796.012.45.332-056.26

BALANCE AND POSTURAL STABILITY IN FOOTBALL PLAYERS WITH HEARING IMPAIRMENT

Daniel SZYMCZYK, Mariusz DRUŻBICKI, Joanna DUDEK, Magdalena SZCZEPANIK, Sławomir SNELA

Institute of Physiotherapy, University of Rzeszow, Poland

РІВНОВАГА І ПОСТУРАЛЬНА СТАБІЛЬНІСТЬ ФУТБОЛІСТІВ З ВАДАМИ СЛУХУ. Даніель ШИМЧИК, Маріуш ДРУЖБІЦКІ, Йоанна ДУДЕК, Магдалєна ЩЕПАНІК, Славомір СНЕЛЯ. *Інститут фізіотерапії, Жешувський Університет, Польща*

Анотація. Утримування рівноваги – це складний процес, який вимагає нормальної функції вестибулярного, візуального та пропріоцептивного апарату. Вестибулярна дисфункція пов'язана з втратою слуху, може призвести до менших або більших специфічних дисбалансів рівноваги і постуральної стабільності.

Ключові слова: постуральний контроль, постурографія, порушення слуху, футбол.

Introduction. Posturography can be defined as a group of methods and techniques used for the assessement of the postural control status and identifying the source of balance and postural stability disorders. Different sensory systems – vestibular, visual and somatosensory are involved in the process of postural control. In order to maintain balance under a variety of environmental situations, these systems should integrate with each other precisely [1] Each sensory system provides the central nervous system with specific information about the position and motion of the body. The visual system plays a predominant role in the development of postural stability in young children, while somatosensory and vestibular systems appear to dominate postural control later in life. Postural control is adult-like by 7-10 years of age [2,3]. Balance impairment is common in elderly people and in patients with vestibular pathology, visual or oculomotor impairment, neurological diseases and musculoskeletal disorders [4,5].

Hearing loss is usually diagnosed in early life. Abnormal or delayed postural development is a common sensorimotor impairment in deaf children and is often associated with vestibular dysfunction. The cochlear and vestibular systems are anatomically and functionally connected, so impairment to either the cochlear or vestibular systems, or both, may cause vestibular disorders and balance dysfunction [6]. The hearing organ and the vestibular system, located next to each other, are integral part of the neuromuscular control system, taking part in coordination and postural control processes [7,8,9].

The data in the literature regarding postural stability in deaf people is limited. Children with hearing loss show a significantly poor performance during the balance tests. The motor development of these children adaptively improved up to 7 years and then plateued. On the other side, studies of postural stability in patients with vestibular dysfunction have shown that the degree of postural sway during quiet stance is normal in conditions in which either visual or somatosensory input is enabled. In contrast, they have a difficulties maintaining postural stability when both visual and somatosensory inputs are inadequate [10].

Force plate posturography techniques allow us to measure the position and displacement of the center of pressure (COP) on the surface of the platform , i.e. during upright stance position. Posturography methods are used to evaluate the active and passive regulation of balance under a variety of conditions. Fundamental elements of most posturography tests include the ability to actively manipulate posture or balance, and evaluate the subject's response to such interventions. Posturography techniques can be classified into two categories, static posturography or dynamic posturography. In static posturography, postural control is evaluated while subjects maintain stance position (usually quiet stance on a stable base of support) [11]. Dynamic posturography concerns the use of experi mentally induced balance perturbations. A common variant is the use of a unstable base of support. Such a platforms can move only in one direction or allow for movement in multiple directions [12].

The aim of the study was to assess and compare balance and postural stability beetwen the deaf and normal hearing indoor football players.

Material and method. 19 deaf football players (mean 26 years, range 18 – 49 years) and and 20 normal-hearing football players (mean age 20 years, range 16 - 34 years) participated in this study. Prior to participation in the study informed written consent was obtained from all subjects and they were asked to complete questionnaire with basic personal details and anthropometric data (age, weight, height). The tensometric force platform (Cosmogamma, Italy) was used for the static posturography tests in this study. The force platform was conected with PC with software for data colecting and processing. The position and displacement of the center of pressure (COP) were measured. Two 30 second tests were performed - in quiet, double - leg standing position on the platform, with opened eyes (test 1) and closed eyes (test 2). Before the trials, the subjects rested for 5 minutes in sitting position. During the test on the platform they stood barefoot and had no visual biofeedback on the PC screen. In order to ensure normalized arrangement of feet during test, the feet spacing pattern built in the platform was used. The subjects were asked to maintain quiet, upright, double – leg standing position with arms along the body for the time of the test. Centre of macular vision for trials with open eyes was at the distance of approximately 1 meter at the height of the subject's eyesight. Before the start of the test, proper position and feet allignment were checked. The recording of data started after subjects adopted stable position and confirmed their readiness for the test.

