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STATIC BODY BALANCE POSTUROGRAPHIC VALUES IN MEDIO-LATERAL AND ANTERIOR-POSTERIOR DIRECTIONS IN CONDITIONS OF UNSTABLE BASE OF SUPPORT IN MEN OLDER THAN 70 YEARS

INTRODUCTION

One of the main reasons for falls among the elderly are disorders of body balance. The results of studies using posturographic equipment show an increased length and number of centre of body pressure (COP) deflections [8]. It is commonly accepted that maintaining stability in stance is a complex task which requires specific reflex reaction on the basis of integration of three types of different inputs: visual, vestibular and somatosensory [4]. The greatest role in balance maintenance plays the sensory information from prioprioceptors [1, 5]. The impact of base of support stability on body balance has been shown to be very significant in fall risk identification among elderly [1, 7].

The aim of the study was to compare the changes of static body balance posturographic values in medio-lateral and anterior-posterior directions in conditions of unstable base of support among 70-year-old and older men. The question was also how the static body balance changes when it is influenced by an unstable base of support.

METHODS

13 men older than 70 years (70-82 years) were examined. The mean values of basic characteristics of the investigated group are presented in Tab. 1.

Table 1. The mean values of basic characteristics of the investigated group (n=13)

	Age (years)	Weight (kg)	Height (cm)	BMI (kg/cm^2)
$\bar{x}$ ±SD	75.1±3.49	86.1±14.08	170.3±8.77	28.4±3.99

All subjects were mobile and none of them declared any falls in the period of one year before the examination.

The estimation of static balance level was carried out with the use of a posturographic system PE 90 made by the Military Institute of Aviation Medicine in Warsaw (a platform with four tensometric force transducers).

Each subject was to perform 2 trials, with differing conditions of base of support. Both trials consisted of maintaining a still, relaxed, upright position without shoes, the arms hanging down: first – on a stable base of support (S), second – on an unstable base of support (U). The following parameters connected with deflections of the vertical projection of COP were analysed:

- general stabilometric parameters: a) mean radius – MR, b) sway area – SA, c) total length – TL, d) mean speed – MS,
- medio-lateral (M-L): a) length – LD, b) mean speed – MS, c) number – ND,
- anterior-posterior (A-P): a) length – LD, b) mean speed – MS, c) number – ND,
- percentage of staying duration time of COP in one of four fields in the Cartesian system: a) front-left – FL, b) front-right – FR, c) back-left – BL, d) back-right – BR.

In order to obtain an unstable base of support two blue (soft) rehabilitation foam pads "Thera-Band Stability Trainers" (The Hygenic Corporation, THERA-BAND®, Akron, OH) were used (dimensions: 16" x 9" x 2"). The foam pads were put parallel to each other on theh surface of the posturografic platform.

In order to verify the significance of differences between trials as well as between M-L and A-P directions in varied conditions of base of support ANOVA was used. In order to check the range of differences between the mean values of posturografic

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parameters in the varied conditions of measurements nominal differences were expressed as percentage values.

The study was approved by a Local Committee of Ethics in Research.

RESULTS

The comparison of parameters in varied conditions (Table 2) showed higher values of general stabilometric parameters ($p \leq 0.001$) as well as M-L and A-P (at least $p \leq 0.01$) in U conditions – excluding ND in M-L direction. The analysis showed no differences between the trials in percentage of staying duration time of COP in four fields in the Cartesian system.

Table 3. Nominal differences between mean values of posturographic parameters of trials in S and U conditions expressed as percentage values

Posturographic parameters				Average value
General stabilometric parameters				
MR	SA	TL	MS	
61.5%	207.6%	96.4%	93.9%	114.9%
M-L direction parameters				
LD	MS	ND		
83.9%	84.5%	20.1%		62.8%
A-P direction parameters				
LD	MS	ND		
109.0%	107.6%	65.2%		93.9%
		Total		**90.5%**

