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EVALUATION OF BALANCE OF OLDER PERSONS USING THE *SIGMA BALANCE PAD*

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Sum mary

This article represents the indices of evaluation of balance for persons aged 60 and older using the Sigma Balance Pad balance evaluation platform. For processing qualitative data, methods of statistical analysis (descriptive statistics, t test comparing averages, Anova test, correlation analysis) were used. The sample group of people who underwent testing included 70 individuals aged 60 or older selected by the method of non-deterministic sampling. Balance was evaluated on 10 objective indicators: maximum left and right deflection, maximum forward and backward deflection (cm), average deflection from the X and Y axes (cm), average speed of movements in the X and Y axes (cm/s), length (cm) and width of view (cm). The study showed that the average speed on the X and Y axes is correlated with the length and width of the view. This means that the largest length and width with respect to the view on the screen is "shown" by those people whose speed on the X and Y axes is greater. When analyzing maximum deflections back and forth certain statistical relations were revealed, which allows to predict tendencies of falling of people to the one side or the other. The maximum deviation to the right is associated with a maximum forward deflection, and maximum deflection to the left with a maximum deviation backward. The results showing the balance of the studied persons in the group of people aged 60 to 70 and older are similar, and hence we can assume that the balance is affected by other factors. Persons who pass the balance test with worse results, often experience falling in real life. The characteristics of balance for the patients suffering from vertebroneurological and neurological diseases are also worse.

INTRODUCTION

Good balance and mobility are the main determinants of quality of life. The balance is characterized by the ability to maintain stability in standing position and in motion. Technical characteristics of the balance are associated with the ability to keep the overall center of body mass within the boundaries of breadth of stance in sitting and standing position and during walking. Balance is a necessary component of daily functional activity, and balance control is a complex and multi-functional factor. The functional task and the environment in which a given task is performed, is predetermined by balance control. Balance can predetermine a lot of confusing factors – environment, complexity of the task, sensorimotor factors [4]. Balance can be evaluated in a standing position (static balance) or in motion (dynamic balance). Stability or ability to maintain a stable position can be measured by the movement of the center of body mass on breadth of stance. Also balance can be evaluated indirectly through observation and objective testing of functional activity [2, 8].

Physiological changes with aging, such as decrease of muscle strength, visual perception, proprioception, range of limbs motion, slowing of reaction time, changes in the sensory system affect the balance and the deviations of its control. Disorders of balance are associated with risk of falling. An essential aspect of mobility is the ability to walk and move safely, without falling, but falling is often found among older people and can result in serious injury, loss of independence and nursing home. Fear of falling affects the social disassociation and restriction of activity [3]. Although the causes of falls vary and are complex, often the factor determining fall is the deviation of the control of manner of walking (balance). These deviations can determine: slips, stumbling, collision or physical interaction with moving or stationary objects in the environment. Keeping the balance regulates the relationship between the center of body mass and the support surface. Moving the center of body mass decreases with the rapid generation of muscular leverage in the ankles, knees or other limbs, expressed in balancing reactions to keep the body in an upright position [6]. However, due to the aging process the superficial and deep sensations of the skin are lost, having an impact on manifestations of balancing reactions [7]. The results of studies, during which the changes of the overall center of body mass were evaluated, demonstrate that the aging process alters or disturbs response of the CNS in a standing position or during voluntary movements. Increasing risk of falling determines response of the legs in a standing position or during walking and the deviation of the lateral control of the body. Due to the aging process the ability to adapt to keeping stability of the body at changes of environment, supporting surfaces or tasks slows down. Abnormal or slow adaptation affects the risk of falling in daily life.

The balance of the human body depends on functional relations of the organism in the integration of multi-segment sensory information and regulation of skeletal-muscular system position. Due to the aging process of the human body, the activity of the elements of the mechanism of balance decreases, and this reduces stability and disrupts the manner of walking [3]. Therefore, early detection of balance disorders is important when assessing functional mobility of older persons and preventing falling [1]. Studies of balance disorders demonstrate that changes of balance recorded by the training device in the form of a vibrating platform help uncover deviations which lead to instability, explain the pathogenesis of these disorders and evaluate compensatory functions of the body. Many studies were undertaken, in

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which various changes were defined in the functional state of the body, occurring due to aging. While conducting these studies, clinical tests were most commonly used to assess functional status, as they are convenient and easy to execute. With the help of instrumental researches of the functional state it is possible to accurately assess changes in functional status; however, the equipment used during these surveys is stationary, and it is more comfortable to test older people in their homes. One of the most commonly used instrumental methods of static balance studying is posturography. This method is used in diagnosis of balance disorders, studying of influence of different factors or for training of statokinetic functions. There are several options of posturography method, which are used for performing tests in vertical position [5].

