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Postural Stability and Physical Activity of Workers Working at Height

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Abstract

The purpose of the study was to analyze the level of postural stability and physical activity of at-height workers.

The study included 34 healthy men aged 25–43. Two groups were identified based on the type of work they performed: at-height workers (HW) (n = 17), and office workers (OW) (n = 17). Physical activity, including physical activity at work, sports activity, and leisure, was assessed with a Baecke questionnaire. For evaluation of postural stability, the one-leg standing test with eyes open and closed was used.

The HW group had a higher rate of average physical activity at work than the OW group (p = .000), whereas the OW group showed greater physical activity during leisure time (p = .000). No differences were found between the groups in terms of sports activity. Postural stability analysis shows that the HW group (p < .05) scored statistically significantly higher values in one-leg standing with eyes closed.

The groups differed in terms of postural stability in favor of HW. At the same time, despite differences in particular aspects, the overall level of PA was similar. This may indicate that postural stability is rather affected by exposure to distress conditions.

Keywords

postural stability, body balance, physical activity, at-height workers

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Work at heights is considered to be particularly dangerous. Tasks such as building, dismantling, and modifying scaffoldings (Zamysłowska-Szmytke & Śliwińska-Kowalska, 2012) carried out on tall buildings—that is, 23 meters (Mousavi, 2015)—force employees to struggle with both the work which they must carry out precisely and difficult weather conditions such as strong winds, rain, and snow. All such work is assigned to men who are not only experienced and highly qualified, but who also possess suitable mental and physical features (Salassa & Zapala, 2009; Zamysłowska-Szmytke & Śliwińska-Kowalska, 2012). In the European Union countries, men working at heights should undergo valid medical examinations, including the ophthalmic, neurological, and laryngological ones. Appropriate experience is required for the works at the heights of above 1 meter.

Assessment of the level of postural stability of at-height workers is a very important element of prevention and case law in occupational medicine. The "Labor Code" (*Journal of Laws*, No. 69, item 332) recommends examinations of the balance system of people working at heights of above 3 meters, as well as below 3 meters and above 1 meter from the surrounding floor level or an outdoor area, as well as on mobile hanging platforms. The scope of the tests to be performed and the exact minimum requirements with regard to the person to be examined are not specified (Zamysłowska-Szmytke & Śliwińska-Kowalska, 2012). Postural stability disorders are among the most common causes of accidents related to working at height (Central Statistical Office, 2012; European Commission, 2009). The consequence of postural instability is imbalance, which, in turn, often leads to tragic

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results such as fractures, hematomas, extensive bruises, or even death (Horak, 2006; Salassa & Zapala, 2009).

Research indicates that counteracting imbalance is only effective when the nervous system is able to identify a destabilizing stimulus within 70–100 ms and to perform a set of typical patterns and muscle-based muscle synergies that restore balance, based on rapid automatic balance-recovery reactions (Boucher, Stuphorn, Logan, Schall, & Palmeri, 2007; Tao, Khan, & Blohm, 2018). The greater the set of these patterns, the longer the process of selecting the appropriate motor reaction (Adkin, Frank, Carpenter, & Peysar, 2000; Töllner, Rangelov, & Müller, 2012). When it is necessary to make a choice, the speed of balance recovery is greatly reduced. This may mean that balance can be more effectively maintained if the potential reflexes used to compensate for the balance are kept to a minimum. According to research, such compensatory measures can be observed in people standing on unstable ground, at great heights, and in the elderly people (Davis, Campbell, Adkin, & Carpenter, 2009; Zamysłowska-Szmytke & Śliwińska-Kowalska, 2012).

Conditions of increased risk when maintaining an erect posture directly affect control of body position (Brown, Sleik, Polych, & Gage, 2002; Huffman, Horslen, Carpenter, & Adkin, 2009). Based on the available results connected to fall risk, it can be concluded that people control their posture through the increase in neuromuscular activity of the lower limb muscles as well as through the stiffening of the ankle joint (Adkin et al., 2000; Vuillerme & Nafati, 2007). Carpenter, Adkin, Brawley, and Frank (2006) noted that both older and young adults use the same ankle-stiffening strategy to cope with increased anxiety and reduced level of confidence related to standing at a height of above 0.4 meters. Evidence indicates that physiological state, anxiety status, and balance efficiency are related to specific changes in attitude and increased balance (Carpenter et al., 2006).