Table 2. Results of ANOVA for posturographic parameters

Base of support	Posturografic parameter			
	General stabilometric parameters			
	MR (mm)	SA (mm^2)	TL (mm)	MS (mm/s)
S	3.9±1.11	375.9±225.56	310.5±111.19	9.8±3.47
U	6.3±1.32***	1156.4±422.25***	609.8±156.70***	19.0±4.90***
	M-L direction parameters			
	LD (mm)	MS (mm/s)	ND (n)	
S	184.7±67.37	5.8±2.20	27.3±12.41	
U	339.8±106.47***	10.7±3.45***	32.8±15.61^{ns}	
	A-P direction parameters			
	LD (mm)	MS (mm/s)	ND (n)	
S	209.5±79.11^{ns}	6.6±2.50^{ns}	28.2±12.38^{ns}	
U	437.9±121.25*** $^{\#}$	13.7±3.84*** $^{\#}$	46.6±15.77** $^{\#}$	
	Percentage of staying duration time in four fields			
	FL (%)	FR (%)	BL (%)	BR (%)
S	28.2±27.99	40.1±32.19	17.5±18.46	14.3±22.04
U	21.8±16.63 ^{ns}	37.8±24.56 ^{ns}	24.4±26.32 ^{ns}	15.9±20.79 ^{ns}

** – $p \leq 0.01$, *** – $p \leq 0.001$, ns – non significant (for comparison of S and U conditions)

$^{\#}$ – $p \leq 0.05$, *ns* – non significant (for comparison of LD, MS and ND in M-L and A-P directions)

The differences between LD, MS and ND in S and U base of support conditions were also checked. There were no differences in S conditions. All the parameters were higher in A-P direction ($p \leq 0.05$) in U conditions.

Table 3 presents nominal differences between the mean values of posturographic parameters in two trials expressed as percentage values. General stabilometric parameters increased 114.9% on average. The greatest difference was noticed for the sway area (207.6%). In the case of M-L and A-P directions parameters they increased 62.8% and 93.9%, respectively. In both cases the greatest changes occurred in the length of deflection (LD) – 83.9% for M-L direction and 109.0% for A-P direction – as well as in the mean speed (MS) – 84.5% and 107.6%, respectively. Taking into account all parameters together the values obtained during the trial in U conditions were almost two times higher than those obtained in S conditions (90.5%).

DISCUSSION

The risk of fall increases when one of the sensory input systems (visual, vestibular and somatosensory) is disturbed. In the study the effect of somatosensory

limitation (unstable base of support) was analysed. As it was expected almost every values of posturograpic parameters (excluding ND in M-L direction) was higher in U conditions than in S conditions (at least $p \leq 0.01$). It is consistent with other results obtained by other authors. Anacker and Di Fabio [1] compared body balance with the use of Sensory Organization Test among falling and nonfalling elderly persons (65-96 years). They found a lower level of body balance among the fallers only in the case of compliant (foam) base of support. In their opinion decreased muscle strength as well as an increased threshold of cutaneous and joint prioprioception constitute a predisposition to larger sways in ankle joints during stance on a foam surface.

The analysis of range of differences between individual parameters showed a general increase in the length, distribution (SA – 207.6% and TL – 96.4%) and speed of deflections (MS – 93.9%) in U conditions. It indicates a lower possibility to control body balance. On the other hand the analysis of deflections in M-L and A-P directions showed an increase in the amplitude and speed of deflections according to the increased difficulty of trial. Higher values of LD (83.9% and 109.0%, respectively) and MS (84.5% and 107.6%, respectively) were observed. The range of differences according to the base of support indicated a greater deterioration of results in the case of A-P direction. There were no differences between the mean values of LD and MS of M-L and A-P directions in S conditions. In the case of U conditions a statistically significant difference for these parameters was found ($p \leq 0.05$). Considering the fact that the elderly fall forward in 60% of cases [2] the obtained results indicate a significant increase of fall risk in conditions of compliant surface.

High standard deviations for variables connected with staying duration time of COP in four fields in the Cartesian system are not sufficient to make univocal conclusions. However, it should be considered that there were no statistical differences in these parameters comparing varied conditions of measurements. It may indicate that the elderly try to realize a similar strategy of balance maintenance independently of the base of support. The highest values were observed in the case of FR field both in S and U conditions (40.1% and 37.8% respectively). It may indicate a greater sense of security when COP is moved forward. Błaszczyk, Hansen and Lowe [3] showed increased dorsiflexion of ankle joints which affects the anterior shift of the centre of gravity (about 1 cm) for more stable situations. It allows for resistance to greater forces acting backward [6]. Longer staying duration time on the right side is probably connected with the shift of COP in the dominant lower limb direction. Błaszczyk et al. [4] using two adjacent force platforms to measure postural sways among the elderly found an asymmetrical body weight distribution (limb load) during stance.

The mean values of individual parameters obtained in U conditions were 90.5% higher on average than in S conditions. Assuming the relationship between the magnitude of posturographic parameters and the fall risk these results showed that the fall risk increases almost twice in unstable base of support conditions. The results of a population cross-sectional study could indicate even greater differences, taking into consideration that the subjects examined in the study were in good general health.

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