701. Physiological factors in the stability of body posture

A. Kilikevičius[1], J. Griškevičius[2], P. Tamošauskas[3], V. Morkūnienė[4], D. Višinskienė[5]
[1, 2] Vilnius Gediminas Technical University, Department of Machine Building
J. Basanavičiaus str. 28, LT-03224 Vilnius, Lithuania
[3, 4, 5] Vilnius Gediminas Technical University, Department of Physical Training
Saulėtekio al. 28, LT-10223 Vilnius, Lithuania
E-mail: [1]*akilikevicius@gmail.com,*[2] *julius.griskevicius@vgtu.lt,* [3] *hinst@vgtu.lt,* [4]*valdakind@gmail.com,* [5] *hinst@vgtu.lt*

(Received 3September 2011; accepted 4 December 2011)

Abstract. This article investigates the oscillations of body posture before and after physical activity with eyes open and closed. The paper analyses visual perception of the surroundings and what impact it has on body balance stability.

Keywords: body posture, physiological factors, accelerometer.

Introduction

Maintaining and ensuring proper body orientation rest on the interaction of skeletal muscles and nervous system. The components of the skeletal muscles, determining balance stability, are the amplitude of motion, flexibility of spine, mechanical muscular characteristics and biomechanical brain correlation [1-3].

Balance is governed by physiological factors, balance organs (cerebellum, inner ear), muscular receptors (Golgi apparatus, spindle; spindles react to stretching, Golgi apparatus to pressure) and vision. Balance is stabilized using visual, vestibular and proprioreceptive information. Optimal interaction of vision and somatosensory impulses enables appropriate control of body segment orientation and stability. Lack of visual information disturbs the control of balance, body segment position and reaction to the surroundings. The significance of balance and movement control gains much more importance in older age and in people having suffered or suffering from nervous system diseases (especially stroke). In those cases deterioration or complete loss of skeletal muscle coordination and general body balance is especially noticeable. This results in aggravated bio-psychosocial functions and adaptation in surrounding environment and society.

The sensory system is actively involved in the control of the motor: it regulates the guidance of movement, is engaged in perception of the environment and movements and fulfils the role of a stimulus for the reflex movements. Vision identifies objects and their movement in the environment, providing with information on the latter, as well as on the position of body segments and movement of the surroundings with respect to other body parts. The same information is also received by other sensory organs – balance apparatus in the inner ear, muscular spindles, Golgi body and joint capsule receptors. Nevertheless, people devoid of vision impairment while moving in space mostly use afferent vision impulses. Having encountered vision impairment motor body reactions are being controlled by information received from tactile, aural or other senses, whereas for people with normal vision this kind of information is only supplementary. Compared with visual, the role of proprioreceptive information in controlling psychomotor functions and stability of people with normal vision is only minimal. Still, with diminishing or disappearing visual information, the lack of it in regulating balance can be compensated by strengthened proprioreceptive, tactile and aural function, which can be evoked by the method of general as well as special physical practice. All the information received by the receptors is administered by the central nervous system, sending nervous impulses to muscles which by contracting and relaxing in turn help to maintain the balance [1].

For many years balance exercises were recommended for rehabilitation. Now it's increasingly practiced as preventive measure to avoid injuries. Therefore, especially what regards elderly people, early balance disorder diagnosis and detection of its onset is very important to functional balance disorder slowdown and fall prevention. The most frequent cause of falls, bone fractures and various workplace and home injuries is balance and coordination disorder. When balance is interrupted, reactions restoring body to its primary position manifest themselves. It is claimed that the main balance stabilizing component is the position of human general centre of mass (GCM) coordinate. It has been identified that when balance is interrupted "the kinematic strategy" switches on and with the help of it the position of body segments changes. This stimulates movement of body GCM and allows maintaining it in the boundaries of the support plane [1, 4].

Central vision enables to identify the surrounding objects, parts of the body and their parameters. Peripheral vision enables to identify the changes in the position of objects and parts of the body reciprocally providing with consciously intangible and inapprehensible information, which is of great importance in motor control. Central and peripheral vision interacts in balance control. Peripheral vision has a greater impact on oscillation forward/backwards than on left/right. Whereas central vision participates in oscillation control of both motion modes. Therefore, many authors [5], investigating the impact of vision on balance control, maintain that balance control while standing is the most significantly influenced by central vision. Any disorder of central vision results in stronger lateral oscillations [6].

