fizjoterapia polska
nr 2/2014 (14)

Dymorfizm płciowy stabilności posturalnej statycznej u dzieci w wieku 9-12 lat

Gender Dimorphism of Postural Static Stability in Children 9 to 12 Years of Age

Marzena Wiernicka[1(A,B,C,D,E,F,G)], Ewa Kamińska[1(B,D,E,F)], Dawid Łochyński[2(B,E,F)], Elżbieta Hurnik[3(C)], Łukasz Michałowski[1(B,E,F)], Daniel Choszczewski[1(B,E,F)], Piotr Kocur[1(B)], Marta Flis-Masłowska[1(B)], Zbigniew Śliwiński[4(D,F)], Jacek Lewandowski[2(B,D)]

Akademia Wychowania Fizycznego im. E. Piaseckiego w Poznaniu, Polska:
[1]Katedra Rehabilitacji Narządu Ruchu, Zakład Kinezyterapii
[2]Katedra Rehabilitacji Narządu Ruchu, Zakład Rehabilitacji Narządu Ruchu
[3]Sekcja Obliczeniowa
[4]Instytut Fizjoterapii, Wydział Nauk o Zdrowiu Uniwersytet Jana Kochanowskiego w Kielcach, Polska

Streszczenie:

Wstęp. Poczucie równowagi jest właściwością zależną od wielu cech układu nerwowego i całego aparatu ruchu, przy czym wysoki poziom poczucia równowagi obrotowej człowiek osiąga około 6 roku życia, jednak równowagi statycznej oraz dynamicznej dopiero około 12 roku życia.
Cel pracy. Określenie różnic dymorficznych stabilności posturalnej w warunkach statyki u dzieci będących w tym samym przedziale wiekowym.
Materiał i metoda. Materiał: 450 dzieci, wiek 9-12 lat, w tym 235 dziewcząt i 215 chłopców. Metoda badań: z wykorzystaniem urządzenia CQ-STAB, ocena długości ścieżki (Sway Path) SP (mm) i wielkości pola zakreślanego (Sway Area) SA (mm^2) przez COP (Centre of pressure) przy zachowanej kontroli wzrokowej (EO) i bez kontroli wzrokowej (EC). Wyniki poddano analizie statystycznej.
Wyniki. Uzyskane wyniki badań nie charakteryzowały się rozkładem normalnym, stąd do obliczeń wykorzystano testy nieparametryczne. Na podstawie analizy stwierdzono, że dziewczęta uzyskały zdecydowanie lepsze wyniki w zakresie długości ścieżki i wielkości pola zakreślanego przez COP określające stabilność statyczną w porównaniu do chłopców, zarówno przy zachowanej kontroli wzrokowej, jak i bez kontroli wzrokowej.
Wnioski. Analiza wyników badań wskazała na lepszą stabilność posturalną określaną w warunkach statyki u badanych dziewcząt niż u chłopców. Różnice międzypłciowe zaobserwowano zarówno w badaniu z oczami otwartymi, jak i zamkniętymi, co może wskazywać na zmienność dynamiki rozwoju funkcjonalnego ośrodkowego układu nerwowego odpowiadającego za kontrolę stabilności posturalnej u dziewcząt i chłopców.

Słowa kluczowe:
stabilność statyczna, dzieci, dymorfizm

Abstract

***Introduction**. Equilibrioception – or sense of balance – is dependent on a number of features of the nervous system and motor system. A rotational sense of balance is fully developed at around 6 years of age; static and dynamic balance, however, is achieved at about 12 years of age.*
***Purpose.** This paper aims to identify dimorphic differences of postural static stability in children of the same age range.*
***Research Material and Method.** Material: The research group consisted of 450 children aged 9 to 12, comprising 235 girls and 215 boys. Research method: The measurement of the Centre of Pressure Sway Path length (mm) and the Sway Area size (mm^2) with Eyes Open and Eyes Closed (EO/EC) using CQ-STAB device. The results have been subjected to statistical analysis.*
***Results.** The results obtained did not present a normal distribution and therefore non-parametric tests were used for the calculations. The analysis shows that girls, when compared with boys, achieved significantly better results in static stability measured by determining both the Sway Path and the Sway Area of the COP, both in EO and EC conditions.*
***Conclusions.** Research results analysis indicated a better postural static stability in females compared to male research participants. Gender differences were observed in the study in both Eyes Open and Eyes Closed conditions; this may indicate functional developmental variability of the central nervous system responsible for postural stability control in girls and boys.*