Software for Cosmogamma balance platform used in this study allows for recording, computation, processing and data storage as well as evaluation and analysis of the following center of pressure (COP) parameters : maximum lateral sway (X axis) [mm], maximum anterior/posterior sway (Y axis) [mm], mean lateral sway (X axis) [mm], mean anterior/posterior sway (Y axis) [mm], path length [mm], average velocity [mm/s], lateral velocity [mm/s], anterior/posterior velocity [mm/s], COP path area (area determined by COP path) [cm 2], area speed [cm 2/s], time within circle of 13 mm; 25 mm; 38 mm; 50 mm [%] distribution of load (right/left side), average load point, postural sway frequency (spectrum of frequency based on Fourier analysis).

Results. Following parameters of center of pressure (COP) were used in this study for further statistical analysis: path length [mm], mean velocity [mm/s], lateral velocity [mm/s], anterior/posterior velocity [mm/s], COP path area [cm 2], maximum lateral sway [mm], maximum anterior/posterior sway [mm], mean lateral sway [mm], mean anterior/posterior sway [mm].

Correlation between age, height, weight, Body Mass Index (BMI) of the subjects and all considered parameters of postural stability tests were analysed. The analysis were made separately for both groups and tests. For the statistical analysis Spearman's rank correlation coefficient was calculated. Table 1 presents the results of Spearman's rank correlation test for all parameters in group of normal hearing football players in test 1 (with eyes opened). Only one statistically significant correlation, between weight and mean anterior/posterior sway, was observed. R value (0.53) in Spearman's rank correlation test indicates an average correlation.

Tab.1

Spearman's rank correlation coefficient value (R) in the group of normal hearing football players, test 1 (opened eyes)

Normal hearing football players, test 1	Age	Weight	Height	BMI
Path lenght (mm)	-0,25	-0,08	-0,11	-0,10
Mean velocity (mm/sec)	-0,34	0,05	0,00	0,02
Lateral velocity (mm/sec)	-0,07	-0,16	0,13	-0,19
Anterior/posterior velocity (mm/sec)	-0,21	-0,11	-0,20	-0,11
COP path area (cm 2)	-0,15	0,23	-0,12	0,14
Max. lateral sway (mm)	-0,13	0,12	-0,01	-0,04
Max. anterior/posterior sway (mm)	-0,19	0,34	-0,11	0,23
Mean lateral sway (mm)	-0,16	0,06	0,29	-0,14
Mean anterior/posterior sway (mm)	-0,22	0,53*	0,05	0,36

In the group of deaf football players, in test 1, correlation between height and almost all considered test parameters were observed (Tab 2). Correlation between height and path lenght, mean velocity, lateral velocity, anterior/posterior velocity, COP path area and mean anterior/posterior sway are statistically significant. Height of the subjects with hearing impairment had an influence on the results of postural stability test with eyes opened. Taller deaf football players were characterized by increased results in test 1.

Tab. 2

Spearman's rank correlation coefficient value (R) in the group of deaf football players, test 1 (opened eyes)

Deaf football players, test 1	Age	Weight	Height	BMI
Path lenght (mm)	-0,08	0,15	0,50*	0,02
Mean velocity (mm/sec)	0,11	0,30	0,62*	0,10
Lateral velocity (mm/sec)	0,08	0,25	0,68*	0,08
Anterior/posterior velocity (mm/sec)	0,12	0,17	0,53*	-0,01
COP path area (cm 2)	0,20	0,29	0,68*	0,05
Max. lateral sway (mm)	0,25	0,32	0,37	0,23
Max. anterior/posterior sway (mm)	0,15	0,22	0,38	0,04
Mean lateral sway (mm)	0,38	0,42	0,43	0,24
Mean anterior/ posterior sway (mm)	0,14	0,13	0,46*	-0,06

The results in test 2 (with eyes closed) were similar. No statistically significant correlation were observed in group of normal hearing football players (Tab. 3). The correlation in this group between age and maximum lateral sway, maximum anterior/posterior sway and mean anterior/posterior sway are weak and not statistically significant.

