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PREVIOUS PHYSICAL ACTIVITY AND BODY BALANCE IN ELDERLY PEOPLE

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ABSTRACT: The purpose of the research was to evaluate the efficiency of body balance regulation in the elderly and verify whether physical activity in adolescence could influence later physical efficiency. Research was carried out on 62 persons aged between 65 and 96 years of age. Fifty people declared that they undertook physical activity in adolescence, while 12 reported no activity. Stabilographic examinations were performed during trials with open and closed eyes on a horizontally situated platform tilted forward and backward. The centre-of-pressure (COP) path length, sway range area and centre-of-pressure velocity (COP velocity) were assessed. The safety margin when a person leans forward and backward was evaluated as well. On a horizontally situated platform, exclusion of visual control in most of the examined participants resulted in a significant increase in values of examined parameters. Tilting the platform caused in both groups an increase in values of all the parameters. These changes were more visible when a trial with eyes closed was performed and the group of active people obtained better results. These people were also able to use the support area more effectively when changing the position of the body. It was found that body balance disorder affects more often elderly people who were less active in adolescence and that with age visual balance control dominates the proprioceptive one. This means that physical activity directed towards, among other things, forming and improving the body balance regulation system is needed at an early age.

KEY WORDS: elderly people, physical activity, stabilometry, body balance

INTRODUCTION

Human life extension and an aging population are typical for highly developed countries. On one hand they are signs of medical improvement and a high standard of life, while on the other hand, they involve increasing need for specialist medical help and create a number of challenges for our economy and society [1,26]. One of the main problems is constantly decreasing physical efficiency of elderly people and, correlated with it, more and more often accentuated, risk of falls and their serious consequences [1,10,14]. Among causes of decreasing physical efficiency not only typical ageing processes are distinguished but also consequences of diseases that people suffered from in the past, some chronic illnesses and characteristic for this age [22,24]. People who have already experienced a fall may suffer from complications, called "post-fall symptoms", which are the main cause of their further restriction and avoidance of activity and include fear of future falling and its consequences [3,18,27]. There is apparently a need for appropriate prophylactic programmes of prevention and treatment but it demands, among other things, recognizing the real causes of the frailty of elderly people. The analysis of ability to control body balance is particular valuable. This is the reason why there are a number of studies based on stabilographic examination.

Given the fact that decreasing physical efficiency in elderly people is the most significant problem, it is important to take into consideration the level of physical ability that people maintain in their later age. Obviously, the general level of physical condition varies from one person to another. It depends on personal characteristics but also the level of physical skills formed in the period of early development and maintained later [20].

In daily living a human being needs to be able to make movements using particular parts of the body but also to maintain automatically a standing position even in difficult conditions – against gravity and in conditions of labile equilibrium [14]. We are not provided with such skills from birth. A new-born child does not have the ability to oppose gravity or to assume any position other than lying. It demands an effective body arrangement regulation mechanism.

It is based on a group of reactions called postural reflexes. Although all these reactions are coupled, the reflexes of balance have a significant role among them. They are based on abundant input information provided mainly by ligaments, joint capsules, muscle and labyrinth proprioceptors. However, visual telereceptors informing about body position in space have an important role as well. Functioning of this mechanism is based on information changing in time and is a kind of servomechanism. A continuous and immediate body correction is a base in such an arrangement (system) and is provided by body postural sway consisting in alternately losing and regaining body balance. In this type of regulation the so-called ankle joint strategy plays a significant role [14,17,19]. It is worth remembering that the ability to maintain the body balance is one of the coordination skills and forming and developing these skills is a very time-consuming process demanding a large number of repetitions [21].

Although motor skills develop spontaneously, their final level is decided, among other things, by sufficient in quality and quantity motor activity as a sort of training [3,7,10]. That is why physical activity in developmental age and its maintenance in later life are so important. Present life style, particularly lack of physical activity, is a constant underlying problem of our civilization [1,3,7,10].

There is a range of special tests focused on assessing efficiency of balance regulation, among them those which take into consideration the specifics of old age. These include: Performance Oriented Mobility Assessment (POMA), Tinetti's test or Berg's Functional Balance Scale, Timed Up and Go Test, Functional Reach Test (Duncan) and Fullerton's Functional Efficiency Test or even the One-Leg Stand test used by Bohannon et al. [5,6,12]. These tests are relatively easy to perform and not expensive, but they give only a general view of potential balance disorders. They do not reveal their mechanism. It is difficult to achieve a full quantification and comparability of scores. Stability tests based on examinations using a stabilometric platform are more sensitive, objective, comparable and provide more complete information [1,8]. What is more, they let us predict potential risk of a fall in the indicated direction, which can help with programming rehabilitation of the examined person.

The aim of performed examinations was to evaluate the efficiency of body balance regulation in elderly people and verify whether physical activity in adolescence may influence the level of this regulation.