Key words:
static stability, children, dimorphism

Research conducted with the National Centre for Research and Development funding within the development project No 13 0070 06

Introduction

A proper body posture is necessary when performing voluntary movements and locomotor activities; it is defined as the vertical position of the body axis in relation to a small support area [1].

Children who are able to keep a standing position develop their motor skills primarily through improving the newly gained skills. Dynamic changes of the body that occur during this period of development establish proportions similar to those found in adults [2]. The body becomes overall more slender and stronger; muscle mass also increases. New proportions create new motor abilities, a favourable limb leverage rat io and an improved ratio between the child's strength and weight. [3]

With the development of the nervous system, new motor possibilities arise; it turns out that relatively accurate symmetrical movements are performed not earlier than at 9 years of age. At that point a child will have a significant sense of rhythm; flexibility and a sense of balance are also developed in that period. Equilibrioception – a sense of balance – is dependent on a number of features of the nervous system and motor system. A rotational sense of balance is fully developed by about 6 years of age; the static and dynamic, however, is achieved at about 12 years of age.

The research results show that in the course of human development a period can be identified when these skills develop more intensively than it takes place during other periods of life [5]. For the sense of balance, with a special emphasis put on directed development of balance and coordination capacity, this intense period, as indicated above, occurs between 7 and 11 years of age [6]. It should be also noted that a critical period for the development of body balance is defined between 11-13 years, when a temporary stasis takes place, also referred to as a regress of the level of ability to maintain body balance [7, 8]. This period is also characterised by intense development of the skeletal system; the corresponding ratio of muscle growth is inefficient. A rapid increase of the length of the lower limbs means that the centre of gravity moves higher, which results in posture and equilibrium disorders [9, 10].

From the neurophysiological perspective, postural reflex i.e. awareness and assessment of body position in space, is a highly developed sense in humans. It is an outcome of afferent information processing provided by visual, vestibular and proprioceptive nerve pathways [11]. Control of posture and postural reflex system reaches full maturity as late as 18-21 years of age [12].

As a result of incomplete afferent information associated with the immaturity of the posture control reflexes, children and young people do not perceive the irregularities in the spine and pelvis position; any attempt at passive correction of the body is met with dissatisfaction. Studies of postures of people with chronic back pain confirm the insufficiency of space-time parameters responsible for the strategy and movement control [13].

Body balance is defined as the ability of the body to maintain its position without outside support, with the exception of uncontrolled falls [5]. Maintaining static body balance is possible when the centre of gravity moves within the anatomical foot support surface [14, 15, 16, 17]. The resulting centre of pressure is identical to the resulting force application point of the ground [18]. The process of maintaining balance involves a continual loss and recovery of body balance. The skill of active restoration of the typical body position in space, should it be lost as a result of destabilising factors, is referred to as stability by Blaszczyk [19].

Postural stability tests are included in the majority of clinical trials assessing physical activity. Postural stability control is tested in three categories, assessing biomechanic, coordination and sensory properties [19]. Postural stability tests in children at different stages of ontogenetic development have been of interest to numerous researchers [20, 21, 22, 23, 24]. Several of these researchers have pointed out that, in children (9-10 years of age), lower values of COP variations were recorded for girls compared to boys of the same age [22, 25, 26]. Peterson suggests that girls aged 7-8 have a better vestibular information system than boys of the same age; this consequently leads to smaller value variations [21].

The paper aimed to determine the dimorphic differences in postural static stability in children of the same age range. It was assumed that postural static stability is better in girls than in boys in the of the same age range.

Research material and methods

The research was conducted on a randomly selected group of 450 children comprising 235 girls and 215 boys aged 9 to 12.

