MONITORING THE LEVEL OF POSTURAL STABILITY PARAMETERS IN RELATION TO FUNCTIONS OF SELECTED PERIPHERAL ANALYSERS

Pavol **ČECH**[1], Ján **JUNGER**[1,2]

1. Faculty of Sports, Department of Sport Kinanthropology, University in Prešov of Prešov
2. Faculty of Physical Education, University of Rzeszow, Rzeszow, Poland

Key words:
- Postural balance,
- Afferent sources of information,
- Centre of Pressure.
- AMTI.

Abstract:

The quality of information from peripheral structures is irreplaceable for proper motor control. Control stabilization system receives information from three sources, namely optical, vestibular and proprioceptive, and focuses on sources providing functionally the most important information.

The purpose of the study was to identify and compare changes of postural stability parameters after elimination of afferent sources of information in selected groups of population.

The research group consisted of 199 participants divided in four groups - active senior women (n = 37), non-sporting individuals (n = 40), students of Physical Education (n = 44) and actively sporting students of Physical Education (n = 78).

Postural stability was measured using a stabilographic method on AMTI AccuSway^{PLUS} force platform. The level of postural stability was assessed in four tests with the feet as wide as the pelvis, namely bipedal stance with and without sight control and bipedal stance with reduced proprioception with and without sight control using the parameters of path of COP (l_{CoP}), 95% confidence ellipse ($EA_{95\%}$), Root Mean Square (RMS_{CoP}) and standard deviation of CoP movement in sagittal and lateral planes (s_{YCoP}, s_{XCoP}).

In the study, we observed various courses of changes of postural stability parameters after restriction of afferent sources of information depending on the tested groups. In the measured groups, we found gradual increase of l_{CoP} after elimination of optical analyser, proprioceptive system as well as after their simultaneous limitation. A similar curve shape was also found in $EA_{95\%}$ and RMS_{CoP} parameters. Analysis of curves of sXCoP and sYCoP parameters indicates that increase of parameters comprehensively describing the movement of CoP is more influenced by body sways in the sagittal plane than those in the lateral plane.

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INTRODUCTION

Control stabilization system, often receiving conflicting information from three sources, includes processes of identification of these pieces of information and focuses on sources providing functionally the most important information [11]. For proper motor control, quality of information from peripheral structures is irreplaceable [12]. Nasher et al. mention that changes in orientation of standing subjects are sensitive to input information from support surface (proprioception and skin receptors sensitive to contact forces and movement of legs), visual information (derived from linear and angular acceleration of the visual field) as well as vestibular information (derived from fluctuations associated with linear and angular acceleration of the head) [11]. Authors Winter [15], Guskiewicz [7], Nagata et al. [10], Vařeka [13], Ferdjallah et al. [5], Winter et al. [16], Blaszczyk & Czerwosz [3], Bertora et al. [2], Cotoros [4] and other agree on the following three components which are involved in controlling and ensuring an upright stance in a normal gravitational field: visual, vestibular and sensomotoric component. In addition to these components, Morasso & Schieppati [9] also mentioned tactile and muscular factors which contribute to stabilization processes. Kapoula & Lê [8] added that ocular muscle information play an important role, too. To maintain normal stability, it is essential that information from peripheral fields from all subsystems is synchronous in phase and time.

AIM

The purpose of this study was to identify and compare changes of postural stability parameters after elimination of afferent sources of information in selected groups of population.

MATERIAL AND METHODS

The research group included 199 participants divided in four groups. The first group (seniors - S) consisted of senior women who practiced 45 minute multimodal workout two times a week. The second group (non-sporting students - NSS) consisted of non-sporting individuals who did not participate in any organised form of exercise with occasional recreational physical activity of low intensity. The third group (physical education students - PES) consisted of students of Physical Education who underwent physical load in both organised and unorganised forms within the study requirements. The last group (physical education and sporting students - PESS) also consisted of students of Physical Education but these in addition to physical load during the courses completed at least three training sessions of different content and form depending on their sport discipline.