Min, Kim, and Parnianpour (2012) investigated the effect of scaffolding height on safety results, taking into account subjective and objective assessments of the postural stability and cardiovascular stress of unexperienced and advanced construction workers. It has been reported that the postural stability of workers with less experience was reduced during work on higher scaffolds with no handrails, while cardiovascular stress and subjective difficulty in maintaining balance increased. DiDomenico, McGorry, Huang, and Blair (2010) undertook an analysis of the perception of postural stability among construction workers making the transition to a standing position. The research included a group of 183 men and six women (from 18 to 63 years). Older participants had better scores in tasks including typical postures for construction work. However, there were no statistical differences between older and younger workers with regard to individual tasks. The authors suggested that the place of work and change of position while performing a given task affects stability of posture while standing, regardless of the construction industry or the age of the employee.

Table 1. Average Values, Standard Deviations, and Differences Between Groups for BMI and Age.

Variable	*M* (*SD*) HW	*M* (*SD*) OW	*t* *df* = 32	*p*
BMI [kg/m^2]	25.72 (1.24)	26.46 (2.77)	−1.01	.322
Age [years]	33.76 (3.09)	32.24 (5.52)	1.00	.326

Note. HW = height workers; OW = office workers; BMI = body mass index; *SD* = standard deviation, *M* = mean.

The mechanism of action of the system responsible for proper control of body posture is ambiguous. Presumably, at-height workers (HW) are characterized by the increased automation of the postural stability system (Huweler, Kandil, Alpers, & Gerlach, 2009; Redfern, Yardley, & Bronstein, 2001). It is currently still undiscovered how the mechanism of action of factors affecting postural stability in the field operates. Nowadays, there has been no research on the analysis of postural stability in relation to the level of physical activity of HW. The impact of the working conditions and long-term experience of HW on the level of their postural stability is also ambiguous. Therefore, it would be valuable to examine the level of postural stability and physical activity of workers working at heights above 1 meter.

The purpose of the study was to analyze the level of postural stability and physical activity of HW. The relation between postural stability and physical activity was also evaluated.

Resources and Methods

Characteristics of the Research Group

The study included a group of 17 healthy men working at height (HW: at-height worker). As a control group, 17 office workers (OW: office worker) were examined. The criteria for participation were as follows: a minimum age of 25 years and verbal contact skills enabling conscious, logical answers, and full mobility. Table 1 presents the basic characteristics of the studied groups of males. The groups did not differ statistically in age or BMI (body mass index).

All participants were informed in details of the study and gave their written consent to the experimental procedure. The study was approved by the Bioethical Committee at Poznan University of Medical Science (Decision No. 1111/16).

Research Methods

A Baecke questionnaire was used to measure physical activity at work (WI), sports activity (e.g., jogging, swimming; SI), and leisure (LI) as well as total index of physical activity (TI; Baecke, Burema, & Frijters, 1982). The questionnaire is valid and reliable to measure habitual physical activity (Florindo & Latorre, 2003). The result was based on the pattern and codes attached to the questionnaire representing the intensity and duration of the activity (three levels of intensity of work activity, three levels of sports intensity, and five levels of frequency of performed activities were established).

For evaluation of postural stability, the one-leg standing test with eyes open (OLST-EO) and closed (OLST-EC) was used. The test assesses balance in a static position and it is conducted to evaluate balance with and without vision control. The subject stands straight, arms lowered alongside the hips, first on one leg with eyes open, and then performs the same test with eyes closed. The countdown should be stopped when the lifted leg touches the floor or when the subject moves his arms away from his body to stabilize his position.

Interpretation: It is assumed that the subject passes the test with eyes open after 45 s and later, with eyes closed, after 15 s (Zasadzka & Wieczorowska-Tobis, 2012).