The main selection criterion was that the subjects be in good health and aged between 9-12 years. The study excluded children with musculo-skeletal disorders and orthopaedic and neurological problems. Anthropometric characteristics did not differ significantly for male and female respondents. The characteristics of the respondents is presented in Table 1.

The research was conducted by measuring the movement of the general centre of pressure (COP). In the study a two-element CQ-STAB stabilometric platform (CQElektronik System, Poland) was used, which allowed the static stability of the body to be determined. The measurements were conducted in a standing position with both feet on the platform, with open and closed eyes [27]. Each series included three 30-second tests separated by a 2-minute break [27]. The best result was chosen for statistical analysis. The study was conducted with the approval of the Bioethics Committee of the Medical University in Poznań.

Table 1. Anthropometric characteristics of respondents

Group	n %	Age [years] min	Age [years] max	Age [years] mean ±SD	Weight [kg] min	Weight [kg] max	Weight [kg] mean ±SD	Height [cm] min	Height [cm] max	Height [cm] mean ±SD
All	450 100%	9	12	10.4 ±0.9	19	97	36.8 ±8.4	112	166	144.1 ±8.35
Girls	235 50.2%	9	12	10.4 ±0.9	20	97	36.7 ±9.2	112	165	143.6 ±8.7
Boys	215 47.8%	9	12	10.4 ±0.9	19	65	36.9 ±4.4	120	166	144.6 ±8

Measured parameters

The following parameters were determined: Sway Path length (mm) and Sway Area (mm^2) of the COP. The device determines the values of SP-EO and SP-EC as well as SA-EO and SA-EC of the COP on both platforms, as well as separately for each of the lower limbs: SP L-EO, SP-R-EO, SP-L-EC, SP-R-EC and SA-L-EO, SA-R-EO, SA-L-EC, SA-R-EC.

In order to verify the normality of the distribution of the data, a Shapiro-Wilk test was conducted. Due to abnormal distribution, statistical analysis was conducted using non-parametric tests (Mann-Whitney U Test).

Results

The first parameter measured was the length of the Sway Path of the COP in EO conditions. The results obtained indicate that the longer Sway Path was recorded for boys for each of the variants analysed; the differences observed were highly statistically significant ($p \leq 0.01$), which indicated that static stability was worse in the boys compared to the girls (Fig 1., Fig. 2., Fig. 3.)

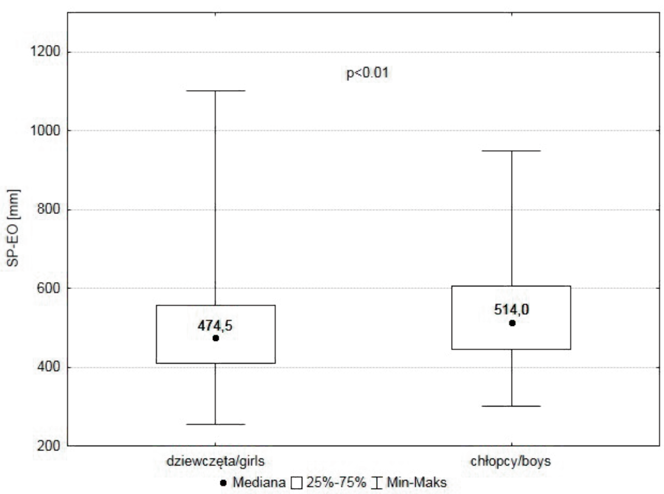

Fig. 1. The differences in length of the SP of the COP observed between the girls and the boys; test carried out in EO conditions