Movement, coordination, movement control, agility disorders as well as dizziness, fainting (loss of consciousness) have brought about analysis of human body balance control. Over the time there have been many different physical and movement disorder classifications presented. Most often they are referred to as physical, orthopedic, or less so as motor or movement disorders. In Lithuania as to disorder classification (1995), group seven consists of physical and motor impairments. This classification constitutes the following disorder groups:

a) general motor disorder of skills;
b) minor motor disorders;
c) movement coordination disorders;
d) movement disorder that could range from minor irregularity to inability to move;
e) apraxia and dyspraxia (partial loss of the ability to coordinate and perform certain purposeful movements and gestures in the absence of motor or sensory impairments such as paralysis);
f) scoliosis (medical condition in which a person's spine is curved from side to side);
g) deformations of parts of a body);
h) other physical and motor impairments.

The most common general term used in literature is physical health problems. Physical and motor impairment can be determined by orthopedic (locomotor system disorders, bone, muscular function disorders) neurological (CNS and PNS disorders), chronic diseases, conditions determining disability etc [1].

Conditions attributed to locomotor dysfunction: bone fractures, osteitis, panosteitis, inflammation of bone, growth interruptions and bone anomalies, osteoporosis, cartilage ossification, bone marrow diseases, osteopathic disorders, rib, bone disorders, cranium, head bone injuries, arthritis, joint inflammation, rheumatic arthritis, muscle inflammation and atrophy, myalgia, other muscular disorders, paralysis, cerebral paralysis, mobility balance disorder, amyortophy, myotrophy, muscular fibre tear, stroke, heart attack.

In literature factors determining physical and mobility disorder are as follows:

1. Prenatal chromosome pathology (Down syndrome, Turner syndrome or dwarfism, Apert syndrome, RETT syndrome etc.);
2. Prenatal fibre deficiency (lip and palate deformities, limb underdevelopment, other congenital body parts deformities);

3. Intrauterine factors (infection, radiation, rhesus factor and other adverse elements);
4. Perinatal trauma or infection (oxygen deficiency, haemorrhage);
5. Postnatal trauma, infections, disorders (chronic diseases, limb loss and etc.).

Any weakened balance component function results in deteriorating stability and disturbed gait in people undergoing aging process (Gauchard, 2003). Mobility impairments can also occur in children, and often they single out from other children of their age in different physical development. They cannot move normally, their movements are uncoordinated, balance is disturbed. The bigger the limitation, the more conspicuous it is. Those are disabled children. Balance disorders can accompany people from different age groups [7, 8]. Therefore, early balance disorder diagnosis and detection is important to both older age people and children alike. In case of the former, the aim is to slow down functional mobility deterioration and for the latter the focus is to bring to full recovery and integrate such a child into normal social life.

Experimental test

The purpose of experimental tests is to evaluate and compare the parameters of static balance in healthy adults (20-25 year-olds) before and after physical activity.

The test was carried out using "Bruel & Kjaer" measuring equipment: three seismic (uniaxial) accelerometers 8344, which traced the oscillation amplitude of human centre of mass for the axes *X*, *Y* and *Z*. Technical characteristics of the accelerometer 8344 is as follows: sensitivity 250±20% mV/ms^{-2}, measure range ±26 ms^{-2}, frequency range 0,2–3000 Hz. During the test portable computer with special software package "Pulse", electrical signal input and processing device 3660-D was used.

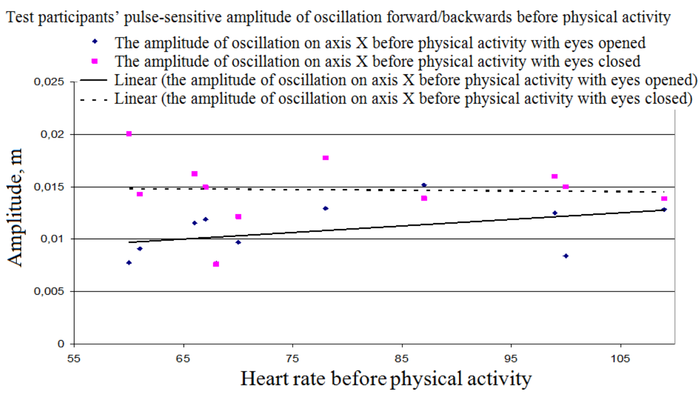

Fig. 1. Linear dependence on heart rate of amplitude of oscillation forward/backwards before physical activity with eyes opened/closed

