Assessment of Postural Stability Using the Zebris Platform in Women above the Age of 60

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Abstract:

Introduction. Balance control and body posture stability disorders progressing with age are caused by the involutionary changes in the function of the motor and nervous systems. However, it is indicated that regular physical activity, also in older adulthood, may have a positive effect on maintaining the functions of individual systems at an optimal level.

Study aim: The aim of the study was to assess the postural stability of women above the age of 60 who declare active lifestyles.

Material and Methods. The research involved 24 women, who were arbitrarily divided into 3 groups according to their calendar age. The younger group consisted of 14 women below the age of 70 years (\( \bar{x} = 65.08; SD = 2.82 \)), whereas the older group comprised 10 older adults, above the age of 70 (\( \bar{x} = 73.62; SD = 2.74 \)). The scope of the study included evaluation of selected postural stability parameters: 95% of the ellipse area covered by the moving COP, statokinesiogram path length, mean speed regarding displacement of the centre of foot pressure, total left and total right foot pressure. The examinations were performed in June 2018 using the Zerbis FDM-S dynamographic platform. The research material collected in this way was subjected to statistical analysis. Basic descriptive statistics were calculated and normality of the distribution of variables was verified using the Shapiro-Wilk test. The Student’s t-test for independent variables or Mann-Whitney’s U-test (depending on the distribution) were used to determine the significance of differences concerning the analysed parameters of postural stability between the groups studied. Furthermore, for 95% of the ellipse area covered by the moving COP, statokinesiogram path and mean speed of the displacement of the centre of foot pressure and standardised profiles were calculated for both chronological age groups. Standardisation of the results was performed using means and standard deviations of the entire material (T scale).

Results. The results of the study indicate a higher level of postural stability among women from the younger group. However, comparative analysis did not reveal any statistically significant intergroup differences. Mean point scores on the T scale in the group of younger women for the 3 variables ranged from 50.98 to 51.60 points, whereas for older women, this was from 48.90 to 48.98 points. The differences between characteristics in the group of younger women totalled ca. 0.62 points, while in the older group, this value was 0.08 points.

Conclusions. Comparative analysis allowed to show that postural stability indices in women above 70 decreased compared to the results obtained for the younger group. Regular physical activity may be one of the significant factors in the prevention of postural stability regression.
Introduction

In scientific literature, balance of the body is defined as the ability to maintain the projection of the body’s centre of gravity within the support surface defined by the contact area of the feet with the ground [1]. While standing, a person strives for a steady state of balance, but never achieves it - alternately losing and regaining it over and over again. This is possible thanks to constantly performed corrective and stabilising movements [2]. This process, referred to as postural stability, means the body’s ability to regain a given position in space after disruption from within the body ceases, as well as from environmental variability and integration with one’s surroundings. Hence, it is recognised that postural stability is a concept broader than that of body balance. The system of controlling steering and regulating stability of posture includes many structures of the nervous system which, together with the musculoskeletal system, maintains the human body in an upright position [1, 3].

Body posture stability changes with age - from childhood to old age. Disturbances in the control of body stability and balance are closely related to involu- tion processes, which are the natural and physiological manifestation of aging. It is estimated that in the elderly, body posture stability is significantly impaired due to the deterioration of the motor and nervous systems, including: weakening of sense organ functions, improper transmission of nerve impulses to the central nervous system, misinterpretation of impulses in the central nervous system, prolonged reaction time, muscle atrophy and diseases of the musculoskeletal system [4, 5, 6].

Vody stability of the elderly is also influenced by comorbidities such as pain, anxiety and depression [4], as well as factors of exogenous origin such as the type of surface as well as auditory, visual or sensory stimuli. This means that the elderly are characterised by a significant limitation in the range and speed of movements related to maintaining balance and a stable body posture [3]. At the same time, it has been indicated in literature on the subject that participation in increased physical activity may have a beneficial effect on improving balance and stability of body posture [7]. This is especially true when the training unit is supplemented with additional balance exercises, as shown in the research conducted by Yaggie and Campbell [8]. However, it can also be observed that in the majority of studies conducted so far, assessing the importance of physical activity for improving balance and control of postural stability, were conducted with the participation of various groups of athletes [7] or younger individuals [8].