Table 1. Characteristics of research sample ($\bar{x} \pm s$)

group	*n*	*age (yr)*	*body weight (kg)*	*body height (cm)*	*BMI (kg/m²)*
S	37	66.4 ± 3.5	72.3 ± 8.3	160.6 ± 5.3	28.1 ± 3.5
NSS	40	21.0 ± 1.7	63.1 ± 10.0	168.8 ± 6.6	22.2 ± 3.0
PES	44	20.6 ± 0.8	68.7 ± 10.2	173.6 ± 8.2	22.7 ± 1.8
PESS	78	20.8 ± 1.2	73.5 ± 10.3	178.2 ± 8.4	23.1 ± 2.2

Diagnostics was carried out under laboratory conditions in the Diagnostics centre at the Faculty of Sports, Presov University at the temperature between 20-22 °C and combination of natural and artificial light.

Testing included measurements of postural stability, body height using an anthropometer and body weight was detected using Omron HBF-514C digital scales with an accuracy of 1.10^{-1}kg.

The level of postural stability was assessed from parameters related to the centre of pressure (hereinafter CoP). CoP of participants was measured using AMTI's AccuSway^{PLUS} [1] force plate. Digital output from the plate was recorded using AMTI's NetForce software the recording frequency of which is 50 Hz. Raw data were further processed using BioAnalysis software.

Participants completed the following four tests of postural stability on the force plate: stance with the feet as wide as the pelvis with sight control (T1; all sensory subsystems involved) and without sight control (T2; vestibular and proprioceptive subsystems involved), stance with the feet as wide as the pelvis on the foam with sight control (T3; optical and vestibular subsystems involved) and without sight control (T4; only vestibular subsystem involved). Each of the test tasks lasted for 20s with a subsequent rest interval between the tests lasting for 30s which was needed for the change of stance and commencement of new measurements.

Changes to postural stability after changing the quality of sensory information were evaluated from parameters comprehensively describing the movement of CoP, namely path of CoP (l_{CoP}), 95% area of confidence ellipse ($EA_{95\%}$) and Root Mean Square (RMS_{CoP}), and parameters characterising the extent of body sways in sagittal and lateral planes, which included standard deviation of the movement of CoP in antero-posterior direction ($s_{Y\,CoP}$) and standard deviation of the movement of CoP in medio-lateral direction ($s_{X\,CoP}$).

From the obtained data we calculated the value of central tendency in terms of median. For graphical representation of the changes to level of postural stability parameters we used a line chart with its subsequent analysis.

RESULTS AND DISCUSSION

Figure 1 depicts a graphical comparison of participants' performance in the parameter which characterizes total path of CoP during the measurement. When comparing T1 and T2 tests we may notice relatively the same course of increase of l_{CoP} parameter's values in all tested groups. Thus elimination of information from visual analyser resulted in deterioration of the tested parameter's level regardless of the tested group. A similar result, increase of middle values of the assessed parameter, was also recorded in comparison of T2 and T3 tests in NSS, PES and PESS groups. In T3 test, amount of information provided by proprioception subsystem was reduced.