In Fig. 1 straight line represents linear dependence of amplitude of oscillation on heart rate forward/backwards before physical activity with eyes opened. Dotted line represents linear dependence of amplitude of oscillation on heart rate forward/backwards before physical activity with eyes closed. It has been noticed that the amplitude of oscillation before physical activity with eyes opened, rises up with higher heart rate, i.e., the higher the heart rate, the greater is the amplitude of oscillation. Whereas the amplitude of oscillation before physical activity with eyes closed with increased heart rate stays steady.

In Fig. 2 straight line represents linear dependence of amplitude of oscillation on heart rate forward/backwards after physical activity with eyes opened. Dotted line represents linear dependence of amplitude of oscillation on heart rate forward/backwards after physical activity with eyes closed. It has been noticed that amplitude of oscillation after physical activity with eyes opened, rises up with higher heart rate, i.e., the higher the heart rate, the greater is the amplitude of oscillation. Whereas the amplitude of oscillation after physical activity with eyes closed with increased heart rate recedes, i.e., the higher the heart rate, the lesser is the amplitude of oscillation.

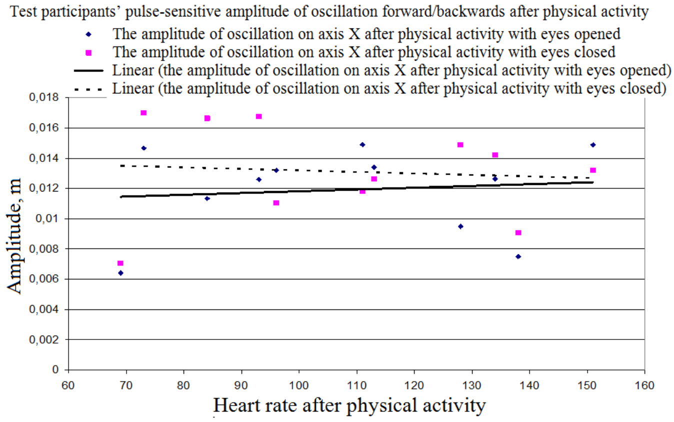

Fig. 2. Linear dependence of amplitude of oscillation on heart rate forward/backwards after physical activity with eyes opened/closed

After comparing Fig. 1 and 2 it has been observed that the amplitude of oscillation forward/backwards before and after physical activity with eyes opened, rises with higher heart rate, i.e., the higher the heart rate, the greater is the amplitude of oscillation. Meanwhile amplitude of oscillation forward/backwards before and after physical activity with eyes closed with higher heart rate slightly decreases.

In Fig. 3 straight line represents linear dependence of lateral amplitude of oscillation on heart rate before physical activity with eyes opened. Dotted line represents linear dependence of lateral amplitude of oscillation on heart rate before physical activity with eyes closed. It has been noticed that lateral amplitude of oscillation before physical activity with eyes opened and closed, rises up with higher heart rate, i.e., the higher the heart rate, the greater is the amplitude of oscillation.

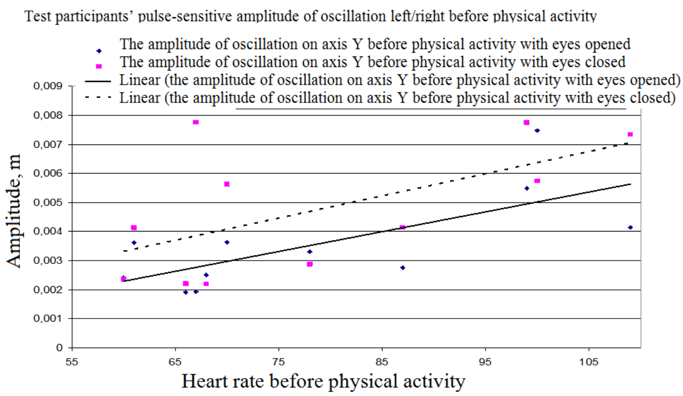

Fig. 3. Linear dependence of lateral amplitude of oscillation on heart rate before physical activity with eyes opened/closed

In Fig. 4 straight line represents linear dependence of lateral amplitude of oscillation on heart rate after physical activity with eyes opened. Dotted line represents linear dependence of lateral amplitude of oscillation on heart rate after physical activity with eyes closed. It has been observed that lateral amplitude of oscillation after physical activity with eyes opened and closed, rises up with higher heart rate, i.e., the higher the heart rate, the greater is the amplitude of oscillation.