Statistical Methods

Student's *t*-test for independent data was used to evaluate differences between groups with regard to quantitative variables (standing on one leg with open and closed eyes tests, physical activity indexes, BMI, age). To determine the correlation between the variables, Pearson's *r* coefficients were calculated, whereas in order to compare the groups with regard to the test concerning standing on one leg with closed eyes, under control of physical activity, Analysis of Covariance (ANCOVA) was used. Calculations were made using Statistica 10.0 (StatSoft Inc., Tulsa, OK).

Results

The HW group scored statistically significantly higher on the OLST with eyes closed (Table 2). Correlations between work index and total index of physical activity and the OLST with eyes closed were reported to be statistically significant (Table 3).

Between groups differences and total physical activity level (covariate) explain around 39% of variance of OLST-EC (adjusted $R^2 = 0.386$). The effect of total physical activity index (covariate) was statistically significant ($F(1.31) = 10.01$, $p < .01$, $\eta^2 = 0.24$) as well as the group effect ($F(1.31) = 11.24$, $p < .01$, $\eta^2 = 0.27$). The HW group scored significantly higher on the OLST-EC than the OW group under control of physical activity (corrected means: HW group: $M = 10.37$, OW group: $M = 6.07$; Figure 1).

Table 2. Average Values, Standard Deviations, and Differences Between Groups for Physical Activity Indexes and Postural Stability Tests.

Variable	*M* (*SD*) HW	*M* (*SD*) OW	*t* *df* = 32	*p*
SI [pts]	4.55 (1.41)	4.59 (1.10)	−0.09	.930
WI [pts]	3.71 (0.51)	2.74 (0.53)	5.43	.000
LI [pts]	2.53 (0.43)	3.26 (0.51)	−4.53	.000
TI [pts]	10.79 (1.62)	10.60 (1.47)	0.37	.712
OLST-EO [s]	45.06 (10.14)	41.88 (14.84)	0.73	.471
OLST-EC [s]	10.50 (5.24)	5.94 (2.84)	3.15	.004

Note. HW = height workers; OW = office workers; *SD* = standard deviation, *M* = mean; SI = sports activity; WI = physical activity at work; LI = physical activity at leisure; TI = total index of physical activity; OLST-EO = one-leg standing test with eyes open; OLST-EC = one-leg standing test with eyes closed.

Table 3. Correlations Between Physical Activity Indices, Age, BMI, and Results of Postural Stability Tests.

Variables	OLST-EO [s]	OLST-EC [s]
WI [pts]	−0.11	0.65***
SI [pts]	0.16	0.25
LI [pts]	−0.09	−0.10
TI [pts]	0.04	0.46**
Age [years]	−0.12	−0.01
BMI [kg/m^2]	0.20	−0.04

Note. ***p* < .01, ****p* < .001; WI = physical activity at work; SI = sports activity; LI = physical activity at leisure; TI = total index of physical activity; BMI = body mass index; OLST-EO = one-leg standing test with eyes open; OLST-EC = one-leg standing test with eyes closed.

Discussion

The level of physical activity was assessed on the basis of the Baecke questionnaire. A significant difference was noted between the average values of physical activity at work and during leisure time. The group of HW reported the greatest physical activity during work. The analysis of the average value of physical activity during leisure time showed lower results for HW. The reduced involvement of HW in physical activity during leisure time is most likely caused by their increased level of physical activity during work (Chau, van der Ploeg, Merom, Chey, & Bauman, 2012; Clemes, O'Connell, & Edwardson, 2014). The reverse situation can be observed in the OW group, in which reduced activity during work is compensated by increased free-time activity. Similar ages, lifestyles, and family models may influence the comparable results in the level of physical activity in both groups of men.