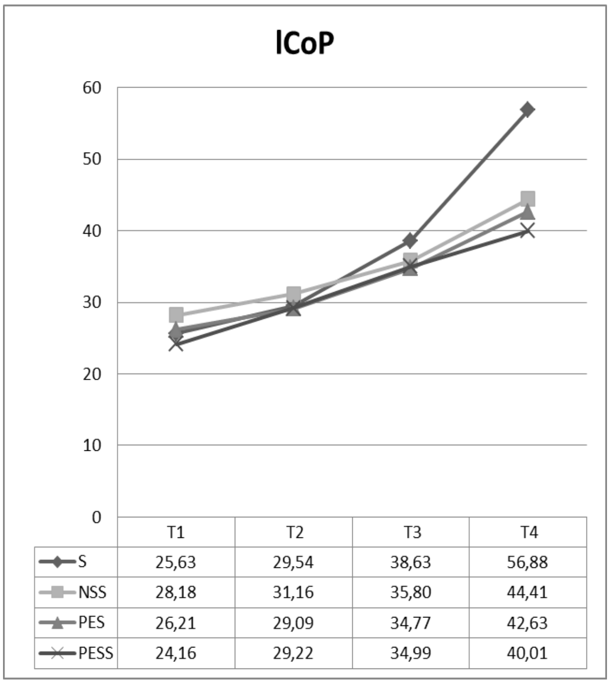


Figure 1. Comparison of the level of l_{CoP}

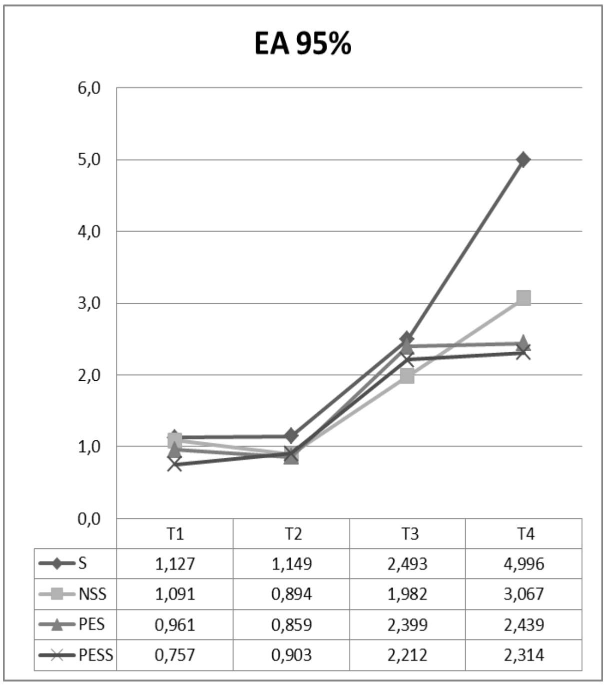


Figure 2. Comparison of the level of $EA_{95\%}$

In the group of senior women (S), there was higher increase of l_{CoP} parameter, which indicates greater determination of postural stability by amount of information provided by proprioceptive subsystem in comparison to younger participants. This difference in the curves of the assessed parameter's changes increased after elimination of optical and proprioceptive sources of information (T4 test). We may state that up to T4 test the course of l_{CoP} parameter's curves was almost linear in NSS, PES and PESS groups, however, when receiving information only from vestibular system curves in two groups (NSS, PES) deflected from linearity and thus the assessed parameter increased more than in the previous tests.

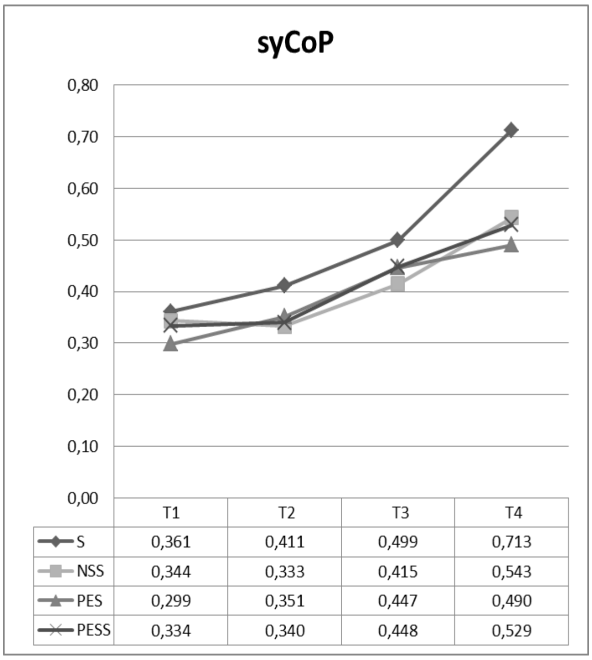
Figure 2 presents changes of median values of the parameter characterising the area of the CoP's movement in the tested groups. After elimination of optical analyser (T2), no significant differences in comparison to the test task with the function of all subsystems (T1) were found in terms of increase of median. However, these changes were recorded when the function of proprioceptive subsystem was eliminated (T3) and the parameter of area of CoP's movement significantly increased in all tested groups (more than 100%). Moreover, after elimination of optical analyser (T4), this trend continued in S and NES groups. The area of CoP's movement did not significantly increase in the groups regularly practising physical activities despite the elimination of another subsystem's function. We believe that it was the result of regularly performed physical activity.

