Aim of the research: To analyse the relationship between posture defects and the speed of the centre of foot pressure in school-age children.
Material and methods: The research included 503 girls and boys aged 12–15 years. The research approach used a spatial photogrammetry technique. Lateral speed and anteroposterior speed of the centre of foot pressure were tested on a Cosmogamma platform.
Results: Lateral speed ranged from 8.22 mm/s with eyes open to 7.63 mm/s with eyes closed. In correct posture, from 8.45 mm/s with eyes open to 7.64 mm/s with eyes closed. In the defective posture, from 7.90 mm/s with eyes open to 7.63 mm/s with eyes closed. Antero-posterior speed varied from 10.50 mm/s with eyes open to 10.56 mm/s with eyes closed. In the correct posture, from 10.73 mm/s with eyes open to 10.64 mm/s with eyes closed. In the defective posture, from 10.17 mm/s with eyes open to 10.45 mm/s with eyes closed.
Conclusions: Analysis of variance of lateral speed showed a significant effect only of test options ($p < 0.002$). Lateral speed in the test with eyes closed significantly decreased both in the correct and defective posture. There were no significant differences, however, in lateral speed between the correct and incorrect posture. Analysis of variance did not show any significant effects for anteroposterior speed.

Streszczenie

Wprowadzenie: Rozwój cywilizacji oraz współczesny styl życia dzieci i młodzieży powoduje ustawiczne zwiększanie się częstości występowania wad postawy.
Cel pracy: Analiza związku między wadami postawy a prędkością środka nacisku stóp u dzieci w wieku szkolnym.
Materiał i metody: Badaniami objęto 503 dziewcząt i chłopców w wieku 12–15 lat. W badaniach postawy zastosowano technikę fotogrametrii przestrzennej. Prędkość boczną i prędkość przednio-tylną środka nacisku stóp badano na platformie Cosmogamma.
Wyniki: Prędkość boczna oscylowała od 8,22 mm/s przy oczach otwartych do 7,63 mm/s przy oczach zamkniętych; w postawie prawidłowej od 8,45 mm/s przy oczach otwartych do 7,64 mm/s przy oczach zamkniętych, a w postawie wadliwej od 7,90 mm/s przy oczach otwartych do 7,63 mm/s przy oczach zamkniętych. Prędkość przednio-tylna oscylowała od 10,50 mm/s przy oczach otwartych do 10,56 mm/s przy oczach zamkniętych; w postawie prawidłowej od 10,73 mm/s przy oczach otwartych do 10,64 mm/s przy oczach zamkniętych, a w postawie wadliwej od 10,17 mm/s przy oczach otwartych do 10,45 mm/s przy oczach zamkniętych.
Wnioski: Analiza wariancji prędkości bocznej wykazała jedynie istotny efekt opcji badania ($p = 0{,}002$). Prędkość boczna w teście przy oczach zamkniętych istotnie się zmniejszyła zarówno w postawie prawidłowej, jak i wadliwej. Nie wystąpiły jednak istotne różnice prędkości bocznej między postawą prawidłową i wadliwą. Analiza wariancji nie wykazała istotnych efektów dla prędkości przednio-tylnej.

Introduction

The development of civilisation and the modern lifestyle of children and teenagers have caused an increase in the number of cases of faulty body posture. The results of attempts to correct body posture are still unsatisfactory. They are an inspiration to verify the programs used and to look for new methods of therapy. Among all body postures the treatment of lateral curvatures of the spine is a long-lasting process, which often continues until adulthood. This defect determines the choice of future career and a kind of performed work. That is why preventive treatment, screening examination, and posture re-education are necessary. The human body is not a rigid Newtonian solid. Maintaining an upright posture is a kind of act of mobility, the ability of coordination, and the development of that coordination is a long-term process, requiring a large number of repetitions. Body posture is a way of keeping a person in a relaxed standing position, of which the external manifestations are a spatial arrangement of each segment of the body and the silhouette of the body. Posture as a way of keeping oneself is not a passive system of the body segments, but belongs to motor acts with a high degree of automation. As a way of keeping oneself, the body posture must be seen as a dynamic act, maintaining an adequate body system in spite of the force of gravity and in the conditions of unstable equilibrium [1–4]. Balance is a certain state of the postural system. This condition is characterised by vertical orientation of the body achieved by balancing the forces working on the body and their moments. Balance is provided by the nervous system by reflexive tension of relevant muscle groups called postural or anti-gravitational muscles. Because the chaotic movements of the centre of gravity are two-dimensional, additional information on the stability of the posture can be obtained by analysing the individual components of the route of statokinesiogram, i.e. separate sway in the sagittal plane and in the frontal plane [5–13].