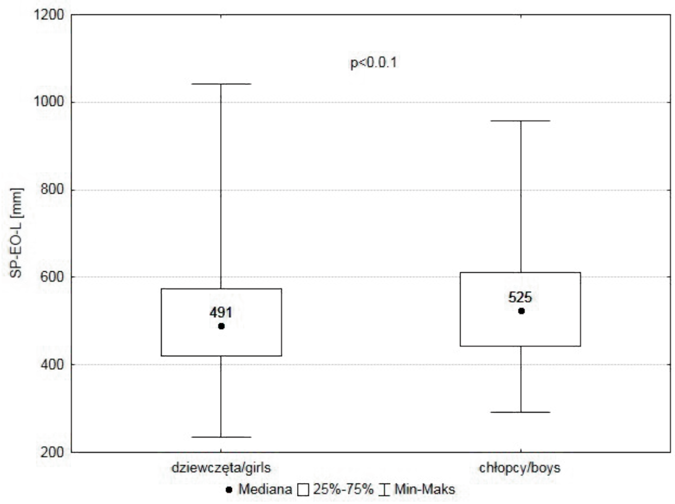

Fig. 2. The differences in length of the SP of the COP, the left lower limb, observed between the girls and the boys; test carried out in EO conditions

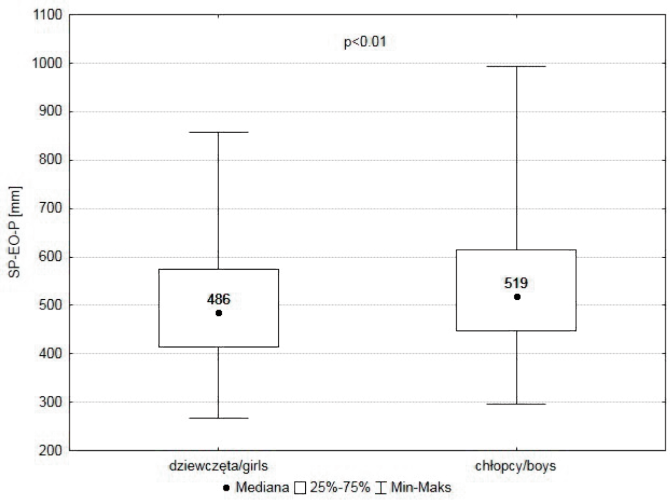

Fig. 3. The differences in length of the Sway Path of the COP, the right lower limb, observed between the girls and the boys; test carried out in EO conditions

The next parameter measured was the size of the Sway Area of the COP in EO conditions. Again, significantly worse results were recorded for boys compared with girls when both lower limbs were considered and also for the right lower limb ($p \leq 0.01$). Interestingly, no significant differences of the Sway Area size of the COP were observed when the left lower limb was considered; the median values in both groups were similar. The results presented above indicate that the male research participants, in order to maintain balance, had a larger Sway Area of the COP (Fig. 4., Fig. 5.)

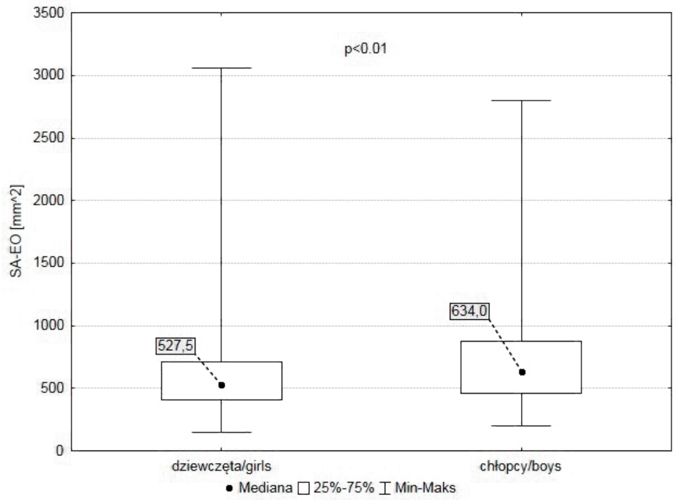

Fig. 4. The differences in size of the SA of the COP observed between the girls and the boys; test carried out in EO conditions

