ABILITY OF MAINTAINING BALANCE IN AMATEUR BOXERS FROM "WALTER" BOXING CLUB

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Abstract:
The study aim was to diagnose the abilities of maintaining balance among the people who train boxing in a boxing club in Rzeszów, Poland. All the examinations that allowed authors to present balance parameters for both groups were carried out using a specialized measurement apparatus. The results of the study were analysed and presented in the form of the tables and charts. The results of the tests demonstrated that the visual perception, or, more specifically, exclusion of this perception, has significant effect on poorer postural stability.

INTRODUCTION

Ability to maintain balanced body posture is very important in everyday life and usually occurs without human awareness. Analysis of this property is not easy; therefore, its first step should be definition of the concept of balance. Ability to maintain balance is a very complex coordination problem. It is affected by a number of factors that are included to two groups that form passive and active systems. The passive system is comprised of the skeleton and joints, whereas the active system includes muscles and the nervous system. Their interaction within a particular motor activity allows for achievement of a specific effect, that is, feeling of balance[1].

The main role in providing information about the state of balance is performed by the vestibular analyser, also termed the sense (organ) of balance. Impulses from the vestibular organ, eyes and proprioreceptors are integrated and analysed in the central nervous system. The most important element used in static balance or during very slow movements is the kinaesthetic analyser, whereas in dynamic balance, the vestibular analyser is what matters the most. Balance is also actively controlled by the cerebellar vermis, which receives information from the sense of balance (vestibular organ), whereas efferent impulses from this body structure are sent to the lateral vestibular nucleus, which allows this part of the cerebellum to control body balance and eyes movements in motion[2].

A number of studies have demonstrated that the course of ontogenetic development occurs in the following order: high development rate during the progressive period, short period of relative stabilization, dynamic involution and small sexual dimorphism with sporadic advantage of females[3].

[1] J. Szopa, E. Mleczko, S. Żak, *Podstawy antropomotoryki*, Wyd. Naukowe PWN, Warsaw-Kraków 1996, p. 93.
[2] W. Mynarski, A. Żywicka, *Empiryczny model koordynacyjnych uwarunkowań motoryczności człowieka,* Wyd. AWF, Katowice 2004, p. 42.
[3] J. Szopa, E. Mleczko, S. Żak, *Podstawy antropomotoryki*, Wyd. Naukowe PWN, Warsaw-Kraków 1996, p. 93.

The main factors in the level of discussed ability are precision, speed, purposefulness and resourceful motor solutions that ensure maintaining or regaining balance[4].

The concept of postural balance and stability are often used interchangeably, which is not always justified. Stability is a wider concept compared to balance and it can be defined as an ability to regain the state of balance after losing it. With respect to human posture, stability is considered as an ability to regain typical body position, disturbed by the effect of destabilizing factors such as motor activity or external forces. Therefore, functional stability means sensitivity of posture to the effect of destabilizing factors. Furthermore, structural stability relates to the changes in the structure of control[5].

Błaszczyk defines balance as 'a particular state of the postural system', characterized by vertical body posture. It is achieved through balancing the forces and torques that act on the body. The state of balance is ensured by the reflexive tension of anti-gravity muscles. This definition relates to the motor organ under static conditions, but it can also concern the dynamic ones. The vertical orientation of the head and body trunk, typical of humans in motion, is maintained by phase muscular activity.

State of balance can be considered in three aspects: static balance, understood as an ability to maintain proper body posture with small lateral sway; symmetry, which is manifested by even load in the support components; dynamic balance, which is an ability of maintaining standing position combined with sway and movements without uncontrolled falls[6]. The dynamic balance is largely determined by the environment, thus by the level of a particular ability in the sensitive period for development of this ability. This type of balance is regarded as an ability of the body to control balance when the point of support changes. A variety of types of movements can be used for analysis of dynamic balance:

- Movements on small support surface
- Movements on small and moving support surface
- Movements with rotation around the body's long axis without support
- Movements with rotation around different axes without support
- Movements with changes in speed and direction
- Movements without a support surface [7]

The balance system is responsible for human spatial orientation, thus sensing position of the body and/or its parts with respect to gravity direction, acceleration in linear and rotational motion and maintaining balance in free standing (static balance) or in motion (dynamic balance) [8]

The balance system works based on the stimuli that flow from the surroundings and transforms them into response signals that reach the effector organs such as muscles of the body trunk, limbs and eyeballs causing reflexive reactions to adjust body posture. Among the patterns responsible for balance control, two separate but synergistically working systems can be emphasized. The role of the first one is to stabilize the eyesight through control of the direction and visual acuity during the activities connected with movements of the head and

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[4] J. Raczek, W. Mynarski, W. Ljach, *Kształtowanie i diagnozowanie koordynacyjnych zdolności motorycznych,* Wyd. AWF, Katowice 2003, pp. 20-21.