In recent years, due to the rapid increase in the number of people above the age of 60 in the population, there has been elevated interest in the issues of preventing premature motor failure in the elderly. The subject of many scientific studies has been focused on reducing morbidity and improving the quality and length of human life, including more and more studies on the assessment regarding the effects of physical activity on the reduction of civilization diseases, as well as the number of falls among the elderly. It is estimated that an appropriate level of balance not only reduces the risk of falls among the elderly, but also facilitates performance of everyday activities in an appropriate manner [5, 6]. Therefore, more and more attention is being paid to the issue of postural stability and balance among seniors.

Assessment of postural stability and maintaining balance in the elderly is most often carried out on the basis of various functional tests. These include: Dynamic Gait Index, Stops Walking When Talking, Timed Get-Up & Go Test, Performance-Oriented Mobility Assessment, Four Square Step Test, One Leg Standing Test, Functional Reach Test, Berg Test and the Step Test, a review and detailed description of which can be found in [4]. However, as a result of dynamic technological progression, devices constructed on the basis of stabilographic platforms are increasingly used in scientific research aimed at assessing postural stability [5]. Currently, there are various types of platforms on the market for the assessment of postural stability indices. They constitute an objective tool for evaluating postural stability, enabling precise registration of COP (centre of pressure) of the feet on the ground and their displacement. One example of this type of device is the single-board Zerbis FDM-S platform. This model consists of calibrated force sensors that allow assessment of density distribution concerning static and dynamic forces that arise under the feet during standing and walking. Another advantage is its small size and weight, which greatly facilitates transportation of the platform, making testing at various locations possible. The use of the stabilographic platform in the elderly allows to determine not only the efficiency of regulation of body posture stability, but also to diagnose early imbalances that increase the risk of falling [5]. This type of apparatus also allows the performance of postural tasks with feedback, which is often used in rehabilitation training [3].

The results of available studies conducted by other authors with the participation of elderly people, in which stabilographic platforms were used as a measurement tool, generally indicate that in people above the age of 60, there are significant involutional changes in the process of balance control and stability of body posture [5, 6]. Hence, taking into account the above observations, the aim of the study was to assess selected indices of postural stability among women aged 60+, declaring an active lifestyle.
Materials and methods

The research material consists of research results (June 2018) during practical workshops at the 2nd National Scientific Conference: “For Healthy and Active Aging”. A total of 24 women declaring an active lifestyle participated in the study. The subjects were divided into 2 groups, the calendar age of women was adopted as the criterion for division:

- the group of younger women above the age of 60 - 14 women (x_{min} = 63.27; x_{max} = 69.29 years),
- the group of older women above the age of 70 - 10 women (x_{min} = 70.10; x_{max} = 78.70 years).

The mean age in the group of younger women was 65.08 ± 2.82 years, while in the older group, this averaged 73.62 ± 2.74 years.

The scope of the research included the measurement of selected postural stability indices: 95% of ellipse area marked by moving COP, length of statokinesiogram path, average velocity of foot COP displacement, total pressure of left and right foot. In the trial, the Zerbis FDM-S dynamographic platform was used. During measurements, the examined person assumed a free standing position with the upper limbs positioned along the trunk, the head in a neutral position and the eyes directed towards a point 2 metres away, the examined person’s eyes open, and the feet placed parallel to the width of the shoulders. The measurement was carried out without shoes. The method of positioning the examined women, as well as the dynamographic platform used in the research, are presented in Figure 1.