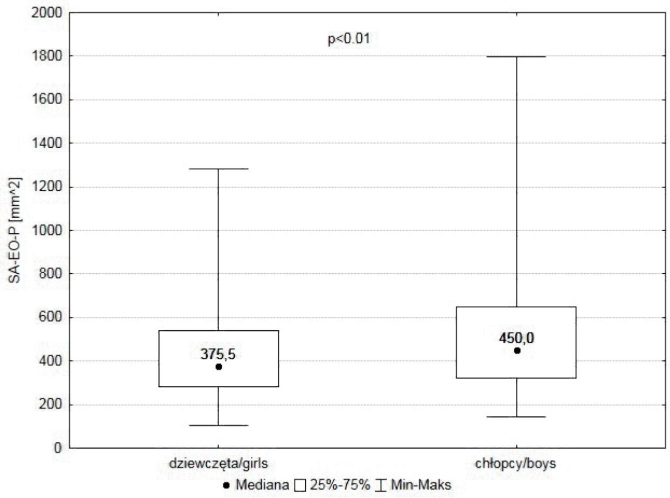

Fig. 5. The differences in size of the SA of the COP observed between the girls and the boys; test carried out in EO conditions

In compliance with the order of diagnostic procedures, the next parameter measured was the length of the Sway Path of the COP in EC conditions. The results were similar to those obtained in EO conditions; the length of the SP was significantly different in both research groups. Under Eyes Closed conditions the Sway Path of the girls was significantly shorter than the boys ($p \leq 0.01$); this indicates that male participants were noticeably less stable than female participants (Fig. 6., Fig. 7., Fig. 8.)

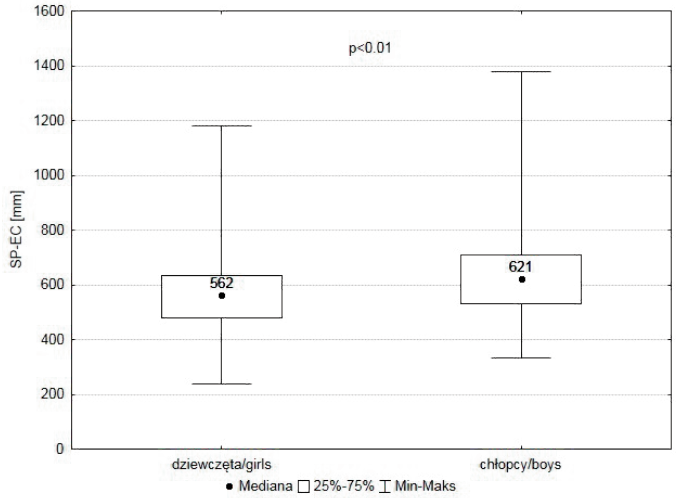

Fig. 6 The differences in length of the SP of the COP observed between the girls and the boys; test carried out in EC conditions

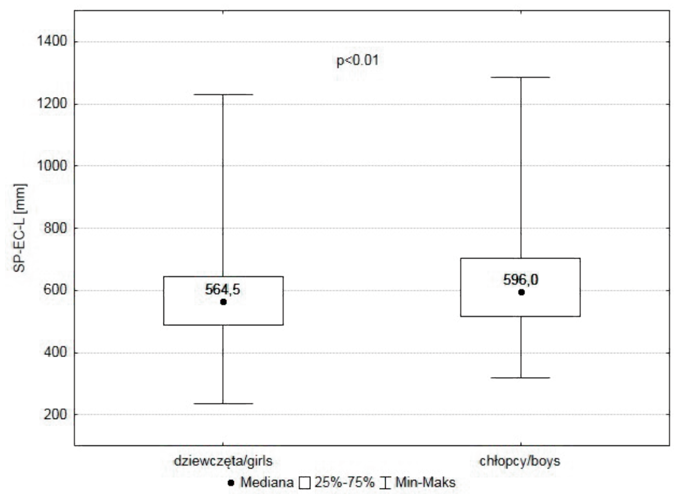

Fig. 7. The differences in length of the SP of the COP, the left lower limb, observed between the girls and the boys; test carried out in EC conditions