MATERIALS AND METHODS

The study group comprised 62 people aged between 65 and 96 years (X=73 ±7.72), 12 men (19.4%) and 50 women (80.6%). The participants did not suffer from any disorders of the nervous system which could have caused body balance problems nor orthopaedic disorders making it impossible to maintain a standing position. People taking medicaments which may cause balance disorders and people with significant visual impairment were excluded. Random examinations were performed. Apart from age and the exclusion criteria described above there were no other limits on inclusion in the examination.

To evaluate previous physical activity a detailed interview was performed. The questions for the interview were formulated according to the Seven Days Physical Activity Questionnaire [13]. Participants were especially questioned about after school activity, activity undertaken as a hobby, lifestyle and favourite forms of physical activity. Fifty people reported doing sport before the age of 35 and some other forms of physical activity until the age 65. These people ('active') were the main group. The control group (12 people) consisted of those who declared that they had a non-active lifestyle in the past. They are called 'non-active'.

The examinations were performed on an AccuGait stabilometric platform by AMTI equipped with the Balance Clinic program (by AMTI) documenting and analysing obtained data. First the examinations were performed on a horizontally situated platform, registering stabilograms with visual (eyes open) control and without visual control (eyes closed). The same measurements were effectuated on the oblique situated platform, tilted forward and backward (in both cases by about 20°). The centre-of-pressure (COP) path length (cm), sway range area (cm^2) and average velocity of COP on the support area ($cm \cdot s^{-1}$) were assessed during each trial. Independently, on the flat situated platform, the capacity to use the base of the support in the X axis was assessed. To obtain these measurements, participants was asked to lean forward to a maximum and then backward. Displacement of the so-called margin of safety was registered during these tests.

All the results were entered in a database and described using Statistica 5.1. In this analysis special attention was paid to the differences of results of stabilometric parameters caused by exclusion of visual control (eyes closed) or a change in support area position. The differences between analogous results of both groups were evaluated as well.

RESULTS

According to our expectations, individual initial results of stabilometric examinations were differentiated. The most significant differentiation refers to sway range area and the COP path length, especially in the trial without visual control (eyes closed). Despite this differentiation, there were also certain regularities. The obtained results concerning the COP path length, either in the trial with visual control (eyes open) or the trial without it (eyes closed), depended partly on the age of participants ($r=0.284$ and $r=0.322$). Sway range area depended on the age as well, but only in the standing position with visual control (eyes open) ($r=0.259$, all $p<0.05$), whereas in the trial without visual control (eyes closed) no significant dependence was noted ($r=0.202$; $p<0.05$).

In most examined persons standing on the horizontally situated platform in the trial with exclusion of visual control, significantly increased COP path length, sway range area and average velocity of COP were noted. These changes were more visible in the 'active' group ($t=2.207$ - 3.957; all $p < 0.032$). The exclusion of visual control (eyes closed) in the 'non-active' group caused only a significant increase in sway range area (t=4.327; p<0.0013), whereas the other two parameters increased insignificantly (both p>0.77). The comparison of the above results showed that during the trial with visual control (eyes opened) the examined parameters in both groups were similar (p=0.93–1.636; all p > 0.9030). During the trial without visual control (eyes closed) significant differences in results of the 'active' in relation to the 'non-active' group included only COP path length (t = 2.469; p=0.0164) and velocity of COP (t = 2.386; p = 0.0201) increasing. Differentiation of sway range area was insignificant (t = 1.357; p = 0.180).

Increased values of all parameters were noted in both groups when the platform was tilted forward. These changes were more visible during the trial with eyes closed. During the trial on the tilted forward platform the exclusion of visual control (eyes closed) in the 'active' group resulted in a significant increase in values of all the parameters (p = 3.119–4.364; all t < 0.002). The most visible changes referred to the COP path length. In the 'non-active' group such a significant influence of visual control on values of stabilometric parameters was not noted (all t < 0.690; all p > 0.506). The comparison of the results in both groups obtained during the trial with visual control standing on the tilted forward platform showed that both groups obtained similar results (all t < 1.355; all p> 0.129). In the trial with exclusion of visual control (eyes closed) a difference in sway range area was not noted (t = 1.076; p>0.286), whereas differences in results of COP path length and average velocity of COP were noted (both t > 2.038; both p < 0.048).

Similar results were obtained after tilting the platform backward. In the trials with and without visual control while standing on the backward tilted platform, in both groups all examined parameters were similar to those obtained while standing on the forward tilted platform. The significance of the obtained differences was analogous as well. The intergroup comparisons were similar but one exception was revealed. In this examination in the trial with visual control (eyes opened) considerably greater values of COP path length and velocity of COP were noted early on in the 'active' than in the 'non-active' group (t = 2.108 and 2.418; both p < 0.043) (Table 1).

