ORIGINAL ARTICLE

TRENDS in
Sport Sciences
2015; **2**(22): 83-88
ISSN 2299-9590

Postural stability in adults under 30 years of age

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Abstract

Introduction. The aim of the present study is to determine the standard values of parameters describing postural stability: COP area, COP length and lower limbs loading symmetry index (SI). Material and Methods. 60 students of physiotherapy from the University School of Physical Education in Poznań participated in the study. In the case of 29 students, contraindications to participating in the study were identified. Ultimately, 31 participants were selected to take 30-second tests performed while standing on both feet, with and without visual control. Results. The standard values of the COP length parameter were determined. In the test with visual control, 6.5% of participants achieved high and very high scores. 87% achieved average scores. In the test without visual control, 9.7% of participants achieved high and very high scores, while 80.6% attained average scores. The SI index had a normal distribution. It showed that most people put the weight onto their left lower limb, both with and without visual control. Conclusion. Healthy, active adults between 21-24 years of age most often bear weight on the left lower limb. The values describing postural stability were above-average.

KEYWORDS: postural control, stability, Symmetry Index, COP.

Received: 12 December 2014
Accepted: 17 February 2015

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What is already known on this topic?
Postural stability control is an important element in evaluating body fitness. It depends on many factors: neurological, orthopedic, and functional, as well as age and gender. Without postural stability, it is not possible to perform even the simplest activities of daily living. Determining the standard values of parameters describing postural stability helps to plan and monitor the rehabilitation process.

Introduction

Postural stability (PS) is the ability of the body to maintain a stable position and to adjust the position in the event of loss of balance [1-5]. PS depends on neurological, orthopedic and functional factors, as well as on people's age and sex.

The neurological factors include neuromuscular control, the level of proprioceptive sensation, and the functioning of the vestibular system [6, 7]. The impact of proprioceptive sensation was investigated by conducting equivalent tests in two variants: with and without visual control. The lack of visual control enforced increased proprioceptive sensation in the subjects. The impact of the vestibular system was verified during the test conducted on patients with ear implants. The interdependence of the auditory system and the vestibular system resulting from their shared location caused the improvement of balance with the improvement of hearing. During the study, the impact of sensory integration (eyesight, hearing, vestibular system, and exteroceptive sensation) on PS was also investigated [7].

The orthopedic factors which have an impact on PS include bone structure and the structure of the lower limbs and feet, condition of the ligaments – especially in the knee joint, and muscular stabilization of these structures [2, 3, 8, 9].

The impact of functional factors on PS can be seen by optimizing the position. In the stable position the feet are parallel and the distance between the heels is 17-30 centimeters [10]. Furthermore, PS is affected by the position of lower limbs, hip control, and the position of the head and the trunk [4]. Changes of the PS parameters were also observed during dynamic movements of the upper limbs [10]. Sports training is yet another functional factor affecting PS. It was observed that properly planned training led to an increase of PS in the participants [3, 5, 11-14].

The last two elements affecting PS are age and sex. Research shows that the best PS is achieved at the age of 15-65 years. The study revealed better postural stability in women [1, 15].

In order to evaluate the PS of a given subject it is necessary to determine the center of pressure (COP). The position of COP slightly changes while maintaining a stable position by the subject. An area is thus created within which COP moves – the so-called COP area. Within the COP area, the path of COP movement can be traced. It is described by COP length. For a more detailed analysis of balance, the differences between kinematic and kinetic parameters of both limbs can be used. To this end we use the values of the loading of the right and left lower limbs to determine the Symmetry Index (SI) [16].

Determination of the standard values of these indexes allows the assessment of PS during monitored sports training or for diagnostic purposes in the rehabilitation of the disabled.

Aim of Study

The aim of the study is to assess postural stability in healthy young people between 21-24 years of age.

Methods

Recruitment procedure

Third-year students of physiotherapy from the University School of Physical Education in Poznań were invited to participate in the study. Figure 1 presents the stages of the recruitment process and conducted study. The inclusion criteria for the study are presented in Table 1. Out of 113 people, 60 agreed to participate in the study. As a result of dysfunctions, 29 patients (43%) were excluded from the study. 28 subjects experienced back or lower limb pain, 5 subjects had suffered lower limb or spinal injury, 2 subjects complained of dysesthesia in the foot and 1 subject reported a neurological disorder.