Tab. 3

Spearman's rank correlation coefficient value (R) in the group of normal hearing football players, test 2 (closed eyes)

Normal hearing football players, test 2	Age	Weight	Height	BMI
Path lenght (mm)	-0,16	-0,03	-0,05	0,00
Mean velocity (mm/sec)	-0,16	-0,03	-0,05	0,00
Lateral velocity (mm/sec)	-0,23	-0,12	0,18	-0,18
Anterior/posterior velocity (mm/sec)	-0,11	0,13	-0,07	0,14
COP path area (cm 2)	-0,25	0,00	0,12	-0,06
Max. lateral sway (mm)	-0,39	0,15	0,18	-0,04
Max. anterior/posterior sway (mm)	-0,44	0,12	0,10	0,00
Mean lateral sway (mm)	-0,10	0,08	0,16	-0,03
Mean anterior/posterior sway (mm)	-0,34	0,08	0,16	-0,02

In the group of deaf football players, in test 2, correlation between height and almost all postural stability test parameters (excluding maximum anterior/posterior sway) were observed (Tab. 4). Correlation between height and path lenght, mean velocity, lateral velocity, anterior/posterior velocity, COP path area, maximum and mean lateral sway are statistically significant. R value in Spearman's rank correlation test for these parameters indicates an average correlation.

Statistical analysis of the obtained results in both groups indicates that only in the group of deaf football players height had an influence on the performance in postural stability test. Taller deaf football players were characterized by increased results in both tests (with eyes opened and closed).

Comparison between the groups of normal hearing and deaf football players in test 1 showed statistically significant differences only in two parameters – maximum and mean lateral sway (Tab. 5). Hearing impairment had no influence on most of parameters in test with opened eyes. Due to the assymetrical distribution of data in both group, median value (Me) of the selected force plate posturography parameters is more valuable. In test 1 mean value and median of path lenght, mean lateral and anterior/posterior velocity were lower in the group of deaf football players, but the difference was insignificant.

Tab.4

Spearman's rank correlation coefficient value (R) in the group of deaf football players, test 2 (closed eyes)

Deaf football players, test 1	Age	Weight	Height	BMI
Path lenght (mm)	0,19	0,36	0,67*	0,17
Mean velocity (mm/sec)	0,17	0,32	0,66*	0,13
Lateral velocity (mm/sec)	0,14	0,23	0,54*	0,03
Anterior/posterior velocity (mm/sec)	0,34	0,44	0,68*	0,25
COP path area (cm 2)	0,16	0,32	0,59*	0,14
Max. lateral sway (mm)	0,20	0,17	0,55*	-0,04
Max. anterior/posterior sway (mm)	0,10	0,26	0,26	0,16
Mean lateral sway (mm)	0,31	0,39	0,59*	0,23
Mean anterior/posterior sway (mm)	0,09	0,43	0,37	0,29

Tab. 5

Comparison of selected parameters of postural stability test between the groups of normal hearing and deaf football players, test 1 (eyes opened)

Parameters Test 1	Group				*p*
	Normal hearing football players ($N = 20$)		Deaf football players ($N = 19$)		
	$\bar{x}$	Me	$\bar{x}$	Me	
Path lenght (mm)	384,1	362,7	337,3	329,7	0,2467
Mean velocity (mm/sec)	18,3	12,3	11,0	11,0	0,1067
Lateral velocity (mm/sec)	6,3	6,0	5,6	5,6	0,3363
Anterior/posterior velocity (mm/sec)	8,1	7,9	6,6	6,6	0,1006
COP path area (cm 2)	2,8	2,2	3,0	2,4	0,6267
Max. lateral sway (mm)	7,2	5,9	8,9	8,8	0,0057**
Max anterior/posterior sway (mm)	9,3	9,3	11,0	8,9	0,8350
Mean lateral sway (mm)	2,3	1,9	2,9	2,5	0,0117*
Mean anterior/posterior sway (mm)	3,0	2,6	3,2	2,7	0,5133

p – Mann-Whitney test results

In test 2 (with eyes closed) no statistically significant differences were observed between the groups (Tab. 6). Lower mean value and median for path lenght, mean velocity, lateral and anterior/posterior velocity, COP path area and maximum anterior/posterior sway in the group of deaf football players may indicate a better postural control, though the difference were insignificant.