The purpose of this article is to assess the balance of older persons using the *Sigma Balance Pad*.

NUMBER OF RESPONDENTS AND RESEARCH METHODOLOGY

The study group was formed from 70 individuals aged 60 and older selected by the method of non-deterministic sampling. Many of the examined people live in Kaunas and Kaunas district.

Used research methods include: analysis of scientific literature; testing (objective evaluation of balance); analysis of statistical data using SPSS 17 (descriptive statistics, t test comparing averages, Anova test).

The study was conducted using the *Sigma Balance Pad* objective balance evaluation platform. The study was conducted in accordance with the defined stages, such as: a) platform calibration; b) providing a person with information about the procedure and warning on how to behave in case of sudden loss of balance; (c) trial testing of balance without data registration (it was allowed to stand on the platform for 1-2 minutes); (c) collection of sociodemographic data; (d) re-calibration of the platform; e) testing the balance with a computer and data registration (during 60 seconds). During the study much attention was paid to monitoring the patient’s condition and ensuring his safety (safe stepping up and down the platform).

The practical significance of this study was achieved, as it was carried out by the professional kinetotherapist. Together with an examined person the expert discussed the obtained data, gave recommendations on how to minimize the risk of falling.

Balance was evaluated in the common group of persons aged 60 or older and in separate groups: a) men and women; (b) group of persons aged 60-69 years and 70 years or older; (c) on the frequency of falling; (d) on diseases.

Balance was evaluated on 10 objective criteria: maximum left and right deflection, maximum backward and forward deflection (cm), average deflection from the X and Y axes (cm), average speed of movement of the track along the X and Y axes (cm/sec); hereinafter only the concepts of average speed, length (cm) and width of view (cm) are used.

RESULTS AND DISCUSSION

The correlation analysis showed that there were statistically significant differences between the individual indicators for balance evaluation (table 1). There is a strong correlation when the correlation coefficient ranges from 0.7 to 1 between the average speed on the X axis and average speed on the Y axis (R=0.83, p=0.00), length (R=0.92, p=0.00) and width of view (R=0.73, R=0.00). Also a strong statistical relationship was determined between the average speed along the Y axis and length (R=0.99, p=0.00) and width of view. It can be concluded that the average speed on the X and Y axes is correlated with the length and width of view. This would mean that the larger length and width of view will be demonstrated by those whose speed at the X and Y axes is greater. Medium (R=0.5-0.7) or weak (R=0.2-0.5) correlation is determined by assessing the maximum right, left, forward and backward deflection. During the analysis of maximum backward and forward deflections a certain connection was revealed, which allows to predict the tendencies of falling. The maximum right deflection is associated with the maximum forward deflection (R=0.32, p=0.01), and the maximum left deflection – with the maximum backward deflection (R=0.59, p=0.00).

In the group of older persons, the maximum left deflection reaches -0,36 cm, right deflection – 0,29 cm. The maximum forward and backward deflections are distributed in a similar way along the axes X and Y.

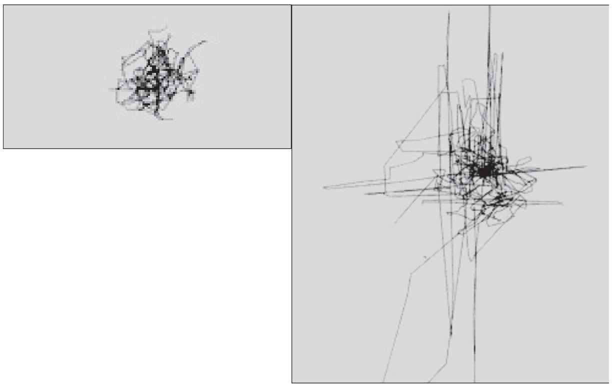
Table 1. Correlation of indices of balance evaluation