The research material collected in this way was subjected to statistical analysis, and basic descriptive statistics were calculated for all analysed variables: arithmetic mean (\(\mu\)), minimum (min), maximum (max) and standard deviation (SD). The normality of the distribution of variables was assessed via the Shapiro-Wilk test, and analysis of intergroup differentiation was also conducted. Depending on the distribution of variables, the Student’s \(t\)-test for independent samples or the non-parametric Mann-Whitney U test were used to assess differences between groups. In the case of the variables: 95% of ellipse surface area marked by moving COP, length of statokinesiogram path and average velocity foot COP displacement - the values normalised on the T-point scale were additionally calculated.

All calculations were performed using the Microsoft Office Excel 2007 spreadsheet and Statistica v.12.0 PL for Windows. The results of the tests applied in statistical analysis were considered statistically significant at the level of \(p \leq 0.05\).

Results

Based on the data collected during the study and the results of statistical calculations, the differentiation in the level of static balance in 2 groups of women (younger and older) was determined. Regardless of the results of statistical significance regarding intergroup differentiation of the analysed variables, the normalised values were assessed. Detailed results of statistical calculations are presented in Tables 1-4 and in Figure 2.
Analysis of the intergroup differentiation of the assessed postural stability indices allows to indicate that the mean value of the ellipse area marked by the foot COP in the group of younger women had a smaller area (170.59 ± 131.10 mm²) compared to the group of older women (198.76 ± 107.79 mm²). The mean value of the statokinesiogram path length in the group of younger women was 489.28 ± 170.53 mm, while COP velocity was 17.13 ± 5.97 mm/sec. Mean values for the statokinesiogram path length and COP velocity in the group of elderly women were 592.39 ± 369.56 mm and 20.75 ± 12.75 mm/sec. In the case of both variables, the arithmetic mean in younger women had a lower value than the results obtained for older women (Tab. 1 and 2). However, comparative analysis of the variables did not reveal any significant differences between groups (Tab. 3). The intergroup differentiation profiles presented in Figure 2 allow to conclude that the mean point value of the analysed variables indicates their higher level among younger women. The arithmetic means of normalised values in the group of older women ranged from 48.90-48.98 points, while in the group of younger women, they totalled 50.98-51.60 points. The range of differences between groups ranged from 2.00 to 2.69 points. Assessing differentiation within features of the analyzed variables, it can be observed that in the group

<table>
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<th>VARIABLE</th>
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<tbody>
<tr>
<td>95% of ellipse area, mm²</td>
<td>170.59</td>
<td>71.34</td>
<td>537.92</td>
<td>131.10</td>
<td>0.69*</td>
<td>0.000</td>
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<tr>
<td>COP path length, mm</td>
<td>489.28</td>
<td>288.46</td>
<td>778.54</td>
<td>170.53</td>
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<td>0.066</td>
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<td>COP mean speed, mm/sec</td>
<td>17.13</td>
<td>10.10</td>
<td>27.27</td>
<td>5.97</td>
<td>0.88</td>
<td>0.067</td>
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<tr>
<td>Total pressure force of left foot, %</td>
<td>48.93</td>
<td>40.18</td>
<td>53.54</td>
<td>3.84</td>
<td>0.92</td>
<td>0.190</td>
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<tr>
<td>Total pressure force of right foot, %</td>
<td>51.07</td>
<td>46.46</td>
<td>59.82</td>
<td>3.84</td>
<td>0.92</td>
<td>0.190</td>
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* lack of normal distribution

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<tr>
<td>95% of ellipse area, mm²</td>
<td>198.76</td>
<td>59.25</td>
<td>433.58</td>
<td>107.79</td>
<td>0.932</td>
<td>0.465</td>
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<td>COP path length, mm</td>
<td>592.39</td>
<td>177.18</td>
<td>1408.72</td>
<td>369.56</td>
<td>0.897</td>
<td>0.203</td>
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<tr>
<td>COP mean speed, mm/sec</td>
<td>20.75</td>
<td>6.20</td>
<td>49.37</td>
<td>12.95</td>
<td>0.897</td>
<td>0.202</td>
</tr>
<tr>
<td>Total pressure force of left foot, %</td>
<td>48.78</td>
<td>37.34</td>
<td>55.08</td>
<td>5.81</td>
<td>0.913</td>
<td>0.302</td>
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<tr>
<td>Total pressure force of right foot, %</td>
<td>51.22</td>
<td>44.93</td>
<td>62.66</td>
<td>5.81</td>
<td>0.913</td>
<td>0.302</td>
</tr>
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* lack of normal distribution