Tab. 6

Comparison of selected parameters of postural stability test between the groups of normal hearing and deaf football players, test 2 (eyes closed)

Parameters Test 2	Group				*p*
	Normal hearing football players ($N = 20$)		Deaf football players ($N = 19$)		
	$\bar{x}$	Me	$\bar{x}$	Me	
Path lenght (mm)	533,6	500,0	425,2	392,0	0,0948
Mean velocity (mm/sec)	17,8	16,7	14,2	13,3	0,1006
Lateral velocity (mm/sec)	8,3	8,3	6,8	6,4	0,1131
Anterior/posterior velocity (mm/sec)	12,0	9,6	9,0	8,1	0,1067
COP path area (cm 2)	4,1	3,9	4,7	3,4	0,9668
Max. lateral sway (mm)	8,9	7,9	9,6	9,4	0,5687
Max. anterior/posterior sway (mm)	11,8	11,7	11,8	9,4	0,9668
Mean lateral sway (mm)	2,6	2,2	3,0	2,7	0,1937
Mean anterior/posterior sway (mm)	3,2	3,0	4,1	3,4	0,1749

p – Mann-Whitney test results

Discussion. Sensory processes in postural balance involve interaction and integration of inputs from vestibular, visual and somatosensory systems. In clinical practice, stabilometry is a diagnostic tool used for the assesement of balance and postural control, which is often coupled with other clinical tests to identify the sensory input deficits [13].

Analysis of the results of our study showed almost no statistically significant differences between the groups of deaf and normal hearing football players in both tests. Statistically significant differences between the groups were observed only in two parameters – maximum and mean lateral sway in test 1. In our study hearing impairment had no influence on most of the postural stability test parameters. Besides, lower value of some of the tests parameters (path length, mean velocity, lateral velocity and anterior/posterior velocity) in the group of deaf football players may indicate insignificantly better postural control in this group. Thus a question arises: are deaf persons really characterized by a worse ability to maintain balance than hearing persons? There are many publications describing types of hearing impairment. However, despite close relationship between vestibular and auditory systems, there are limited data regarding postural control system efficiency in these groups.

Wierzbicka-Damska et al. examined a group of boys with hearing impairment and healthy boys as a reference group. For the assessement of postural stability the tensometric platform was used. Two tests were performed, with eyes opened and closed. The results of this study show that postural control in children with hearing impairment is similar to healthy children. The results are surprising, also due to the fact that the control group consisted of boys practising shooting [14]. The results of the study of Grabara also showed us that deaf children are characterized by a better postural stability during quiet standing than hearing children [15]. Despite the vestibular loss, most deaf children reach an adequate postural and gait control. The plastic changes that occur as a consequence of deafness illustrate that the central nervous system also adapts to auditory deprivation by the use of substitutive strategies [16]. This fact indicates that exercise intervention focused on substitution strategies may enhance postural control abilities of children with hearing impairment.

Probably in the group of deaf person the information from proprioceptors and skin receptors are good enough to compensate any disturbances in the reception of information from the other organs controlling balance. Besides the fact of high level of physical activity in the group of football players with hearing impairments participating in our study may have some influence on the good results in balance and postural stability tests.