Figures 3 and 4 illustrate recorded changes of parameters describing variability of CoP sways in its partial directions. We may notice that fluctuations of CoP in the sagittal plane (s_{YCoP}) were higher in all test tasks and all tested groups than in the median plane (s_{XCoP}).

As we noted in l_{CoP} parameters gradual increase of middle values along with the order and complexity of the test tasks, in the case of s_{XCoP} parameter we recorded decrease in comparison of T1 and T2 tests in all tested groups. In antero-posterior direction, we recorded increase of median value in S, PES and PESS groups; on the contrary, in the last group it slightly decreased. In the stance on the foam when proprioceptive subsystem's function was reduced (T3), variability of CoP sways significantly increased in both partial directions. Significant changes also occurred in s_{XCoP} parameter which especially increased in medio-lateral plane. After simultaneous reduction of visual and proprioceptive control (T4), we observed increase of middle value of variability of CoP's movement in antero-posterior direction in all groups. However, results in medio-lateral plane were not so clear when increase of the middle value was only detected in S and NES groups. It appears that physical activity of PES and PESS groups could have positively influenced stabilization of the vertical body position in medio-lateral plane. Moreover, these groups also achieved the best values in antero-posterior direction.

Postural control system receives sensory information on body position in space mainly from three subsystems. Proportion of individual components in postural stability control has not been fully verified yet. According to Véle [14], if any sensory component is limited, the movement is possible due to higher activation of another sensory component; the same also works in maintaining posture. Results of study [6] indicate that visual information play more important role in maintaining postural stability in dynamic conditions than in stationary conditions.

Experimental studies confirm a crucial share of proprioception in maintaining postural stability in a quiet stance [13]. Nagata et al. [10] found that if in normal subjects (in terms of possible disorders) feedback from somatosensory subsystem is sufficient to keep the stance, in case of visual system, cooperation with other systems (somatosensory or vestibular) is necessary for maintaining the stable stance. Similarly, Guskiewicz [7] notes that under normal conditions information from visual and somatosensory subsystem is sufficient for maintaining stability. It means that labyrinth is not essential for maintaining stability while proprioception is.



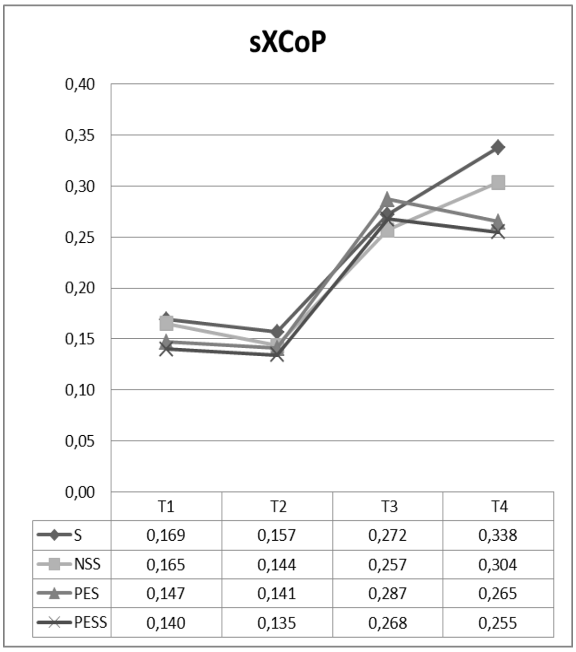


Figure 3 Comparison of the level of s_{XCoP} **Figure 4** Comparison of the level of s_{YCOP}

CONCLUSIONS

Postural stability is qualitative characteristics of the body which influences amount of individual's ordinary day activities regardless of age category or activity performed.

Relying on the above mentioned results we may state that any change of quality of afferent sources of information results in deterioration of postural stability. The most significant influence on the level of postural stability was found in quality of information from proprioceptive subsystem. In addition, regular physical activity appears to have a positive impact on body sways size in partial directions of the movement, especially in terms of areal extent. Similarly, participants' age is a variable which participates in individual's overall disposition in maintaining postural stability.

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