Participants

The study involved 31 participants: 21 women and 10 men, aged 21-24 years. Table 2 presents selected somatic features of the group.

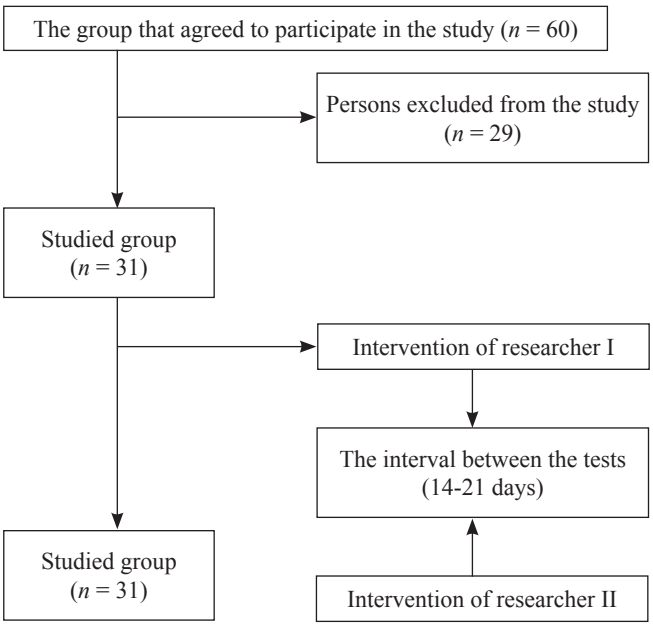

Figure 1. Diagram of the recruitment procedures and tests

Table 1. Inclusion and exclusion criteria for study participants

Inclusion criteria	Exclusion criteria
• persons with visual impairments corrected by glasses or contact lenses; • consent of the subject to taking part in the study	• injuries of the spine, upper and lower limbs suffered within the 12 months preceding the date of the study; • the presence of back pain; • dysesthesia in the feet caused e.g. by frostbite or diabetes; • neurological diseases; • eye diseases and visual impairments

Table 2. Description of somatic features in the studied group (n = 31)

	Age [years]	Body weight [kg]	Body height [m]	BMI [kg/m^2]
$\bar{x}$ ± SD	21 ± 0.74	64.84 ± 12.16	1.72 ± 0.10	21.85 ± 2.79
min. – max	21 – 24	34 – 96	1.63 – 1.95	19 – 26

Outcome measures

PS was evaluated using the following parameters: COP area, COP length and SI. When it came to the evaluation of the COP area, the results of the measurements were given in mm^2. The results of the COP length measurements recorded during the tests were used for the purpose of a simplified assessment of the balance mechanism by individual researchers. This assessment was done using a five-point scale: very low $x_i > \bar{x} + 2SD$, low $\bar{x} + SD < x_i \leq \bar{x} + 2SD$, average $\bar{x} - SD \leq x_i \leq \bar{x} + SD$; high $\bar{x} - 2SD \leq x_i < \bar{x} - SD$, very high $x_i < \bar{x} - 2SD$, where x_i is the value of the COP length parameter, $\bar{x}$ is the mean value of the COP length parameter achieved by the studied group, and SD is the standard deviation from the mean. For stabilographic tests, the assessment is inversely proportional to the value of the feature. This means that that the more efficient the balancing mechanism, the smaller the value of COP length [6].

In order to assess the symmetry of feet loading in standing, the SI index was determined according to Robinson's method. The values of the index should be interpreted as follows:

- positive SI – greater loading of the right side
- negative SI – greater loading of the left side [16].

The basic values required to calculate these indexes were obtained with the use of the Zebris FDM-TDL apparatus and Win FDM-T software with the Stance module. The measurement was made on a treadmill platform 94.8 × 40.6 cm. The force measurement range was 1-100N/cm^2, and the signal sampling rate was 100 Hz. During the measurements the treadmill remained motionless.