TABLE I. AVERAGE VALUES OF COP PATH LENGTH, SWAY RANGE AREA AND VELOCITY OF COP IN BOTH GROUPS – DURING THE TRIAL PERFORMED STANDING WITH AND WITHOUT VISUAL CONTROL (OPEN EYES – OE AND CLOSED EYES – CE) ON THE HORIZONTALLY SITUATED PLATFORM, ON THE FORWARD TILTED PLATFORM AND ON THE BACKWARD TILTED PLATFORM

Variable		Active		Non-active	
		CE	OE	CE	OE
Horizontally situated platform	Path length (cm)	73.5	58.4	44.2	43.6
	Sway (cm^2)	7.9	5.4	2.5	3.3
	Velocity ($cm \cdot s^{-1}$)	2.4	1.9	1.5	1.5
Forward tilted platform	Path length (cm)	78.9	60.7	51.6	48.7
	Sway (cm^2)	9.7	5.2	3.5	3.3
	Velocity ($cm \cdot s^{-1}$)	2.6	2.0	1.7	1.6
Backward tilted platform	Path length (cm)	76.9	63.1	51.6	47.4
	Sway (cm^2)	8.9	7.5	3.6	4.4
	Velocity ($cm \cdot s^{-1}$)	2.6	2.1	1.7	1.5

On the horizontally situated platform the margin of safety from the front and from the back was similar in both groups and no significant difference was noted (both t <1.613; both p > 0.112). The 'active' group members were able to lean forward and back more than 'non-active' subjects. It was proved by a significant decrease in the margin of safety in both directions (both t > 5.137; both p<0.0001), whereas 'non-active' subjects were not able to use the support area properly, because an attempt to lean forward and backward did not result in a significant decrease in this margin (both p > 0.067) (Table 2, Table 3).

TABLE 2. AVERAGE VALUES OF THE SAFETY MARGIN FROM THE FRONT AND FROM THE BACK IN BOTH GROUPS – IN A FREE UPRIGHT POSITION AND WHILE LEANING TOWARD THE LIMIT OF STABILITY ON THE HORIZONTALLY SITUATED PLATFORM (cm)

	Active		Non-active	
Anterior limit of stability	US	FI	US	FI
	4,4	3,8	4,4	4,1
Posterior limit of stability	US	BI	US	BI
	3,5	3,1	3,7	3,7

Summarizing the above results, it can be noted that in the examination effectuated with visual control the groups were different only in two parameters. On the horizontally situated and tilted backward platform a larger average velocity of COP was noted in the 'active' group, whereas on the tilted forward platform no difference was noted. Just exclusion of visual control caused that a higher differentiation of results in both groups was visible. In the 'active' group in every position of the platform the exclusion of eye control resulted in a significant increase in COP path length, in magnitude of sway range area and in average velocity of COP. In the 'non-active' group such significant reactions to the exclusion of visual control were not

TABLE 3. CHANGES IN AVERAGE VALUES OF COP PATH LENGTH (cm) AFTER TILTING THE PLATFORM FORWARD AND BACKWARD IN COMPARISON WITH INITIAL RESULTS OBTAINED ON THE HORIZONTALLY SITUATED PLATFORM IN BOTH GROUPS – IN THE TRIAL WITH OPEN (OE) AND CLOSED (CE) EYES

	Active		Non-active	
	CE	OE	CE	OE
Platform titled backward	78,1	64,5	51,6	47,4
Platform titled forward	81,2	62,3	51,1	47,9
Platform arranged horizontally	72,8	58,0	44,5	43,6

noted. On that score only decrease in sway range area on the horizontally situated platform and increase in the COP path length on the forward tilted platform were noted in this group. However, direct intergroup comparisons showed that during the trial with eyes closed the 'active' group differed from the 'non-active' group particularly in a significantly longer COP path length and velocity of COP (in all positions of the platform). What is more, the 'active' subjects were able to use the support area much better in the past. This fact is shown by the ability to approach COP to the anterior and posterior limit of this area (significant decrease in the safety margin) maintaining body stability.

DISCUSSION

Decreasing physical efficiency with age and development of functional disorder in elderly people are serious problems. The elderly are often not able to cope well with basic everyday duties. Incidents of falling which occur in everyday trivial circumstances can be particularly dangerous for them. The cause of this problem is not only poor postural balance regulation but also general physical skills which do not enable the person to react properly in the event of a sudden loss of balance. Accordingly, people engaged in geriatric care seem to be showing more interest in this problem. Prophylactic programmes of prevention and treatment are being researched. Studies referring to body balance regulation in the elderly have been carried out [1,2, 9,10,12,17,20,25].