Table 1. Descriptive statistics and results of Shapiro-Wilk test in the group of younger women

Table 2. Descriptive statistics and results of Shapiro-Wilk test in the group of older women

Fig. 2. Normalised values of analysed variables in 2 groups of women
of younger women, the values is 0.62 points, while in the older group, this was 0.08 points. The results of assessment regarding inter-feature differentiation are presented in Table 4.

Referring to the results of the foot pressure distribution on the ground, it can be stated that the total pressure of the left foot on the ground in older women was 48.78 ± 5.81%, while in younger women, this equalled 48.93 ± 3.84%. Analysis of the Student’s t-test results (Tab. 3) showed no statistically significant differences between groups in the level of the left foot pressure distribution. In the case of the right foot, it may also be observed that in the group of younger women, the total pressure force of the right foot was 51.07 ± 3.84%, while in the case of older women, it was 51.22 ± 5.01%. The obtained results of the Student’s t-test presented in Table 3 do not allow to noted any significant differences between groups regarding the analysed variable.

### Discussion

All people are subject to changes under the influence of environmental factors, as well as processes that take place in the body – including aging. The changes that occur as a result of aging are relatively irreversible and cover the entire body, and therefore, have impact on the state of human functioning.

The systems responsible for the regulation of balance processes and stability of body posture are also subject to aging, which causes progressive disturbance in their functions over time [4]. This is confirmed by the results of research conducted by the authors of other publications, who indicate a significant reduction in the level of postural stability indices among women above the age of 60 compared to younger women [5, 6]. In the case of the results obtained in the presented study, it can be observed that women aged 60+ present a higher level of postural stability in relation to seniors older by a decade. The obtained results also allow to indicate that women from the younger group were characterised by more even loading on both limbs while standing than the women assigned to the older group. This means that all involutional changes that take place within the nervous and musculoskeletal systems affect balance control and body posture stability. Of course, it should be noted that in the results obtained in this study, no significant differences were observed between groups. Such results may be the result of a small mean age difference between the studied groups of women, which was about 8 years. Referring to the results of the above-cited publications [5, 6], the difference in age between women from both compared groups was approximately 40 years. Another reason for the lack of significant intergroup differences in the obtained results may be the insufficient sample size.

A separate issue is the influence of an active lifestyle on maintaining functions of the systems responsible for controlling body posture stability in the elderly. The majority of available studies on the impact of physical exercise on the level of balance control and stable body posture are mainly focused on groups of athletes [7]. The results of the cited studies indicate a beneficial effect of physical exercise on improvement in the ability to maintain balance among athletes training winter sports. However, there are still few publications aimed at determining the impact of physical activity on the functional fitness of people above the age of 60 or even older. It is suggested that this may...
be caused by considerable methodological problems related to the organisation and collection of research material. Based on the results of the authors' research, it can be assumed that the lack of significant differences between groups was also caused by the active lifestyle of seniors from both of the tested groups. As a result, the involution changes taking place within the systems responsible for controlling balance and body posture stability are milder. Therefore, the obtained results inspire further research and exploration in this area, because the changes taking place in the structure of currently living populations justify the social need for interest in these issues.

Conclusions

The results of the analysis carried out allow formulation of the following conclusions:

1. The obtained results indicate a decrease in the level of assessed postural stability indices in women above the age of 70 in relation to the results obtained by younger women.
2. Decreased body posture stability with age is confirmed by the results obtained by other authors. At the same time, it was found that systematic physical activity may be a significant factor counteracting the regression of postural stability in the elderly.

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