CORELLATION THE BODY WEIGHT TO SELECTED STABILOMETRIC PARAMETERS

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Abstract

Mass is an important factor that has an influence on the stability of the human body. The hypothesis is the higher the mass, the higher the stability. The proportionality of the human body when considering body mass and physical height are expressed by the BMI (body mass index). Our goal was to verify a correlation between BMI and postural stability with the use of stabilometry tests on baropodometric platforms to confirm or refute the mentioned hypothesis. A total of 184 healthy subjects (73 females and 111 male) participated in the measurement and performed a bipedal test with their eyes open and closed, where the evaluated parameters were the confidence ellipse area and the length of the oscillation. After a statistical assessment of the measurements, we can confirm that having the eyes open or closed has an influence on the confidence ellipse area and the length of oscillation. The measured values show that the confidence ellipse area and the length of oscillation are not dependent on the BMI.

Keywords

BMI, stabilometry, confidence ellipse, length of oscillation

Introduction

Several studies show the adverse effect of obesity or malnutrition on muscle performance, balance, stability, coordination, fatigue, foot posture index [1], upright standing position [2, 3] and is associated with increased risk of injury and musculoskeletal disorders.

According to the World Health Organization (WHO), obesity is one of the biggest health challenges of the 21st century, as the prevalence of obesity has tripled in several EU countries since the 1980s. With regard to obesity, there are a number of ways to assess body composition (the proportion of fat, water, muscle, organs, and bones), but in most cases the simplest way to estimate it is to measure a person's height and weight (BMI expressed in kg/m^2) and is one of the contemporary methods used to define obesity. However, it does not speak to proportionality of the human body and simply expresses the ratio of body mass to physical height.

A higher quantity of fat in the body is generally associated with being overweight and obesity, which can affect the location of centre of gravity of the body and can negatively affect postural stability. The position of the centre of gravity when standing upright is approximately 5 cm above the junction of the femoral heads in the plane of symmetry of the body in the pelvis behind the pubic symphysis. The centre of gravity (COG) is located ventrally under the second sacral vertebra [4–9]. The storing the body fat in abdominal or upper part of human body can lead to shifting of COG higher. Men have a higher tendency to accumulate abdominal visceral fat compared to women. The location of the overall centre of gravity is 0.5 to 2% higher in men compared to women. Stability of human body is affected by the conditions such as size of the base of support, the centre of gravity of the subject's body being as close as possible to the place of support and the distance of the axes of gravity from the edge of the base of support [8, 10–14].

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Information from the vestibular apparatus and proprioceptive receptors in muscles, tendons, joint capsule and ligaments (which provide information on the position of the head and individual body segments), [15–17] is needed to maintain balance and stability, but always in cooperation with other senses, of which vision has proven to be the most important [6, 11, 14, 16, 18, 19].

Measurements generated using a baropodometer are accurate, instantaneous and repeatable and provide an orthostatic and functional assessment of a patient (static, dynamic and stabilometric tests) [5, 9, 18, 20–22]. The device makes it possible to determine the distribution of pressure over selected parts of the sole of the foot as well as over the entire area of the foot, as well as maximum pressure.

Accordingly, the current research objective is to identify the relationship between BMI and postural stability on the base of Romberg tests of a bipedal static test with eyes open and closed, where the evaluated parameters were the confidence ellipse area and the length of the oscillation in a healthy young sample using stabilometric device.

Methods

Young healthy students (184) aged 18 to 28, attending the Technical University in Kosice, Slovakia, participated in the study. There were 73 women and 111 men. Subjects have been known the potential risks and benefits and signed a consent form to be admitted. This study was accepted Ethical commission TUKE in Slovakia. All the protocols were approved by the ethical committee on human research and followed ethical standards NO 6737/2021.

The environmental conditions for the measurements required the fulfilment of specific criteria with respect to lighting, noise and the colours and temperature of the room itself. The environment in which the measurement was performed seemed calm with the limitation of interfering external elements. The average measured value of noise intensity in the room was 36 dB. During measurement, the light intensity value was 500 lx provided using artificial lighting. The room temperature was 20 °C throughout the measurements.

