23rd International Conference
ENGINEERING MECHANICS 2017
Svratka, Czech Republic, 15 – 18 May 2017

ANALYSIS OF RELATIONSHIP BETWEEN POSTURAL STABILITY AND DEGREE OF VISUAL IMPAIRMENT

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Abstract: *The aim of study was to evaluate the postural stability in patients with various degree of visual impairment. Statistical analysis of influence of degree of visual impairment on postural stability opposed to people perfectly sighted also was conducted. The studies was conducted on 30 patients with various degree of visual impairment and 10 patients perfectly sighted. Postural stability was tested using two diagnostic machines. The patient stood in its habitual position with its arms lowered along its body and its feet spacing on hip width. In this position were done some tests, where patients were obligated to adopt two positions their bodies in variants with opened and closed eyes. Next, the stabilographic parameters were measured. Conducted statistical analysis of results from research allows to propose a conclusion that there is significant statistical dependence between degree of eyesight dysfunction and ability to maintain stable posture. The conducted researches revealed the influence of lack of visual control on increase of most of stabilographic parameters values.*

Keywords: Postural stability, People with various degree of visual impairment, One – way ANOVA test.

1. Introduction

Proper human posture is the necessary condition to realize of most his movement and physical activity. This is the reason why most of clinical test includes stability study. Stabilography is non-invasive diagnostic method that allows to estimate humans' stability system. In case of proper and stable position the projection of center of mass (CoM) which is simultaneously center of gravity (CoG) on the support base (BoS) is vertical (Mitchell, 2007 and Sturnieks, 2004). Studies based on ground reaction forces measurement in order to diagnose balance maintenance system are made by stabilographic platforms.

Humans eyesight is one of three basic input channels, other are aurical and somatosensoric control subsystem that is used to control position and its regulations (Abdelhafiz et al., 2003 and Schwartz et al., 2005). The complexity of the problems of the people with various degree of visual impairment in the context of normal gait and stable position are very big. Humans' visual system delivers 80 % information for perception which is essential to maintain structural stability. According to these data people with eyesight dysfunction has worse stability self-control (Friedrich et al., 2008). According to Schwesig (2011), the visual system of patients with birth defects in contrast to people with acquired disability is based on other incentives from the birth, and this leads to better posture control in situations where eyesight is ineffective. The results of studies provided by article of de Araújo et al. (2014) confirms that blind children has postural stability disorders. Tomomitsu (2013) research results suggest that feedback from visual system is necessary to maintain the body balance. Mentioned researchers found that visually impaired people has worse postural stability than people without eyesight dysfunctions. Conclusions were drawn both on dynamic tests and balance tests on the edge of the foam. Ray et al. (2008) reports that adults that have lost their sight uses more hip-joint moves than people well seeing to maintain balance.

Presented studies were designed to find and describe relationship between degree of visual impairment and problems with balance of the body in patients.

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2. Materials and Methods

Researches were conducted on groups of patients with the following of degrees of visual impairment (there were no other dysfunctions legally or biological):

group 1: low vision;

group 2: partially sighted;

group 3: totally congenitally blind.

The results of these researches were compared with results of researches in patients perfectly sighted - control group. In every group studies were conducted for 10 patients. The all patients gave their informed consent prior to their participate in the study.

It is known that accuracy of stability measurements is dependent on conditions during tests. Because of that presented results of research in this article are based on recommendations Kapteyn'a, (1983).

Postural stability was tested using stabilographic platform AMT1, including software that allows measurements of ground reaction forces, foot point of contact with the ground, centre of pressure (CoP) in real time.

The patient stood in its habitual position with its arms lowered along its body and its feet spacing on hip width. In this position were done some tests, where patients were obligated to adopt two positions their bodies in variants with open (variant is marked as OE) and closed eyes – this one wasn't applied to 3'rd group (this variant is marked as CE): standing on left leg (position marked as LL); standing on right leg (position marked as RL).

Comparison of stabilographic parameters received from test with eyes opened and closed, allows to assess the role of the visual senses involved in postural control. By measuring pressure force on ground and moment of force location of CoP has been found. Six different motion parameters of CoP have been evaluated: SP – total path length, on both axes, in millimeters; SPAP – statokinesiogram path length on the OY axis (the sagittal plane), in millimeters; SPML – statokinesiogram path length on the OX axis (the coronal plane), millimeters; MA – the mean amplitude (radius) of CoP, on both axes, in millimeters; MV – mean velocity of the CoP movement, on both axes, in millimeters per second; SA- sway area of the CoP point, in square millimeters.