[5] J. W. Błaszczyk, *Biomechanika kliniczna*, PZWL, Warsaw 2004

[6] Lee A., i In., *Quantitative and clinical measures of static standing balance in hemiparetic and normal subjects*, Psych. Ther., 68, 6, 970-876, 1988, A. Kwolek, M. Drużbicki, *Wykorzystanie platformy do ćwiczeń równowagi z zastosowaniem biologicznego sprzężenia zwrotnego u chorych po udarze mózgu,* Fizjoterapia, 7, 3, 3-6, Wrocław 1999, J.W. Błaszczyk, *Biomechanika kliniczna*, PZWL, Warsaw 2004

[7] W. Starosta, *Koordynacja ruchowa człowieka*. (in:) Motoryczność człowieka -jej struktura, zmienność i uwarunkowania. Monografie No. 310, Wyd. AWF, Poznań 1993.

[8] M. Strzecha, H. Knapik, P. Baranowski, J. Pasiak, *Człowiek ma zazwyczaj dwie nogi – ujęcie stabilograficzne*, Annales Universitatis Mariae Curie-Skłodowska, Sectio D, Lublin 2008

the whole body. The second system is responsible for stabilization of body posture and also for maintaining the body in the state of balance, both in motion and at rest. [9]

STUDY AIM AND BASIC RESEARCH PROBLEMS

The study aim is to identify and determine the ability of maintaining balance with eyes open and eyes closed with an example of the athletes who train in "WALTER" boxing club in Rzeszów. The research problem in the study is the assessment of the scope of dynamic balance. In order to achieve the research goal, the author of the study proposed the following research questions:

1. What is the level of dynamic balance in the subjects included in the study?

2. How does limitation of the field of vision affect postural stability in boxers?

Furthermore, in order to carry out an in-depth analysis of the research problem, the following specific questions were asked:

1. How does boxing training impact on the length of the pathway left by the centre of pressure with eyes open and eyes closed?
2. How does boxing training impact on the surface area covered with the recorded pathway of the centre of pressure with eyes open and eyes closed?
3. How does boxing training impact on the velocity of the displacement of the centre of pressure with eyes open and eyes closed?

RESEARCH MATERIAL

The study covered 10 subjects who trained boxing in Rzeszów, Poland, Subcarpathian Voivodeship. It was found based on the documentation obtained from the boxing coach in the club that all the subjects in the study had at least 5 years of training experience and average training experience of the whole group was ca. 10 years. All the subjects are involved in comprehensive, intensive training sessions, 3 times a week on average. The investigations of this group were carried out during the final phase of the pre-competition period, which allowed for measurements at the moment when the athletes' fitness reached the upper threshold in the season. Table 1 presents minimum, maximum and mean values of basic body dimensions and the values for the body mass index in the group of the boxers studied.

Table 1. Characteristics of the group who trains boxing

Body Height [cm]			**Body Mass [kg]**			**BMI [kg/m2]**		
min.	max.	mean	min.	max.	mean	min.	max.	mean
160	180	170	52	105	82.5	32.2	36.2	32.6

Source: author's own study.

All the subjects in the study were informed about the aim, nature and methodology of the examinations. Each person gave their consent to participate in the full research program.

A subject was asked to stand relaxed, barefoot and in a sport uniform on the AccuGait dynamographic balance platform. The examination consisted in two tests, performed one after another. During the first test, the subject had to adopt the standing position with eyes open (EO), with arms relaxed, along the body trunk and feet positioned forward (without rotation in talocrural joint), hip width apart. In this position, the authors recorded the stabilometric parameters. During the second test, the authors carried out the examination with the same

[9] M. Held-Ziółkowska, *Równowaga statyczna i dynamiczna ciała, część 1. Organizacja zmysłowa i biomechanika układu równowagi.* Mag. ORL, V, 2, 39-46, Warsaw 2006

body position but with eyes closed (EC), and again, recorded the above parameters. Each test took 30 seconds and a person was asked not to perform additional movements. When a movement was made with upper extremity, lower extremity or head, the examination was aborted and repeated.