	Max left deflection	Max right deflection	Max backward deflection	Max forward deflection	X axis deflection	Y axis deflection	X axis average speed	Y axis average speed	View length	View width
Max left deflection (R) *value P*	1,00	-0,08 0,50	**0,59 0,00**	-0,14 0,23	**0,54 0,00**	0,35 0,00	**-0,54 0,00**	-0,47 0,00	**-0,52 0,00**	**-0,73 0,00**
Max right deflection (R) *value P*	-0,08 0,50	1,00	**-0,26 0,03**	**0,32 0,01**	**0,55 0,00**	-0,01 0,93	**0,54 0,00**	**0,40 0,00**	**0,48 0,00**	**0,59 0,00**
Max backward deflection (R) *value P*	**0,59 0,00**	**-0,26 0,03**	1,00	0,15 0,21	0,16 0,17	**0,68 0,00**	**-0,42 0,00**	**-0,47 0,00**	**-0,44 0,00**	**-0,63 0,00**
Max forward deflection (R) *value P*	-0,14 0,23	**0,32 0,01**	0,15 0,21	1,00	0,17 0,16	**0,56 0,00**	**0,40 0,00**	**0,41 0,00**	**0,47 0,00**	**0,50 0,00**
X axis deflection (R) *value P*	**0,54 0,00**	**0,55 0,00**	0,16 0,17	0,17 0,16	1,00	**0,29 0,01**	-0,04 0,73	-0,04 0,74	-0,05 0,70	-0,05 0,68
Y axis deflection (R) *value P*	**0,35 0,00**	-0,01 0,93	**0,68 0,00**	**0,56 0,00**	**0,29 0,01**	1,00	-0,07 0,58	-0,03 0,79	-0,02 0,90	-0,15 0,21
X axis average speed (R) *value P*	**-0,54 0,00**	**0,54 0,00**	**-0,42 0,00**	**0,40 0,00**	-0,04 0,73	-0,07 0,58	1,00	**0,83 0,00**	**0,92 0,00**	**0,73 0,00**
Y axis average speed (R) *value P*	**-0,47 0,00**	**0,40 0,00**	**-0,47 0,00**	**0,41 0,00**	-0,04 0,74	-0,03 0,79	**0,83 0,00**	1,00	**0,93 0,00**	**0,68 0,00**
View length (R) *value P*	**-0,52 0,00**	**0,48 0,00**	**-0,44 0,00**	**0,47 0,00**	-0,05 0,70	-0,02 0,90	**0,92 0,00**	**0,93 0,00**	1,00	**0,74 0,00**
View width (R) *value P*	**-0,73 0,00**	**0,59 0,00**	**-0,63 0,00**	**0,50 0,00**	-0,05 0,68	-0,15 0,21	**0,73 0,00**	**0,68 0,00**	**0,74 0,00**	1,00

Table 2. Objective indices of balance evaluation

Indices	Max left deflection	Max right deflection	Max backward deflection	Max forward deflection	X axis deflection	Y axis deflection	X axis average speed	Y axis average speed	View length	View width
Average value	**-0,36**	**0,29**	**-0,34**	**0,37**	**-0,03**	**0,01**	**0,20**	**0,22**	**16,75**	**0,53**
St. deflection	0,22	0,19	0,25	0,22	0,12	0,12	0,09	0,11	6,54	0,49
Minimum	-0,95	-0,04	-1	-0,19	-0,62	-0,4	0,09	0,09	7,32	0,06
Maximum	-0,02	1	0,06	1	0,16	0,32	0,56	0,68	44,43	2,61

Fig. 1. Balance examination samples (A – figure showing good balance, B – figure showing inadequate balance)



A **B**

The maximum backward deflection reaches 0.34 cm, forward deflection – 0.37 cm. The average number of deflections from the X axis reaches 0.20 cm/sec, Y axis 0.22 cm/sec. The length of view reaches 16.75 cm and the width is 0.53 cm^2. Minimum and maximum indicators value are allocated in different ways. The minimum value of the maximum left deflection is 0.95 cm, while the maximum is -0.02 cm. The maximum left deflection reaches 0.04-1 cm, the maximum backward deflection is -1-0.06, the maximum forward deflection is -0.19-1 cm. Deflection from the X axis reaches -0.62-0.16 cm, from Y axis -0.4-0.32 cm. The minimum value of average speed along the X axis is 0.09 cm/sec and the maximum is 0.56 cm/sec. There are quite large differences between the average speed on the Y axis (ranging from 0.09 to 0.68 cm/sec). In the studied population there are obviously different lengths (from 7.32 to 44.43 cm) and width of view (from 0.06 to 2.61 cm^2) (table 2).