References

1. *Hsu Ying-Shuo.* Assessing the development of balance function in children using stabilometry/ Kuan Chen-Chieh, Young Yi-Ho //. Intetnational Journal of Pediatric Otorhinolaryngology. – 73 (2009) 737-740.
2. *Peterka R.* Sensorimotor integration in human postural control / Peterka R // J. Neurophysiol. – 88 (3) (2002) 1097-1118.
3. *Horak F.* Postural perturbations: new insights for treatment of balance disorders / Horak F., Henry S., Shumway-Cook A // Phys Ther. – 77 (5) (1997) 517-533.
4. *Tinetti M. E.* Clinical practice. Preventing falls in elderly persons / Tinetti M. E. // N. Engl. J. Med. – 2003; 348 (1):42-9.
5. Why old people fall (and how to stop them) / Voermans N. C., Snijders A. H., Schoon Y., Bloem B. R. // Pract. Neurol. – 2007;7(3):158-71.
6. Evidence of progressive delay of motor development in children with sensorineural hearing loss and concurrent vestibular dysfunction / Rine R.M., Cornwall G., Gan K. [et al.] // Percept. Mot. Skills – 90 (3, Pt 2) (2000) – P. 1101-1112.
7. *Horak F. B.* Postural strategies associated with somatosensory and vestibular loss / Horak F. B., Nasher L. M., Diener H. C. // Exp. Brain Res. – 1990 ; 82(1), 167–177.
8. Vestibular deficits in deaf children. Otolaryngol / Selz P. A., Girardi M., Konrad H. R., Hughes, L. F. // Head Neck Surg. – 1999; 115(1). – P. 70–77.

9. A test of static and dynamic balance function in children with cochlear implants: the vestibular Olympics / Cushing S. L., Chia R., James A. L. [et al.] // Arch Otolaryngol Head Neck Surg. – 2008; 134(1). – P. 34–38.

10. Age-related changes of single- limb standing balance in children with and without deafness / An Mi-hee, Yi Chung-hwi, Jeon Hye-seon, Park So-yeon // Int. J. Pediatr. Otorhinolaryngol. – 73 (2009). – P. 1539-1544.

11. Limited control strategies with the loss of vestibular function / Creath R., Kiemel T., Horak F, Jeka J.J. // Exp Brain Res. – 2002; 145 (3):323-33.Aug.

12. Age-dependent variations in the directional sensivity of balance corrections and compensatory arm movements in man / Allum J.H., Carpenter M.G., Honegger F. [et al.] // J. Physiol. – 2002; 542 (Pt 2). – P .643-63. .

13. Static and dynamic posturography in patients with vestibular and cerebellar lesions / Baloh R.W., Jacobson K.M., Beykirch K., Honrubia V. // Arch. Neurol. – 55 (1998). – P. 649-654.

14. Postural stability in 10-16 years old boys with hearing impairment / Wierzbicka-Damska I., Samołyk A., Jethon Z. [et al.] // Fizj.Pol. – 2005; 5 (2):143-148.

15. *Grabara M.* Dysfunkcje narządu słuchu a asymetria postawy ciała / Grabara M. // Fizj.Pol. – 2006; 2 (4). – P. 121-125.

16. Balance sensory organization in children with profound hearing loss and cochlear implants / Juarez H., Angeli S., Juarez A. [et al.] // Int. J. Pediatr. Otorhinolaryngol. – 71 (2007). – P. 629-637.

RÓWNOWAGA I STABILNOŚĆ POSTURALNA PIŁKARZY Z ZABURZENIAMI SŁUCHU

Daniel SZYMCZYK, Mariusz DRUŻBICKI, Joanna DUDEK, Magdalena SZCZEPANIK, Sławomir SNELA

Instytut Fizjoterapii, Uniwersytet Rzeszowski, Polska

Anotacja. Utrzymanie równowagi jest złożonym procesem, który wymaga prawidłowej funkcji układu przedsionkowego, wzrokowego i proprioceptywnego. Zaburzenie funkcji układu przedsionkowego, związane z utrata słuchu, może powodować występowanie mniej czy bardziej specyficznych zaburzeń równowagi i stabilności posturalnej.

Słowa kluczowe : kontrola posturalna, posturografia, zaburzenia słuchu, piłka nożna

BALANCE AND POSTURAL STABILITY IN FOOTBALL PLAYERS WITH HEARING IMPAIRMENT

Daniel SZYMCZYK, Mariusz DRUŻBICKI, Joanna DUDEK, Magdalena SZCZEPANIK, Sławomir SNELA

Institute of Physiotherapy, University of Rzeszow, Poland

Annotation. Maintenance of balance is a complex process which requires a proper function of vestibular, visual and proprioceptive systems. Impaired function of the vestibular system, associated with hearing loss , may result in more or less specific balance and postural stability disorder.

Key words: postural control, posturography, hearing impairment, football.