After completion of the standing tests on the platform, several anthropometric measurements were carried out for each study participant. These measurements were recorded once.

The anthropometric indices measured included:

1. body height [cm] - this index was measured by means of the anthropometer with the accuracy of 0.5 cm. The subject was measured barefoot, standing in a relaxed upright position (so-called basic Frankfurt position),
2. Body mass [kg]: this parameter was measured by means of medical scales with accuracy of 0.1 kg. The subject started the measurement in a light sport uniform, without shoes,
3. BMI index [kg/m^2]: this index was determined based on the above indices by dividing body mass [kg] of the subject by square body height [m].

All the above examinations and measurements were carried out on the third of March 2011 in WALTER sports hall in Rzeszów, Poland, in the morning. The temperature in the hall was 19 degrees Celsius.

The test that measured postural stability was carried out by means of an AccuGait dynamographic platform, manufactured by AMTI. Standard evaluation of stability was carried out for free standing with eyes open and eyes closed (Romberg test). The measurements were also recorded for the parameters of the center of foot pressure (COP), which are closely connected with displacement of the general centre of gravity (COG).

The present study focused exclusively on the measurements of the following indices (parameters) of body stability:

1. Maximum range of the COP displacement in the frontal and saggital planes [cm], which is the distance between the extreme maximum displacements of the COP in lateral and anterior-posterior direction.
2. Variability of position of the COP [cm] in both planes of movement: frontal and saggital. Index of variability means a standard deviation from the mean value of the COP pathway and represents the degree of dispersion of the displacement of this point with respect to the mean value.
3. The surface area for oscillation ellipse for the COP [cm^2] is the surface area for the ellipse drawn by the moving point of the COP on the base surface. It should be emphasized that the option of the software compatible with the force plate that allows for calculation of this surface area automatically rejects 5% of the extreme results while 95% of the data are considered for the analysis.
4. Mean velocity of displacement of the COP [mm/s] is the ratio of the length of the pathway for displacement of the COP in all the directions to the time (20 s). Length of the pathway is the total of the distances between the positions of the COP in consecutive samples of the pathway. Velocity of the COP represents the rate of changes in position of this point, which reflects the speed of initiation of postural response in standing[10].

All the parameters of balance were calculated using BioAnalysis software, compatible with the program that records data from the AccuGait platform. This software was developed by AMTI and is designed to be used in biomechanics.

[10] M. Sobera, *Charakterystyka procesu utrzymywania równowagi ciała u dzieci w wieku 2-7 lat.* Studia i Monografie *No.* 97, Wyd. AWF, Wrocław 2010.

Parameters of sway for both tests in the group were described by means of typical quantitative characteristics: minimum and maximum values, arithmetic means and standard deviations. Then, the results of the test with eyes open (EO) were compared with the results of the test with eyes closed (EC) in the group of boxers.

RESULTS

Evaluation of balance in the group studied used indices concerning the centre of pressure (COP), calculated by the software. Each of the above indices was evaluated for the whole group by comparing the mean results measured with eyes open and eyes closed. The results in the tables coloured in red concern the parameters used in the statistical analysis.

Table 5 presents the results of the test with eyes open (EO) while Table 6 presents the results of the test with eyes closed (EC).