Assessment Procedure: A brief information about the study was provided to each participant. All subjects fulfilled personal questionnaire. The questionnaire was used to obtain information about the measured subject (age, gender, physical activity, the foot size, serious medical issues, glasses). Exclusion criteria were balance disorders, problems with hearing, neurological problems or injuries of the lower limb, foot and back pain, decreased foot sensibility, previous injury or surgery of back or abdomen, plantar fasciitis, neuropathy, lower limb discrepancy, tibialis anterior or posterior dysfunction. Participants were asked do not any physical activity 2 days before testing. The same researcher, in the same settings at the testing day, did the data recording.

Instrumentation used for measurement: Baropodometer Diasu (Rome, Italy), technical parameters: baropodometric plate 50 cm length, resolu-tion xy: 16bit, scan type: matrix scan 16bit, accuracy ±2%, software Milletrix (Diagnostic Support, Diasu Health Technologies, Rome, Italy).

Body mass index assessment and calculation: A calibrated stature meter KT-GF06A (KINDCARE, Zhejiang, China) with a digital scale was used to examine the participants' heights. Weights of participants were assessed using the Omron body composition monitor BF511 (Omron Healthcare Europe B.V., Hoofddorp, Netherlands). The BMI was determined by dividing weight over/ height squared (kg/m^2) for each participant.

Subjects were distributed based on BMI into four groups: Group I (underweight): 27 individuals (20 females and 7 males) with BMI lower than 18.5 kg/m^2. Group II (normal): 81 individuals (38 females and 43 males) with BMI ranged from 18.5 to 24.9 kg/m^2. Group III (overweight): 42 individuals (7 females and 35 males) with BMI ranged from 25 to 29.9 kg/m^2. Group IV (obese): 34 individuals (8 females and 26 males) with BMI more than 30 kg/m^2.

Measurement conditions: Each subject was instructed to relax their feet for 15 minutes prior to the measurements. The tests were explained to each participant and the researcher entered the personal information. The feet of the participants were placed bare in their underwear on the podobarometric platform. The measured subject was in Romberg's position on the baropodometer. Their feet were at an angle of 30°. Their upper extremities were held along their sides with these palms facing forward. They were instructed to breathe regularly, calmly. The participant was instructed to keep looking at an eye-level mark placed on the wall in front of him over the duration of the test.

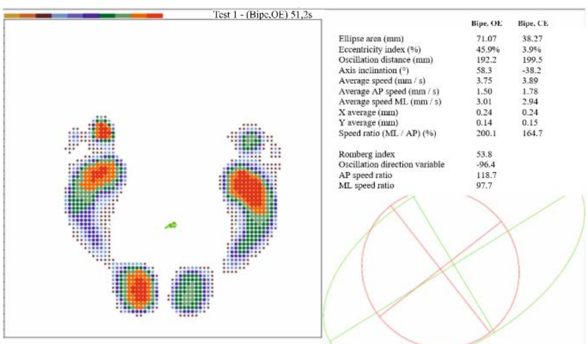

Fig. 1: Stabilometric test result with plotted confidence ellipses and given values of measured parameters with descriptions in English.

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To complete measurements to assess and verify the relationship between BMI and postural stability, we applied a bipedal static test lasting 51.2 seconds (Fig. 1). The measurements were completed in two phases: with the eyes open (OE) and with the eyes closed (CE). Upon completion, the appropriate graphs, ellipses, measured values, a graph with the evaluated centre of gravity and its movements during the entire length of the test were plotted. The values of the confidence ellipse area and the length of oscillation were selected from the parameters generated by the Milletrix software and compared to BMI.

The oscillation length and the confidence ellipse area with the eyes open and closed were the monitored parameters, which were evaluated in conjunction with the BMI parameter and assessed using statistical methods. Outliers were excluded from the files before evaluating the measured data. Analysis of data was performed using Statistica program (StatSoft CR s.r.o., Czechia).

The significance level of 0.05 was used. The values of the Shapiro-Wilk test value make it clear that the presumption of normality was violated.

The non-parametric Wilcoxon signed-rank test was used to compare the confidence ellipse area and the length of oscillation with eyes open and closed instead of the parametric t-test.

Same stabilometric parameters were monitored depending on BMI, where it was found differences between the four groups according to BMI. The non-parametric form of the ANOVA (Kruskal-Wallis one-way analysis of variance) test was used to identify differences between groups by BMI.

Results

Selected parameters from individual stabilometric protocols were summarized into the Table 1.

Table 1: Statistical processing of results.