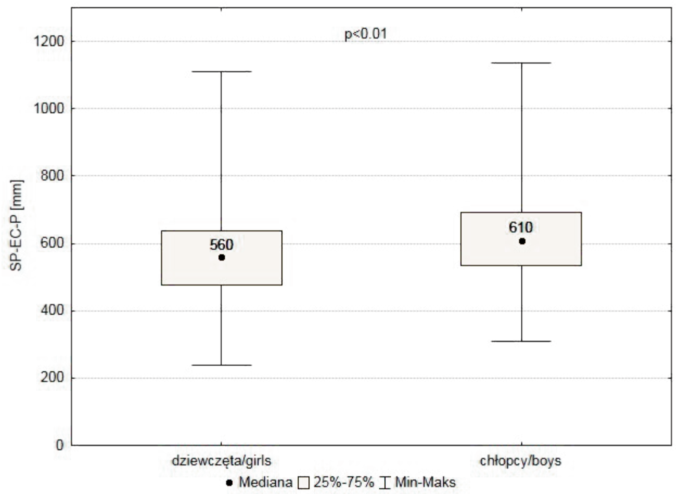

Fig. 8. The differences in length of the SP of the COP, the right lower limb, observed between the girls and the boys; test carried out in EO conditions

The last measured parameter was the Sway Area of the COP, in Eyes Closed conditions. Similarly to the research conducted in Eyes Open conditions, significant differences were observed for the SA-EC (both lower limbs) and SA-R-EC (right lower limb); no differences were observed for the

SA-L-EC (left lower limb). Where the differences observed were significant, poorer results were recorded for male respondents (p≤0.01). These results of the analysis show that, in order to maintain the balance, the Sway Area of the COP for boys was greater, even with closed eyes. (Fig. 9., Fig. 10.)

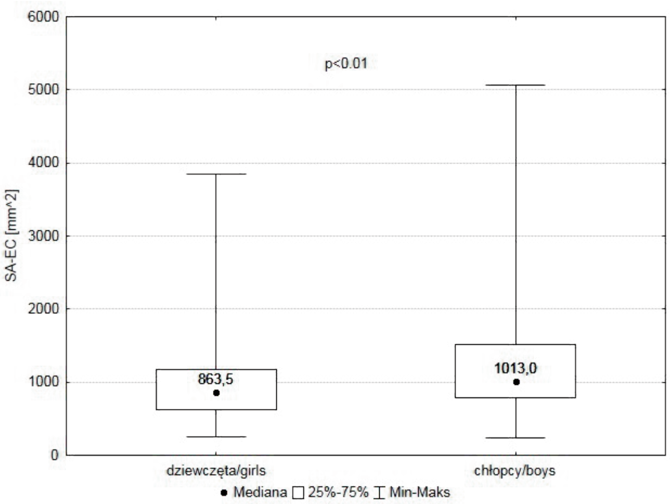

Fig. 9. The differences in size of the SA of the COP observed between the girls and the boys; test carried out in EC conditions

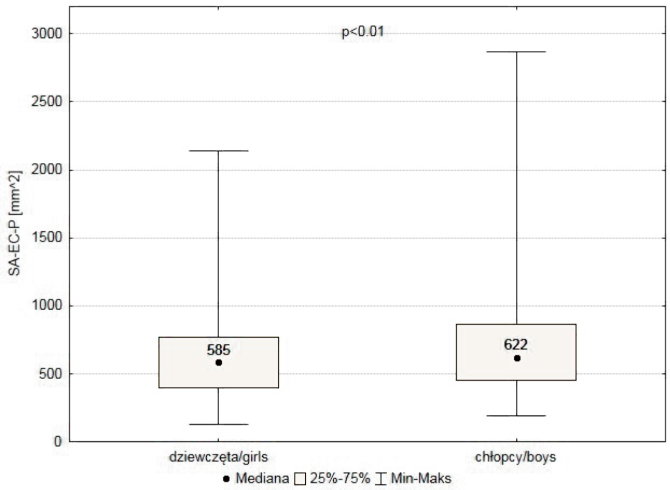

Fig. 10. The differences in size of the SA of the COP observed between the girls and the boys; test carried out in EC conditions