Aim of the research

The aim of the study was to analyse the relationship between body posture in the sagittal plane and the speed of the centre of foot pressure in school-age children, tested by Romberg test.

Material and methods

The research included 503 girls and boys aged 12–15 years from randomly selected Primary School No 13 and Secondary School No 4, in Starachowice. The study group consisted of 247 (49.11%) girls and 256 (50.89%) boys. Of these, 60 were 12-year-old girls (24.29%), 60 were 13-year-old girls (24.29%), 65 were 14-year-old girls (26.32%), and 62 were 15-year-old girls (25.10%). Sixty-five were 12-year-old boys (25.39), 61 were 13-year-old boys (23.83%), 60 were 14-year-old boys (23.44%), and 70 were and 15-year-old boys (27.34%). The size distributions of age and sex groups did not differ significantly. The study was performed in November and December 2005. To study body posture a spatial photogrammetry technique was used based on the effect of projection moiré (Figure 1) [14, 15]. The lateral speed and anteroposterior speed of the centre of foot pressure were tested on Cosmogamma platform using an Emildue R50300. The test was carried out for the standard evaluation of stability in a relaxed standing position (Romberg test) consisting of two successive trials lasting 30 s each: first with eyes open (OE – open eyes) and second with eyes closed (CE – closed eyes) (Figure 2) [16]. The lower the value of the parameters, the more accurate the process of posture control.

Statistical analysis

For statistical analysis the following were used: the arithmetic mean (*x*), the standard deviation (s), Kruskal-Wallis's analysis of variance, Kolmogorov-Smirnov test, and for post hoc analysis – the Bonferroni test [17].

Results

Analysis of variance showed a significant difference in the body height in relation to sex ($p \le 0.001$), a significant difference in terms of age ($p \le 0.001$), and significant interaction of the age and gender on the height of the tested ($p \le 0.001$). In the test group there was a significant difference in body mass in relation to gender ($p \le 0.03$), a significant difference in terms of age ($p \le 0.001$), and significant interaction of gender and the age on body mass of the tested children ($p \le 0.001$). There was a significant variation in body mass index (BMI) in relation to age ($p \le 0.004$). No significant difference was observed in relation to gender. There was no significant interaction of gender and age on BMI. The body postures of the tested were divided into correct (K_1, R_2, L_1 types) and defective groups based on a modification of Wolański typology. Defective postures included K_2, L_2, and R_1P types, i.e. round, concave, and flat back [4]. Two hundred and ninety-seven (59.05%) correct postures were observed and 206 (40,95%) were defective. The lateral speed of the tested varied from 8.22 mm/s with OE to 7.63 mm/s with CE. The difference in Romberg test was 0.59. Variations in the correct posture were from 8.45 mm/s with OE to 7.64 mm/s with CE. The difference in Romberg test was 0.82. Variations in the defective posture were from 7.90 mm/s with OE to 7.63 mm/s with CE. The difference in Romberg test was 0.27 (Table 1, Figure 3). Antero-posterior speed varied from 10.50 mm/s with OE to 10.56 mm/s with CE. The difference in Romberg test was 0.06. Variations in the correct posture were from 10.73 mm/s with OE

Figure 1. The apparatus for the test by moiré method [15]