Fig. 1 shows the different results of the evaluation of balance of the examined persons.

Fig. 2. Objective indices of balance evaluation considering the gender of examined people

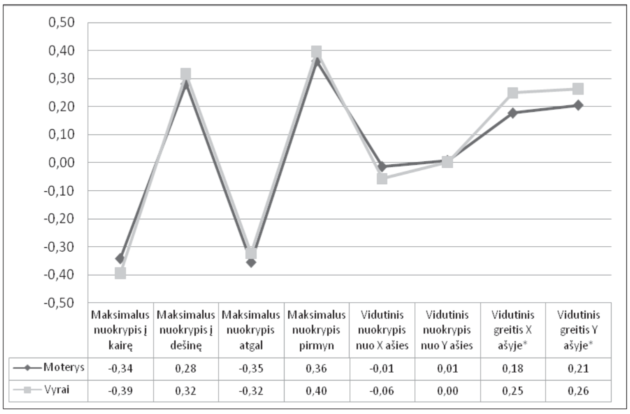
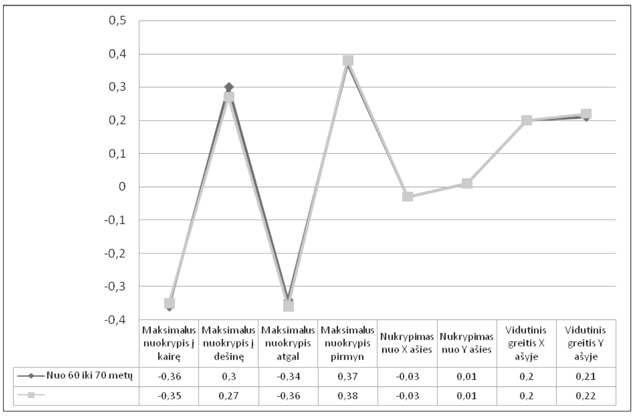


Table 3. Difference between the length and the width of balance view by social and demographic groups and considering frequency of falling of examined people

Groups	View length (cm)	View width (cm²)
Gender		
Female	15.78	0.53
Male	18.88	0.54
Age		
60-70	16.00	0.54
70 and older	17.85	0.50
Falling frequency		
Few times per month	17.16	0.84
Once a month and more rarely	15.70	0.40

Fig. 3. Objective indices of balance evaluation considering ages of examined people



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In situation A we see a more concentrated view slightly deviated from the 0 value. Another illustrative figure shows possible large balance disturbances, in which all indices are widely distributed along the X and Y axes.

When comparing objective indices of balance between men and women some statistical differences were revealed (T test, p≤0.05). In female group the average speed along the X axis was up to 0.18 cm/h, in male group – 0.25 cm/s (t=-3.450, p=0.001). The average speed on the Y axis was also greater in the male group and reached to 0.26 cm/sec, and in the female group it was 0.21 cm/sec (t=-2.162, p=0.034). Although statistically significant differences were not obtained, however, it can be seen that the maximum left, right, forward deflections are bigger in male group (Fig. 1). When assessing the length and width of view in male and female group no statistically significant differences were found (table 3).

When comparing the results of two groups it was revealed that persons aged 60-70 and over 70 have very similar balance indices (t test, p≥0,05). No statistically significant differences were found during evaluation of maximum right and left deflection, maximum forward and backward deflection, average deflection from the X and Y axes, average speed at the axes X and Y (Fig. 3). When assessing the length and width of view no statistically significant differences in both age groups were found as well (table 3).