Discussion

The analysis of the results obtained indicates that girls have a significantly better better static posture stability; this was observed in both test conditions (Eyes Open / Eyes Closed), and also when the variable was limb pressure (both lower limbs, only right, only left). The results obtained confirmed the research hypothesis. The analysis of the results obtained confirms that girls have a significantly better static stability. Similar results were obtained by Lee and Lin. They found that the mean radius of the COP of girls had a much smaller value than of boys, both in EO and EC conditions. They also found that the mean radius of the COP of children with mesomorphic musculature had a significantly smaller value than that of ectomorphic, endomorphic and obese children in the EC conditions [22]. Gender differences were probably observed due to the greater body weight of the boys. The somatotype differences could stem from lower hight and a greater muscle structure in the mesomorphic type. In this research, male and female participants were of similar body weight (36.7 ±9.2 for the girls, and 36.9 ±7.4 for the boys) and height (143.6 ±8.7 for the girls and 144.6 ±8,0 for the boys); therefore no significant differences were determined. Carter and Heath somatotype is a review of the human body characteristics in relation to three

elements: adiposity (endomorphism), muscle structure (mesomorphism) and linearity (ectomorfism) [22].
Smith et al. examined children aged 8-12. Female participants had significantly better results i.e. shorter COP Path Velocity ($p < 0.05$), a smaller COP Radial Displacement ($p<0.05$) and smaller COP Area Velocity ($p<0.05$) compared to the males. Correlation analysis indicated that increasing age anthropometric parameters as well as PA level of physical activity correlated with a reduced COP and improved postural stability [20]. Female participants had significantly higher results in these three parameters in correlation with age (COP: -0.83 for the girls and -0.36 for the boys, $p<0.05$), height (COP: -0.89 for the girls and -0.45 for the boys, $p <0.05$) and body weight, BMI, foot size and physical activity level (COP: -0.44 for the girls, $p<0.05$). In contrast, no statistically significant correlation between these three parameters and physical activity level (PA) were observed for the boys. This suggests that girls' physical activity may be an important factor in the development of muscle strength, coordination and body balance, resulting in better postural stability. In this research the female participants ($n = 9$) were heavier and taller than the males ($n = 17$) [20].
On the other hand, a few other studies indicated that there is no difference between girls and boys in the free standing test [23]. Lebiedowska and Syczewska did not identify a statistically significant correlation between height, weight and age and the research parameters [23]. Thus, it seems to be reasonable to analyse these relationships in a much greater research group. Sobera also found that there are no differences in the right and left foot pressure while maintaining balance in a standing position in neither children 2-4 years of age, nor in adults; this thesis is not confirmed by current research. In contrast, a noticeable difference in the speed of movement of the foot pressure point on the ground was observed; this may reflect the efficiency of the central nervous system, different in the two research groups [24].
In conclusion, the interdependencies between basic anthropometric parameters and the static stability indicators as evidenced in this research should be analysed further. The results obtained by this research show that it is necessary to promote physical activity among children, especially among boys, and more attention should be paid to the directed development of equilibrium and coordination capacities in this age range.

Conclusions

1. Analysis of the results obtained indicates a better postural static stability in female participants rather than male participants.
2. Gender differences were observed in both Eyes Open and Eyes Closed conditions; this may indicate the functional developmental variability of the central nervous system responsible for the postural stability control in girls and boys.

adres do korespondencji / corresponding author

Dr Marzena Wiernicka
p.o. kierownik Zakładu Kinezyterapii
ul. Królowej Jadwigi 27/39, 60-871 Poznań,
e-mail: wiernicka@awf.poznan.pl
tel: +48 61 835 51 49