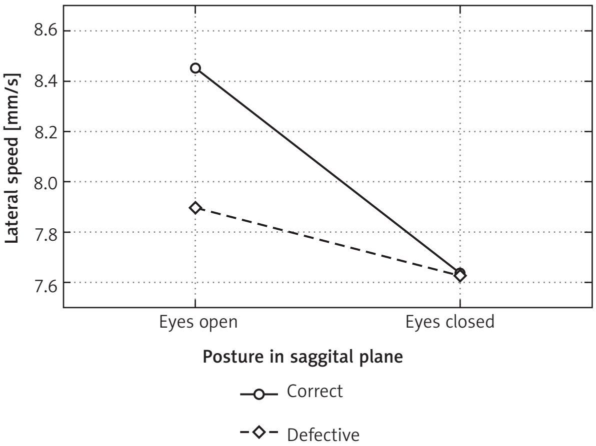

Figure 3. Lateral speed

to 10.64 mm/s with CE. The difference in Romberg test was 0.09. Variations in the incorrect posture were from 10.17 mm/s with OE to 10.45 mm/s with CE. The difference in Romberg test was 0.28 (Table 2, Figure 4).

Discussion

My own research proves the fact that there are a large number of children and teenagers with faulty body postures. These are predominantly cases of lateral curvature of the spine (52%), followed by scoliosis (47%), then concave backs (20%), flat backs (20%), and round backs (0.80%) [18]. Body balance is ensured by integration in nervous system of peripheral control, ascending, conventionally known as ankle-head steering and descending head-ankle. Just these two types of control ensure a stable upright posture during relaxed standing and during locomotion. Both controls are complementary, so the failure of one of them may be compensated by the activity of the other. Consequently, in a complex system responsible for the control of posture two distinct but interdependent systems can be distinguished. The first is the system-stabilising look, which consists of control of the direction of visual acuity during movements of the head and the whole body. The second is the system stabiliing posture, which keeps the body in balance at rest and in motion. Both systems, the stabilising look and stabilising posture, differ in their source of receptor information, information about the motor reactions of the various parts of the body, and the involvement of different motion pathways in central nervous system. They are closely interdependent because the stabilisation of looks is not possible until the body and head with the eyeballs are also not stable. However, the correct vision, which depends on the stable look, is one of the main senses enabling control and stabilisation of the posture. Among the unconditioned reflexes with which a child is born, an important place is occupied by reactions known as posture reflexes. The latter are numerous and include three groups: static, setting, and balance reactions, with many subgroups. All these reactions are connected and in essence provide the stability of the adopted posture (static reactions), allow the adoption of proper posture after im-

Figure 2. The Cosmogamma platform, Emildue R50300 [16]

Table 1. Lateral speed

Independent variables	Lateral speed [mm/s]						Difference (OE-CE)
	OE			CE			
	x	*n*	*s*	*x*	*n*	*s*	
Correct posture	8.45	297	4.00	7.64	297	3.08	0.82
Defective posture	7.90	206	3.52	7.63	206	2.91	0.27
Total	8.22	503	3.82	7.63	503	3.01	0.59

Table 2. Anteroposterior speed

Independent variables	Anteroposterior speed [mm/s]						Difference (OE-CE)
	OE			CE			
	x	*n*	*s*	*x*	*n*	*s*	
Correct posture	10.73	297	3.62	10.64	297	3.87	0.09
Defective posture	10.17	206	3.59	10.45	206	3.82	–0.28
Total	10.50	503	3.62	10.56	503	3.84	–0.06

proper position (setting and straightening reflexes), and ensure the balance of the body upon changes of position of the centre of gravity (balance reflexes). These reflexes are somehow built into the mechanism of regulation of body posture. However, earlier in the course of development, the conditioned reflexes are formed, based on unconditioned reflexes, which in turn form a chain of reflexively conditioned actions called dynamic stereotype. Further repetition of stimuli and responses leads in turn to the production of motion habits, and those, in turn, form the basis of the automation of motor actions [5, 18]. The development of sensory organisation for balance control in children is still unclear. Steindl, Kunz, Schrott-Fischer, and Scholtz studied the effects of age and gender on maturation of sensory systems and balance control in relation to gender and age. They studied a total of 128 children aged from 3 to 16 years and 23 adults using the Sensory Organisation Test (Test Equi). Age-related changes during the test procedure showed a development tendency of the sensory process. The influence of proprioceptive information on balance seemed to be completely developed between 3 and 4 years of age. Visual and vestibular information reached the level of adults between 15 and 16 years of age. Significant differences between girls and boys were also shown. Age-related assessment of sensory organisation for balance control (posture-defect mechanisms can be used for differentiation between physiological and pathological results in balance control) can be used for monitoring therapy progress of hyperactivity or learning disability [19]. Analysis of variance with the double classification showed a significant effect of test options ($p \leq 0.002$). Lateral speed in the test with CE significantly decreased in both the correct and defective postures (Table 3). Post-hoc analysis (Bonferoni test) confirmed this effect. In the test with CE the value of the lateral speed significantly decreased in both the correct and defective postures (Table 4). Since the parameters of the lateral speed in the test with CE do not deteriorate we are dealing with a lack of skills in the use of vision in the process of maintaining body balance among younger children. There is a lack of adequate coordination between vision and the motor system, which in children is in the process of ongoing development. However, there were no significant differences laterally between the correct and incorrect posture. Analysis of variance with double classification did not show any significant effects for anteroposterior speed. There were no significant differences in anteroposterior speed between the correct and incorrect posture (Table 5). Posture defects observed in the population of children aged 12–15 years did not