Ten measurements were performed sequentially, the first 5 with eyes open (EO), and the next 5 in the same position but with eyes closed (EC). After each measurement, the participant had to step off the treadmill for it to be calibrated. During the tests with eyes open the participant's gaze was focused on a point of reference located on the wall at a distance of 1 meter from the participant.

During the measurements, the participant was standing on the platform barefoot, with their feet rotated outward at the degree of 14°, with heels 4 cm apart, parallel to each other. The participant assumed and maintained a standing position with the arms down the trunk and the head upright for 30 seconds [8, 13, 15]. The tests were conducted in silence, since auditory stimuli may affect postural reflexes [5]. Before the test, each participant received the same verbal instructions. The procedure is presented in Table 3. The study was conducted in the morning, between 9 a.m. and 11 a.m. The PS tests based on this procedure were performed by two researchers on two dates for each participant. The interval between the tests was 14-21 days.

Table 3. The procedure followed during postural stability tests

The sequence of steps taken to assess postural stability using the Zebris FDM-TDL apparatus
1. Entering the participant's personal data into the computer
2. Informing the participant about the course of the experiment
3. Asking the participant to take their shoes and socks off
4. Disinfecting the platform
5. Calibration of the device
6. Entering the platform and placing their feet at designated points
7. Checking the position of the feet
8. Informing the participant about the position he or she is to assume: gaze fixed straight ahead (focused at a designated point on the wall), upper limbs along the trunk
9. Measurement of postural stability – pressing the ENTER key
10. Stepping off the platform
11. Calibration of the device
12. See Step 6

Statistical methods

The statistical analysis was performed using STATISTICA 2009. The variables tested were represented with the use of descriptive statistics such as mean value, standard deviation, and minimum and maximum values. Using the Wilcoxon matched pairs test, the difference between the tests with eyes open and eyes closed was verified. Pearson's chi square test was used to investigate the relationship between the frequency of loading of the right and the left lower limb. The level of statistical significance was set at $p < 0.05$.

Results

During the study, no statistically significant differences in the results of the tests conducted on the first and the second date were observed [17]. A normal distribution of the values of the COP area, COP length and SI parameters was recorded among the participants. This distribution was observed both in tests with eyes open and eyes closed. Table 4 presents the mean values of COP area and COP length. For these factors, significant differences between the tests with eyes open and eyes closed were noted (Wilcoxon test, $p < 0.05$). There was a significant increase in the values of measured parameters in the test without visual control.

Next, the ranges of the values of COP-length in the studied group were presented. Using the above classification, an average level of postural condition in the test with eyes open was recorded in 87% of participants. 6.5% of participants achieved a very high and high level, and 6.5% achieved a low or very low level. In the test with eyes closed, 80.6% of participants achieved average results, 9.7% a very high and high level, and 9.7% a very low and low level (Table 5).

Below are the SI index individual results (Figure 2). It was observed that the loading of the left lower limb was more frequent, both in the tests with eyes open and closed, however, these changes are not statistically significant.

Discussion

During the analysis, significant differences in the values of COP area in the tests with eyes open and eyes closed were recorded. The results achieved by the participants in the test with eyes closed were on average twice as high. In the case of the EC test, also the COP length results indicated that the path of the center of pressure was extended in the participants. This indicates deterioration of the PS in the absence of visual control [6, 7]. Training aimed at increasing proprioceptive control may be a solution to this problem. Based on the available sources it should be assumed that such training should cover both the structures of the lower limbs, and the exercises for the overall body posture [5, 8, 9, 11-14].

However, the comparison of the results of the participants with the standard values of COP length indicates the outstanding ability of the players to maintain PS [6]. This is also evidenced by the results of the SI index of subjects [16], most of which are in the range from –10% to 10%. Further analysis of the SI index value indicates that in the test with and without visual control the participants more often bore weight on the left foot. The observed differences in the loading of the right and left limbs are not statistically significant. Perhaps the tendency to stabilize the position on the left leg is connected with the right-hand body laterality of the subjects tested. Previous studies show more frequent resting on the leg opposite to the dominant upper limb [2].