3. Results

Based on the data obtained from stabilograms analyzed the balance parameters of the patients in the test with open and closed eyes. Values of parameters determined from stabilograms for both variants are shown in Tabs. 1 – 4.Researches results were developed statistically. Results were subjected to one - way ANOVA variance analysis (Bartolucci, 2016, Boddy, 2009 and Tamhane, 2009). In situation where developed results allowed to reject null hypothesis, the Tukey-Kramer test was executed. Next step after developing HSD values was comparison of mean values of researched group with each other. This allows to verify, if both groups are statistically significant.

Tabs. 1 and 2contains results of one – way ANOVA and Tukey-Kramer tests for CE and OE variants for the LL test.

Tab. 1: Results of ANOVA and HSD tests of motion parameters of CoP for LLCE.

	Anova		Tukey's test	group 1 and group 2	group 1 and control group	group 2 and control group
	F	$f_{a-1,\nu,\alpha}$	HSD			
SP	5019.18	3.354	149.4	2004.49	5960.56	3956.07
SPAP	598.32	3.354	3.10	44.03	69.51	22.92
SPML	392.45	3.354	0.228	2.15	0.286	2.33
MA	83.09	3.354	1.94	1.703	9.49	7.78
MV	404.87	3.354	205.74	166.05	402.1	536.4
SA	2312.58	3.4668	199.33	104.6	70.5	4006.9

Tab. 2: Results of ANOVA and HSD tests of motion parameters of CoP for LLOE.

	Anova		Tukey's test	group 1 and group 3	group 1 and group 2	group 1 and control group	group 3 and group 2	group 3 and control group	group 2 and control group
	F	$f_{a-1,\nu,\alpha}$	HSD						
SP	5219.7	2.86	374.9	938.4	12.1	49.4	12126.3	16389	62.7
SPAP	916.5	2.86	4.187	25.59	41.62	32.98	16.46	7.78	9.35
SPML	1783.7	2.86	1.811	21.18	46.176	23.98	24.98	2.79	22.19
MA	596.64	2.86	0.79	5.14	12.26	0.695	7.16	4.446	11.606
MV	5652.5	2.86	70.08	562.19	3213.18	20.28	2650.9	541.9	192.9
SA	4096.1	2.86	150.12	1152.5	3856.2	48.6	3098.1	1034.3	4096.3

Tabs. 3 and 4contains results of one – way ANOVA and Tukey-Kramer tests for CE and OE variants for the RL test.

Tab. 3: Results of ANOVA and HSD tests of motion parameters of CoP for RLCE.

	Anova		Tukey's test	group 1 and group 2	group 1 and control group	group 2 and control group
	F	$f_{a-1,\nu,\alpha}$	HSD			
SP	843.8	3.354	24.26	28.15	85.48	71.32
SPAP	958.23	3.354	19.16	98.12	21.12	174.68
SPML	6819.3	3.354	8.432	156.13	98.11	9.143
MA	74.72	3.354	0.154	0.103	1.89	1.97
MV	407.3	3.354	14.36	7.86	32.03	31.47
SA	4660.8	3.354	1.501	2.011	174.3	202.3

Tab. 4: Results of ANOVA and HSD tests of motion parameters of CoP for RLOE.

	Anova		Tukey's test	group 1 and group 3	group 1 and group 2	group 1 and control group	group 3 and group 2	group 3 and control group	group 2 and control group
	F	$f_{a-1,\nu,\alpha}$	HSD						
SP	589.16	2.86	100.1	228.79	178.3	187.3	267.4	228.6	198.3
SPAP	1034.67	2.86	3.98	129.7	129.45	21.13	9.12	125.13	174.26
SPML	3126.6	2.86	1.467	58.56	14.78	51.35	59.89	87.98	41.65
MA	47.97	2.86	0.283	0.321	0.998	0.154	0.876	0.678	1.178
MV	324.56	2.86	2.11	12.27	2.87	1.67	15.89	12.03	4.967
SA	4509.67	2.86	2.69	27.14	62.34	20.34	78.9	23.67	68.13

Tabs. 1 – 4 contain results achieved with one-way ANOVA method. In all cases the F results were greater than which was calculated according to Bartolucci, (2016), Boddy, (2009) and Tamhane (2009). Therefore hypothesis about equality of mean values of motion parameters of CoP was rejected. It was found statistically significant influence of degree of visual impairment on stable position of patient. Mentioned tables includes also results of Tukey-Kramer tests. Absolute values of difference of mean values between groups larger than calculated HSD value according to Boddy, (2009) and Tamhane (2009) are marked with boldface font in grey cells.