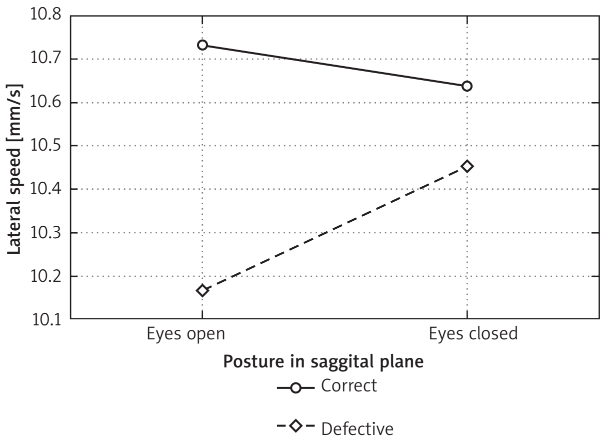

Figure 4. Anteroposterior speed

Table 3. Analysis of variance with double classification for lateral speed

Independent variables	DF effect	MS effect	DF error	MS error	*F*	Value of *p*
Posture	1	19.48	501	15.614	1.24	0.26
Test option	1	71.62	501	7.97	8.98	0.002
Interaction	1	18.04	501	7.97	2.26	0.133

DF – degree of freedom, MS – mean square, F – relation of MS effect to MS error, p – level of significance

Table 4. Post hoc analysis (Bonferroni test) for lateral speed

Independent variables	Test options	(1) **8.45**	(2) **7.63**	(3) **7.89**	(4) **7.62**
Correct posture	LS (OE)		0.003	0.730	0.049
Correct posture	LS (CE)	0.003		1.000	1.000
Defective posture	LS (OE)	0.730	1.000		1.000
Defective posture	LS (CE)	0.050	1.000	1.000	

Table 5. Analysis of variance with double classification for anteroposterior speed

Independent variables	DF effect	MS effect	DF error	MS error	*F*	Value of *p*
Posture	1	33.82	501	20.47	1.65	0.19
Test option	1	2.17	501	7.34	0.29	0.58
Interaction	1	8.66	501	7.34	1.17	0.27

affect the speed of COP in the assessment carried out on the Cosmogamma balance platform. Lateral speed differences with eyes open and closed may be a measure of maturation assessment of the visual inspection of balance in 12–15-year-old children. Therefore, the problem of relations between body posture in the sagittal plane and the speed of the centre of the foot pressure requires further research and analysis.

Conclusions

Analysis of variance with double classification of lateral speed showed a significant effect of the test option. Lateral speed in the test with CE significantly decreased in both the correct and defective posture. Post-hoc analysis (Bonferoni test) confirmed this effect. There were no significant differences in lateral speed between the correct and incorrect posture. Analysis of variance with the double classification did not show any significant effects for anteroposterior speed. There were no significant differences in anteroposterior speed between the correct and incorrect posture. Posture defects observed in the population of children aged 12–15 years did not affect the speed of COP in the assessment carried out on the Cosmogamma balance platform. Lateral speed differences with eyes open and closed may be a measure of maturation assessment of the visual inspection of balance in 12–15-year-old children. The problem of relations between body posture in the sagittal plane and the speed of the centre of foot pressure requires further research.

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