Table 5. Results of the test with eyes open (EO)

Parameters	Max	Min	Avg	SD
COP-X Avg (cm.)	1.705	-0.57	0.521	2.366
COP-Y Avg (cm.)	2.406	-7.91	-3.684	9.037
COP-X Max (cm.)	1.761	0.344	0.842	1.537
COP-X Min (cm.)	-0.353	-2.125	-1.027	1.763
COP-Y Max (cm.)	6.644	0.792	3.066	6.784
COP-Y Min (cm.)	-0.944	-5.763	-1.911	4.557
Standard Deviation - X COP	0.511	0.114	0.265	0.412
Standard Deviation - Y COP	1.013	0.303	0.654	0.875
Avg. Displacement along X (cm.)	0.359	0.088	0.202	0.307
Avg. Displacement along Y (cm.)	0.672	0.202	0.404	0.451
Avg. Radial Displacement (cm.)	0.687	0.235	0.494	0.477
Standard Deviation - Radial Disp.	0.932	0.218	0.501	0.864
Corelation Coefficient	0.697	-0.642	-0.14	1.413
95% Ellipse Slope	89.692	-88.636	-27.534	253.958
SD - Major Axis of 95%Ellipse	1.021	0.202	0.543	0.944
SD - Minor Axis of 95%Ellipse	0.837	0.257	0.425	0.571
95% Ellipse Area (cm..cm.)	9.081	0.695	3.214	8.966
Avg Velocity (cm/sec)	2.34	1.343	1.612	1.064
Length (cm.)	70.194	40.282	48.351	31.934

Source: author's own study.

Table 6. Results of the test with eyes closed (EC)

Parameters	Max	Min	Avg	SD
COP-X Avg (cm.)	2.015	-0.384	0.73	2.457
COP-Y Avg (cm.)	2.473	-6.747	-3.646	9.267
COP-X Max (cm.)	1.075	0.324	0.554	0.816
COP-X Min (cm.)	-0.274	-2.015	-0.874	1.87
COP-Y Max (cm.)	6.747	0.861	3.011	7.605
COP-Y Min (cm.)	-0.988	-3.73	-1.481	2.447
Standard Deviation - X COP	0.472	0.124	0.228	0.366
Standard Deviation - Y COP	1.221	0.274	0.685	1.068
Avg. Displacement along X (cm.)	0.33	0.093	0.17	0.246
Avg. Displacement along Y (cm.)	0.584	0.208	0.418	0.41
Avg. Radial Displacement (cm.)	0.678	0.249	0.483	0.466
Standard Deviation - Radial Disp.	1.125	0.196	0.517	1.144
Corelation Coefficient	0.395	-0.798	-0.118	1.383
95% Ellipse Slope	87.474	-88.429	0.549	286.659
SD - Major Axis of 95%Ellipse	1.151	0.164	0.561	1
SD - Minor Axis of 95%Ellipse	1.008	0.16	0.43	0.739
95% Ellipse Area (cm..cm.)	7.635	0.816	2.836	7.249
Avg Velocity (cm/sec)	2.406	1.239	1.748	1.233
Length (cm.)	72.191	37.156	52.442	36.997

Source: author's own study.

The charts below present the data for the group of boxers concerning the position of the centre of pressure on the platform with respect to the system of X and Y axes. Chart 4 relates to the test with eyes open (EO) while Chart 5 concerns the test with eyes closed (EC).

The first of the analysed parameters is the length of the pathway drawn by the projection of the centre of gravity (COP). The value of this parameter obtained during the measurement of visual control (eyes open/eyes closed). This index allows for evaluation of the maximum scope of 'sway' in standing position in anterior-posterior and lateral directions. Healthy humans allow for 'balancing' with the COP within the area marked by the external contours of the feet. The statistically significant difference was found in the test with both legs and eyes open: a rise in the length of the pathway was recorded for eyes open by 1.413, with standard deviation of -0.14. Under normal conditions, human never sways within this range; it should be noted that subjects in this study were the boxers who train based on a regular basis.

The balance was evaluated in the study group with consideration of mean oscillation of the COP along X axis (lateral direction). The software used for the balance platform allowed for positioning of the centre of gravity within a Cartesian coordinate system. In this test, mean oscillation along the X axis was higher for eyes open by 0.521 with standard deviation of 2.366. This difference was highly statistically significant compared to the test with eyes closed, where mean pathway length was 0.71.

Evaluation of balance in the group studied with consideration of mean oscillation of the COP along Y axis (in anterior-posterior direction) did not exhibit statistically significant differences between the first and the second test standing on both feet with eyes open and eyes closed. In both tests, the result with eyes open was -3.684 (with standard deviation of 9.037), and, with eyes closed this value was -3.646 (with standard deviation of 9.267).