Piśmiennictwo/ References

1. Błaszczyk JW, Czerwosz L. Stabilność posturalna w procesie starzenia. Gerontologia Polska 2005; tom 13 nr 1: 25-36.
2. Wilczyński J.: Korekcja wad postawy człowieka. Anthropos, Starachowice; 2001.
3. Bober T, Zawadzki J. Biomechanika układu ruchu człowieka. BK, Wrocław; 2003.
4. Wolański N. Rozwój biologiczny człowieka. PWN Warszawa; 2012.
5. Starosta W. Motoryczne zdolności koordynacyjne (znaczenie, struktura, uwarunkowania, kształtowanie). Warszawa; 2003.
6. Żak S, Sterkowicz S. Wpływ skoku pokwitaniowego wysokości ciała i wieku dziewcząt na wybrane koordynacyjne zdolności motoryczne. Antropomotoryka AWF Kraków 2004; nr 28: 45-53.
7. Kostiukow A, Rostkowska E, Samborski W. Badanie zdolności zachowania równowagi ciała. Roczniki Pomorskiej Akademii Medycznej w Szczecinie 2009; 55, 3:102-109.
8. Starosta W. Globalna i lokalna koordynacja ruchowa w wychowaniu fizycznym i w sporcie. Warszawa, Międzynarodowe Stowarzyszenie Motoryki Sportowej; Gorzów Wielkopolski, Zamiejscowy Wydział Kultury Fizycznej; 2006.
9. Nowotny J, Saulicz E. Niektóre zaburzenia statyki ciała i ich korekcja. AWF Katowice;1993.
10. Grzegorzewska J. i wsp. Wady postawy dzieci i młodzieży. Wychowanie Fizyczne i Zdrowotne 2007; 4: 9-11.
11. Nowicki J. Rola narządu przedsionkowego w układzie równowagi fizycznej ciała. Pol Przegl Med. Lot 2004;10:121-134.
12. Veldhuizen AG, Wever DJ, Webb PJ. The etiology of idiopathic scoliosis: biomechanical and neuromuscular factors. European Spine Journal 2000; 9: 178–184.
13. Descarreaux M, Blouin JS, Teasdale N. Repositioning accurancy and movement parameters in low back pain subjets and healthy control subjects. European Spine Journal 2005; 14: 185–191.
14. Błaszczyk J W. Kontrola stabilności postawy ciała. Kosmos 1993a; 42(2): 473-486.
15. Błaszczyk JW, Hansen PD, Lowe DL. Postural sway and perception of the upright stance stability borders. Perception, 1993; 22 (11): 1333-1341.
16. Jonsson E, Seiger A, Hirschfeld H. One-leg stance in healthy young and elderly adults: a measure of postural steadiness? Clinical Biomechanics 2004; 19:688-694.
17. Mochizuki L, Duarte M, Amadio AC, Zatsiorsky VM, Latash ML. Changes in postural sway and its fractions in conditions of postural instability. Journal of Applied Biomechanics 2006: 22: 51-60.
18. Golema M. Stabilność pozycji stojącej. Studia i Monografie AWF Wrocław, 1987:17.
19. Błaszczyk JW. Biomechanika Kliniczna. Warszawa PZWL, 2004;192-232.
20. Smith AW, Ulmer FF, Wong DP. Gender Differences in Postural Stability Among Children. Journal of Human Kinetics 2012; vol. 33: 25-32.
21. Peterson ML, Christou E, Rosengren KS. Children achieve adult-like sensory integration during stance at 12-years old. Gait Posture 2006 Jun; 23(4):455-63.
22. Lee Alex JY, Lin Wei-Hsiu. The Influcence of Gender and Somatotype on Single-Leg Upright standing Postural Stability in Children. Human Kinetics, Inc. Journal of Applied Biomechanics 2007; 23(3):173-179.
23. Lebiedowska MK, Syczewska M. Invariant sway properties in children. Gait Posture 2000; 12:200-204.
24. Sobera M. Równowaga ciała w naturalnej pozycji stojącej u małych dzieci i u osób dorosłych. Annales Universitatis Mariae Curie-Skłodowska Lublin Polonia 2005; Vol. LX, Suppl. XVI, 487: 153-156.
25. Geldhof E, Cardon G, De Bourdeauhujij I, Danneels L, Cooreits P, Vanderstreten G, De Clerq D. Static and dynamic standing balance test-retest reliability and references avlues in 9 to 10 yar old children. Eur J Pediatr 2006;65(110):779-786.
26. Nolan L, Grigorenko A, Thorstensson A. Balance control: sex and age differences in 9-to16 -year-olds. Dev Med Child Neurol 2005 Jul; 47(7):449-54.
27. Birmingham TB. Test-retest reliability of lower extremity functional instability measures. Clinical Journal of Sport Medicine 2000; 10:264-268.