Health and physical efficiency in the elderly are significantly different. The reason for this fact is not only illnesses, but also the level of previous physical activity and present lifestyle [1,3,5,10]. In the literature on human motor function it is accentuated that training considerably influences motor skills [2,10,17,21]. Physical activity is its equivalent in everyday life – more precisely, its type and intensity. Therefore, the level of physical fitness of the elderly depends on previous physical activity – whether and how someone worked toward achieving an optimal level of physical efficiency [3]. It is difficult to credibly evaluate physical activity in the adolescence of present seniors. That is why in this study an examined person was classified as active if he reported having been rather active in adolescence. In a similar way, the second group of participants comprised those who clearly said that they were not physically active.

The results of stabilometric parameters of both groups differed from each other and were better in the active group. These differences were significantly greater in trials without visual control. This fact can prove the importance of visual control in the elderly. Although different degrees of domination of particular elements of the balance control system are indicated, in this age group the visual control is considered to be preponderant in comparison with proprioceptive control [11,16].

The surface on which we move every day is often tilted in different directions or it is simply crooked. Capability to handle such conditions determines the level of safety and ability to prevent a potential fall resulting from loss of balance. The studies on the tilted supporting area allow us to obtain interesting information on this subject. It was observed that in elderly people after exclusion of visual control the 'ankle joint strategy' in body balance regulation is less effective. Tilt of the surface forces a change in the arrangement of ankle joints. Normally the system informs us about body stability in relation to the ground and usually initiates compensating displacements of higher situated segments of the body, leading to establishing its balance. However, when a change in the arrangement of ankle joints is forced, the vestibular system and connected with the visual control space orientation play a greater role. That is why assessment of basic stabilometric parameters on a tilted surface seems to be a worthy element of studies on human abilities to adapt to a crooked ground surface [4,11,15,16,23].

Body balance is another issue. In the context of the risk of a fall it is worth evaluating within what limits a human can safely move his body or change its position so that he keeps within the limits of stability. Ability to steer consciously the position of the body's centre of gravity proves the high level of balance ability. Passing by COP a stability limit often forces a strategy based on increasing the supporting area though a step forward, a step backward or additional support with the use of an arm, which can be a problem for elderly and frail people. In normal conditions the safety margin is large enough to permit a human to adopt different working positions and perform everyday activities. In other words, the COP can displace safely over nearly the whole supporting area in physically efficient people. Fear of falling results in 'using' the support area on a limited range; it means that a larger safety margin is left [4]. In this context it is interesting and very important that less active people in the past were considerably worse in using the support area, especially in a backward direction. In addition to that, the obtained results revealed that in elderly people the distance of the COP sway area border from the posterior stability border when maintaining a free standing position is dangerously small, which increases the risk of a fall in the backward direction. This area is recognized as the weakest link of body balance control in the elderly and their loss of stability most often involves falls in such a direction [4]. The results concerning the stability of the elderly may prove stronger motor confidence of people who were active in the past and stronger dependence on visual control of those non-active in the past.

A number of authors claim that efficiency of the postural stability system decreases with age [1,4,7,17,23]. Prophylactic activities and activities maintaining physical efficiency would be needed. According to the results obtained in the field of prophylaxis, constant care about physical activity in early years of life seems to be crucially important – especially those kinds of activity which give an opportunity to develop coordination skills [4]. There is not much time regarding the fact that in the beginning of the fourth decade of human life a progressive process of decrease in stability and body balance regulation abilities starts. It is possible that in the context of risks of falling, work on two crucial elements would be needed – on earlier improvement of protective reactions which quickly increase the supporting area at the moment of potential risk of a fall, and on improvement of proprioceptive body stability control decreasing dependence on visual control in elderly people. This last element seems to be important regarding the fact that visual impairments at this age occur frequently. In the elderly it is necessary to keep active but also a kind of functional training leading to maintaining body balance skills at a relatively high level would be recommended [2,7,9,17,19]. Stabilometric examination facilitates detailed evaluation of individual needs and is helpful to plan a prophylactic and curative treatment in this age group. Such examinations can provide valuable information about weak links of the stability regulation system of a person or even inform early enough about potential risk of a fall.

The group of participants in this study was not numerous. Hence the conclusions presented below have a preliminary character and indicated tendencies require further systematic studies. It would be interesting to perform analogous examinations among people with documented sport achievements.

CONCLUSIONS

1. Efficiency of balance regulation in the elderly is differentiated.
2. Balance regulation disorder refers especially to elderly people with a lower level of physical activity in the past.
3. Visual control of body balance dominates proprioceptive control with age, and because of frequent visual impairments in the elderly it can increase the risk of falls.
4. Physical activity in early years of life based on, among other things, forming and developing body balance regulation is needed. Stabilometric examinations can provide significant information which is helpful in prophylaxis of falls and programming physical efficiency improvement in elderly people.

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