The surface area for oscillation ellipse for the COP is the surface area for the ellipse drawn by the COP moving on the base surface. The values obtained in the study that determine the surface area of 95% of the ellipse are also varied in terms of the test with eyes open and eyes closed. The test with EO yielded much better results in evaluation of the abilities to maintain balance with the above parameters compared to the test with eyes closed.

Mean velocity of the COP displacement is the ratio of the length of the pathway of the COP displacement in all the directions to time. Length of the pathway is the total of the distances between the positions of the COP in consecutive samples of the pathway. The total length of the pathway in the test with eyes open was 48.351, with the mean for the group that amounted to 1.612. This value for the test with eyes closed was 52.442, with the mean of 1.748.

CONCLUSIONS

The results of the tests demonstrated that the visual perception, or, more specifically, exclusion of this perception, has significant effect on poorer postural stability.

Four of six balance parameters studied were characterized by better results in tests with eyes open compared to the results from the tests with eyes closed. Mean velocity of displacement of the centre of gravity and the length of the pathway of the centre of gravity are the two parameters which seem to be the most relevant since they are characterized by reproducibility. In the case of the group in the study, the above parameters are characterized by better results in tests with eyes open.

The results are partially consistent with the results obtained by other authors. Schieppati, Nardone[11] and Viitasalo et al.[12] demonstrated an increased postural sway during free, relaxed standing. Furthermore, Horak et al.[13], Beckley et al.[14] and Bloem and co-authors[15] found normal or even reduced postural sway among the ill people. Some studied have demonstrated increased sway in frontal plane with respect to the age groups[16], whereas others found substantial increases in the sway in the saggital plane[17]. These discrepancies

[11] M. Schiepati, A. Nardone, *Free and supported stance in Parkinson's disease. The effect of posture and postural set on leg muscle response to perturbation, and its relation to the severity of the disease.* Brain No. 114: 1227-44, 1991

[12] M.K. Viitasalo, V. Kampman, K.A Sotaniemi, S. Leppävuori, V.V Myllylä, J.T Korpelainen, *Analysis of sway in Parkinson's disease using a new inclinometry-based method.* Mov Disord No. 17: 663-69, 2002

[13] F.B. Horak, J.G. Nutt, L.M. Nashner, *Postural inflexibility in Parkinsonian subiects*. J Neurol Sci No. 44:46-58, 1992.

[14] D.J. Beckley, B.R. Bloem, M.P. Remler, *Impaired scaling of long latency postural reflexes in patients with Parkinson's disease.* Electroencephalogr Clin Neurophysiol No. 89: 22-28. 155, 1993.

[15] B.R. Bloem, D.J. Beckley, J.G. van Dijk, A.H. Zwinderman, R.A.C. Roos, *Are medium and long latency reflexes a screening tool for early Parkinson's disease?* J Neurol Sci No. 113: 38-42.

[16] E.E. Van Wegan, R.E. van Emmerik, R.C. Wagenaar, T. Ellis, *Stability boundaries and lateral postural control in Parkinson's disease.* Motor Control No. 5:254-69, 2001.

[17] J.W. Błaszczyk, P.D. Hansen, D.L. Lowe, *Evaluation of the postural stability in man: Movement and posture interaction.* Acta Neurobiol Exp No. 53(1):155-60, 1993a.

might be caused by both the time of the study (time during preparation to competition) and the size of the group studied. No differences in the sway range were found in a study by Marchese et al.[18] carried out among the patients with Parkinson's disease and in healthy elderly subjects in the case of the tests with eyes open and closed. However, exclusion of visual stimuli caused in both cases a deterioration of postural stability. This was manifested in an increased sway area, increased sway ranges in frontal and sagittal planes.

Regarding the proposed research questions, the author found that the subjects who trained boxing achieved similar results as those obtained by other researchers. This concerned both the results with eyes open and with eyes closed. Limitation of visual control has essential effect on deterioration of the abilities to maintain balance.

The above theoretical investigations and the results obtained in the study lead to the following conclusions:

1. Ability of maintaining balance is improved when visual perception is used.
2. Limitation of visual control causes a deterioration of postural stability.
3. Many years of regular boxing training sessions reduce postural sway in anterior-posterior direction and increase sway value in lateral direction.
4. Well-oriented boxing training should take into consideration the exercises with limitation of the visual field of the athlete in order to improve postural stability and proprioception.

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