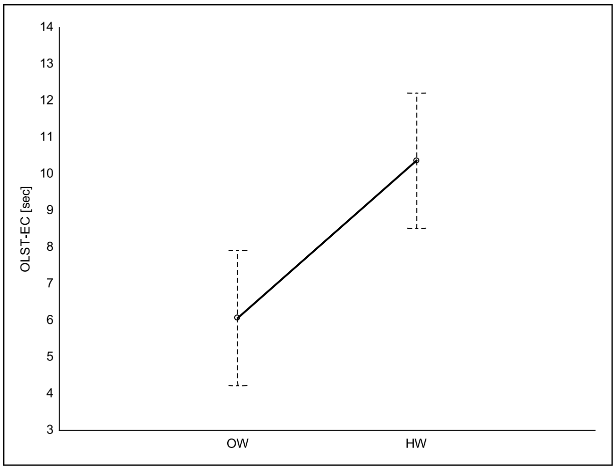

Figure 1. Differences between corrected means for one-leg standing test with eyes closed for office (OW) and high workers (HW) group.

In the case of postural stability, a significant difference was noted in the OLST-EC. The HW group achieved better results even under control of total physical activity level. Presumably, the superior postural stability of HW results from the daily training of particular muscle groups used in the occupational tasks of the at-height worker, balance training related to the conditions and nature of this work, as well as the level of physical activity (Gatti, Giovanni, & Migliaccio, 2014; Lee & Nussbaum, 2012; Yan, Li, Li, & Zhang, 2017).

Punakallio (2003) studied the influence of age, occupation, and physical activity on the functional and postural stability of physical workers. The analysis included firefighters (men, $n = 69$), construction workers (men, $n = 52$), nursing staff (women, $n = 51$), and home care workers (women, $n = 66$). The age of the respondents ranged from 23 to 61 years. Balance was tested with the use of a force platform. In addition, functional balance was also assessed by means of walking on a wooden board. Construction workers obtained better results than firefighters, and both groups had better functional balance and were characterized by higher levels of physical activity than home and nursing staff.

Similar results emerge from the studies of Prioli, Freitas Júnior, and Barela (2005), who analyzed the effects of physical activity on control in the posture of the elderly and the relationship between visual information and body balance. The study included 16 physically inactive elderly people, 16 active elderly people, and 16 young adults (ages: 63.3, 64.3, and 21.7 years, respectively). Inactive elderly people had more difficulty to discriminate and integrate sensory information than active elderly and young adults. It has been concluded that physical activity seems to help in maintaining the appropriate level of posture control and sensory interaction. Age and lack of physical activity can be responsible for insufficient posture control and vice versa; physical activity can modulate the posture control of people of all ages.

Min et al. (2012) studied objective measures of the postural stability, cardiovascular stress, and subjective difficulty in maintaining postural balance among four novice and four expert construction workers with experience with regard to scaffold frames. The experts were 9.3 years older than the novices and had 15 more years of experience in the job. At a lower level of worker experience, a higher scaffold height, and in the absence of a handrail, postural stability was significantly reduced, while cardiovascular stress increased.

Similar results emerge from the studies by DiDomenico et al. (2010), who analyzed the effects of postural stability of construction workers upon standing, after working in different postures. Based on both studies, it can be stated that the workplace and the experience of HW affect their postural stability, regardless of the industry and the age of the worker.

Adkin et al. (2000) analyzed whether posture control correlates with the level of risk of the posture. In conditions of increased posture risk such as alterations in surface height, greater posture control was observed in young, healthy adults (20.3 ± 1.3 years). In addition, postural control precisely matched the level of danger and increased with the level of experience (i.e., prior experience of postural threat) of the tested person. The control of posture was also influenced by the order in which the threat to posture was experienced. These results may be validated by the results of the research obtained in this article.

Finally, some limitations of this study must be mentioned. First of all, the experimental group is relatively small. The study conducted on a larger sample could have generated a stronger overall evidence base. Another limitation is that there was no analysis of physical activity level in leisure time in the context of socioeconomic status. Finally, precise assessment of the level of physical activity in daily life of HW using accelerometers, for example, Actigraph (especially in the context of timeline of performed activity during day), could help enhance the analysis of obtained results.

Conclusion

The study has shown that the increased risk of a posture leads to more conscious posture control on the part of HW. As for postural stability, the groups differed in favor of the HW. At the same time, despite differences in particular aspects, the overall level of physical activity was similar. This may indicate that postural stability is rather affected by exposure to distress conditions, such as work at heights.

Declaration of Conflicting Interests

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