4. Conclusions

Results of research are proof that different eyesight dysfunction causes different problems for control body balance. Comparative analysis of CoP parameters from stabilograms for LL-body position shows that most of these parameters (SP, SPAP, MA, MV and SA) were increased in experiments with exclusion visual control (CE) in contrast to a situation where eyesight body control was enabled (OE). This applied to all research groups. Simultaneously exclusion visual control for this position led to shortening of path length in the coronal plane (SPML). Reverse situation occurred in cause of RL-position. In this situation exclusion visual control causes decrease of the parameter for all 4 research groups. Research did not give a clear result. For control group the parameters SP, SPAP, MV hasn't changed in OE and CE variant, values MS and SPA parameters increased when eyesight control was disabled. Reverse situation appears in case of 1'st and 2'nd group (3'rd group hasn't taken part in CE variant research). For these groups MA and SA parameters haven't changed, and SP, SPAP and MV decreased its value.

Conducted experiments shows that exclusion visual control disabling causes increase of most stabilograms parameters. Obtained results suggest that next research should take into account possibility that left-handiness may affect body-balance control skill.

Statistical analysis shows that exclusion visual control (CE) in both positions, exclusion visual control for patients with 1st and 2nd group significantly worsens body balance control. Only comparison of MA and MV parameters for patients with some degree of visual impairment appears statistically irrelevant. Mentioned patients weren't able to maintain balance in both situations with or without visual control. Statistics analysis from research carried in both positions with open eyes (OE) shows that degree of visual impairment is statistical significance important for balance control skill. Only small defects appears to be no statistical significance.

References

Abdelhafiz, A.H. and Austin, C.A. (2003) Vision factors should be assessed in older people presenting with falls or hip fracture. Age Ageing, 32, pp. 26-30

Bartolucci, A.A., Singh, K.P. and Bae, S. (2016) Introduction to statistical analysis of laboratory data. John Wiley & Sons, 2016.

Boddy, R. and Smith, G. (2009) Statistical Methods in Practice. John Wiley & Sons, 2009.

De Araújo, P.P., De Moura Filho, O.F., Valenti, V.E. et al. (2014) Stabilometric parameters analysis in children with visual disorder. International Archives of Medicine, 7:1.

Friedrich, M., Grein, H.J., Wicher, C., Schuetze, J., Mueller, A. et al. (2008) Influence of pathologic and simulated visual dysfunctions on the postural system. Experimental Brain Research, 186, 2, pp. 305-314.

Kapteyn, T.S., Bles, W., Njiokiktjien, C.J., Kodde, L., Massen. C.H. and Mol, J.M. (1983) Standardization in platform stabilometry being a part of posturography. Agressologie: Revue Internationale de Physio-biologie et de Pharmacologie Appliquees aux Effets de L'agression, 24, 7, pp. 321-326.

Mitchell, S., McCaskie, A., Francis, R., Peaston, R., Birrell, F. and Lingard, E. (2007) The need for a falls prevention programme for patients undergoing hip and knee replacement surgery. Journal of Orthopaedic Nursing, 11, 2, pp. 98-103.

Ray, C.T., Horvat, M., Croce, R., Mason, R.C. and Wolf, S.L. (2008) The impact of vision loss on postural stability and balance strategies in individuals with profound vision loss. Gait Posture, 28, 1, pp. 58-61.

Schwartz, S., Segal, O., Barkana, Y., Schwesig, R., Avni, I. and Morad, Y. (2005) The effect of cataract surgery on postural control. Investigative ophthalmology & visual science, 46, pp. 920-924.

Sturnieks, D.L., Tiedemann, A., Chapman, K., Munro, B., Murray, S.M. and Lord, S.R. (2004) Physiological risk factors for falls in older people with lower limb arthritis. The Journal of Rheumatology, 31, 11, pp. 2272-2279.

Schwesig, R., Goldich. Y., Hahn, A., Müller A., Kohen-Raz, R., Kluttig, A., et al. (2011) Postural control in subjects with visual impairment. European Journal Ophthalmology, 21, 3, pp. 303-309.

Tamhane, A.C. (2009) Statistical Analysis of Designed Experiments: Theory and Applications. John Wiley &Sons.

Tomomitsu, M.S., Alonso, A.C., Morimoto, E., Bobbio, T.G. and Greve, J.M. (2013) Static and dynamic postural control in low-vision and normal-vision adults. Clinics, 68, 4, pp. 517-521.