For a more complete definition of characteristics of balance in the group of older people not only objective data was analyzed, but the subjective data as well. The objective indices of balance evaluation were compared with the frequency of falling for these individuals (Fig. 4). It shall be noted that the test results for evaluating the balance were worse for those who more often experienced falling. Maximum left deflection for individuals who fall several times per month reached -0.57 cm, and for those who fall once a month and more rarely it was -0.36 cm. This finding is statistically significant (t=-2.155, p=0.041). Also, there were differences between the maximum right deflection.

In the group of persons who often experience falling, the maximum average number of right deflections reached 0.38 cm, including -0.21 cm in the other group (t=2.309, p=0.029). In group of those who fall more frequently, a larger average number of deflections from the X axis was detected (t=-2.101, p=0.045) and almost half a large view area, where t=3.143, p=0.004 (table 3). Thus, it can be stated that there is a correlation between objective and subjective balance evaluation. Persons who pass the balance test with getting worse results fall more often in real life.

Considering the kinds of diseases, only some balance evaluation indices differ (table 4). The largest maximum left deflection was identified in individuals suffering from vertebroneurological (-0.43 cm) and neurological diseases (-0.51 cm). In almost all cases the characteristics reflecting the balance of the individuals suffering from vertebroneurological and neurological diseases were much removed from the initial points (0), having large deflections along the X and Y axes. Greater deflection from the X axis was detected between the individuals with neurological problems (F=3.821, p=0.014). It can be assumed that in future, after increasing the examined sample and its focused formation considering specific diseases, it will be possible to obtain accurate balance evaluation results, which can successfully be applied in clinical practice and which can open new opportunities for further research.

Fig. 4. Objective indices of balance evaluation considering frequency of falling

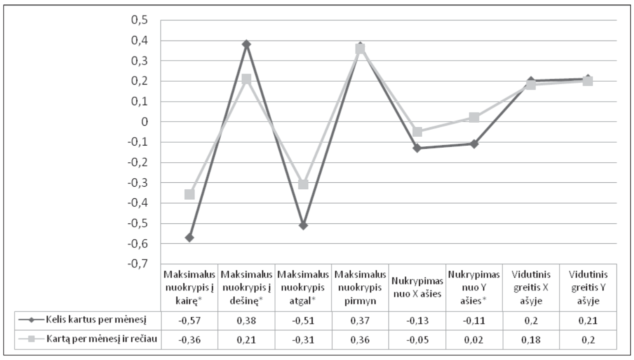

Table 4. Balance evaluation indices considering specified diseases

Indices	Cardiovascular diseases	Vertebroneurological diseases	Neurological diseases	Other diseases
Max left deflection	**-0,31**	**-0,43**	**-0,51**	**-0,32**
Max right deflection	**0,29**	**0,33**	**0,21**	**0,30**
Max backward deflection	**-0,26**	**-0,42**	**-0,38**	**-0,34**
Max backward deflection	**0,43**	**0,33**	**0,38**	**0,37**
X axis deflection	**-0,01**	**-0,02**	**-0,15**	**-0,01**
Y axis deflection	**0,00**	**-0,03**	**0,00**	**0,02**
X axis average speed	**0,18**	**0,19**	**0,18**	**0,21**
Y axis average speed	**0,18**	**0,21**	**0,20**	**0,24**
View length	**14,84**	**16,98**	**15,79**	**17,28**
View width	**0,42**	**0,65**	**0,56**	**0,52**

CONCLUSIONS

1. The study showed that the average speed on the X and Y axes is correlated with the length and width of the view. This means that the largest length and width with respect to the view on the screen is “shown” by those people whose speed on the X and Y axes is greater. When analyzing maximum deflections back and forth certain statistical relations were revealed, which allows to predict tendencies of falling of people to the one side or the other. The maximum deviation to the right is associated with a maximum forward deflection, and maximum deflection to the left with a maximum deviation backward.

2. Maximum left, right, forward deflections are the biggest in group of male respondents. The results showing the balance of the studied persons in the group of people aged 60 to 70 and older are similar, and hence we can assume that the balance is affected by other factors. Persons who pass the balance test with getting worse results fall more often in real life. The individuals suffering from vertebroneurological and neurological diseases have worse balance evaluation indices.

3. In future, after increasing the examined sample and its focused formation considering specific diseases, it will be possible to obtain accurate balance evaluation results, which can successfully be applied in clinical practice and which can open new opportunities for further research.