Table 4. The mean values and the minimum and maximum for COP area and COP length measured using the Zebris FDM-TDL apparatus

	Eyes closed	Eyes open	Wilcoxon matched pairs test
	$\bar{x} \pm$ SD (min. – max)	$\bar{x} \pm$ SD (min. – max)	p
COP area	68.74 ± 32.35 (26.36 – 171.64)	35.84 ± 18.62 (16.39 – 105.74)	0.0001
COP length	240.98 ± 47.83 (175.44 – 377.45)	181.15 ± 28.50 (153.99 – 279.96)	0.0001

**statistically significant at $p \leq 0.05$*

Table 5. Ranges of the values of COP path for evaluating postural condition

	COP length [mm]				
Test	Very low	Low	Average	High	Very high
Eyes open	> 238	237 ÷ 210	209 ÷ 154	153 ÷ 124	124 >
Eyes closed	> 337	336 ÷ 289	288 ÷ 193	192 ÷ 144	145 >

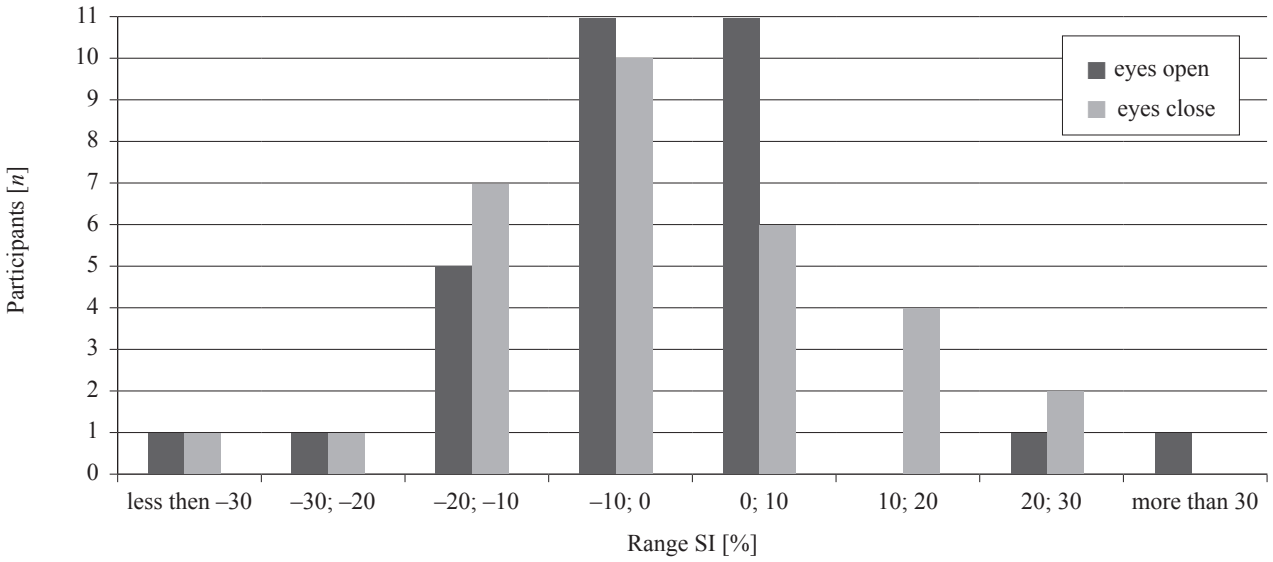

Figure 2. SI frequency distribution histogram for the tests in standing on both feet with eyes open and closed in the studied group

Some of the limitations of the conducted study include a relatively small number of participants, the majority of women among the participants, and the fact that the participants regularly practiced sports. The foregoing factors can have a significant impact on the interpretation of the results of the study [1, 3, 5, 11-15].

What this study adds?
This study sets the standards of postural stability for healthy, active adults between 21-24 years of age, for the following parameters: COP area, COP length and SI, in tests with and without visual control. It also presents the procedure for postural stability testing with the use of the Zebris FDM-TDL apparatus.

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