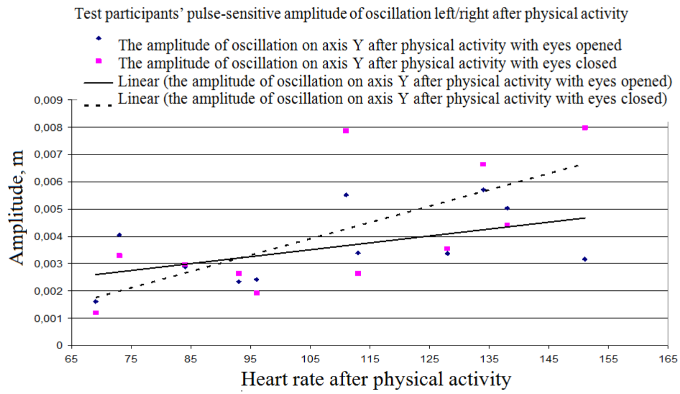

Fig. 4. Linear dependence of lateral amplitude of oscillation on heart rate after physical activity with eyes opened/closed

After comparing Fig. 3 and 4 it has been observed that lateral amplitude of oscillation before physical activity with eyes closed and raised pulse is 23% higher than with eyes opened. The same goes with amplitude of oscillation after physical activity when with higher heart rate the amplitude of oscillation rises by 30%.

Conclusions

Physical activity affects human body balance. During it the internal stability (homeostasis) of the human body changes and because of that it has to adapt: in order to function properly, its various functions and structures have to adjust to psychophysical load and it results in higher amplitude of oscillation after physical activity. The research has revealed that:

1. After analyzing the amplitude of oscillation forward/backwards before and after physical activity with eyes opened/closed, it can be stated that the visual perception of the surroundings has an impact on person's balance stability as testing balance with eyes closed, the amplitude of oscillation has risen. The average increase in forward/backwards amplitude before physical activity (with eyes opened/closed) is 1,5 times and after physical activity it is 2,5 times.
2. With eyes closed, the average of amplitude of oscillation sideways before physical activity was 0,0039 m and after physical activity it was 0,0044 m. When comparing the amplitude of oscillation sideways with eyes closed before and after physical activity it can be observed that the amplitude of oscillation after physical activity with eyes closed has increased by 11,37%. Comparing the amplitude of oscillation sideways before and after physical activity *with eyes opened* and the amplitude of oscillation sideways before and after physical activity *with eyes closed*, it has been noticed that the amplitude of oscillation sideways before and after physical activity with eyes opened has doubled.

References

[1] **Muckus K.** Biomechanikos pagrindai. Lietuvos kūno kultūros akademija. Kaunas, 2006, p. 300.

[2] **Aminian K., Najafi B.** Capturing human motion using body-fixed sensors: outdoor measurement and clinical applications. Comp. Anim. Virt. Worlds, 2004, p. 79–94.

[3] **Chen K. Y., Bassett D. R., Jr.** The technology of accelerometry-based activity monitors: Current and future. Med. Sci. Sports. Exerc., 2005, p. 490–500.

[4] **Griškevičius J., Jarmalienė E., Maskeliūnaitė I.** Žmogaus pusiausvyros tyrimas. Mechanika, medžiagų inžinerija, pramonės inžinerija ir vadyba, 2009, 1 tomas, Nr. 2.

[5] **Griškevičius J., Jarmalienė E., Šešok A., Daunoravičienė K., Kizilova N.** Evaluation of human postural balance in quiet standing by direct measurement of human body center of mass acceleration. Journal of Vibroengineering, 2009, p. 556–561.

[6] **Mathie M. J., Coster A. C. F., Lovell N. H., Celler B. G.** Accelerometry: providing an integrated, practical method for long-term, ambulatory monitoring of human movement. Physiol. Meas., 2004, p. 1–20.

[7] **Moe-Nilssen R., Helbostad J. L.** Trunk accelerometry as a measure of balance control during quiet standing. Gait Posture, 2002, p. 1–8.