	Ellipse area (mm^2)		Length of oscillation (mm)		BMI (kg/m^2)
	OE	CE	OE	CE	
Count	184	184	184	184	184
Mean	53.58	35.52	215.26	275.57	24.77
Median	34.16	27.21	205.35	272.55	23.75
Min	0.47	0.57	87.50	95.70	15.52
Max	169.02	99.76	426.60	554.70	39.54
St. deviation	48.55	27.75	77.53	106.21	5.88
SW – p value	0.0000	0.0000	0.0000	0.0003	0.0000

Using the Wilcoxon signed-rank test, we determined that the $p<0.0001$ ($p = 0.0350$ for female and $p < 0.0001$ for male) for the confidence ellipse area, which means that the null hypothesis on the equality of mean values can be rejected at a level of significance of 0.05. There is a statistically significant difference for all groups (the "position" of the eyes affects the size of the area of the confidence ellipse).

For the length of oscillation is $p < 0.0001$ ($p < 0.0001$ for female and $p < 0.0001$ for male) ($p < 0.05$), which means that the null hypothesis on the equality of mean values can be rejected at a level of significance of 0.05. There is a statistically significant difference (the elimination of visual perception affects both the confidence ellipse area and the length of oscillation).

The comparison gender effect (group of female and male) for the size of the area of the confidence ellipse, there is no statistically significant difference between women and men (for OE $p = 0.0728$, for CE $p = 0.2243$), which means that gender does not affect the size of the area of the confidence ellipse. When comparing the group of women and men for the length of the oscillation, there is a statistically significant difference between women and men (OE $p = 0.0044$, CE $p = 0.0103$), which means that gender affects the length of the oscillation, male population has higher values than female population.

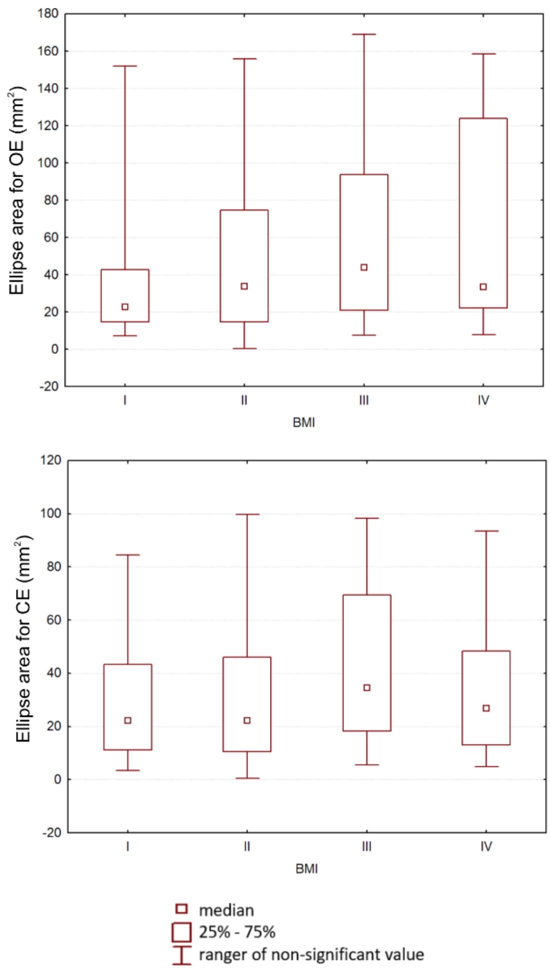

Fig. 2: Ellipse area in individual categories of BMI (CE: closed eyes, OE: open eyes).

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In assessing the influence of BMI on the confidence ellipse area using the Kruskal-Wallis test, a p value of p = 0.1346 ($p > 0.05$) was identified with OE and a p value of p = 0.1928 ($p > 0.05$) was identified the CE, which means that the confidence ellipse area with the eyes closed is smaller than with the eyes open and conversely the length of oscillation with the eyes closed is larger is than with the eyes open.

There is not a statistically significant difference between the groups, and therefore the confidence ellipse area with OE and CE is not dependent upon BMI. This is depicted graphically in Fig. 2.

In assessing the influence of BMI on the length of oscillation using the Kruskal-Wallis test, a p value of p = 0.1826 ($p < 0.05$) was identified with OE and a p value of p = 0.0842 ($p < 0.05$) was identified with CE. The null hypothesis on the equality of mean values can be rejected, which means that there is a statistically significant difference, and the length of oscillation with the eyes open and closed not depends on BMI. This is depicted graphically in Fig. 3.

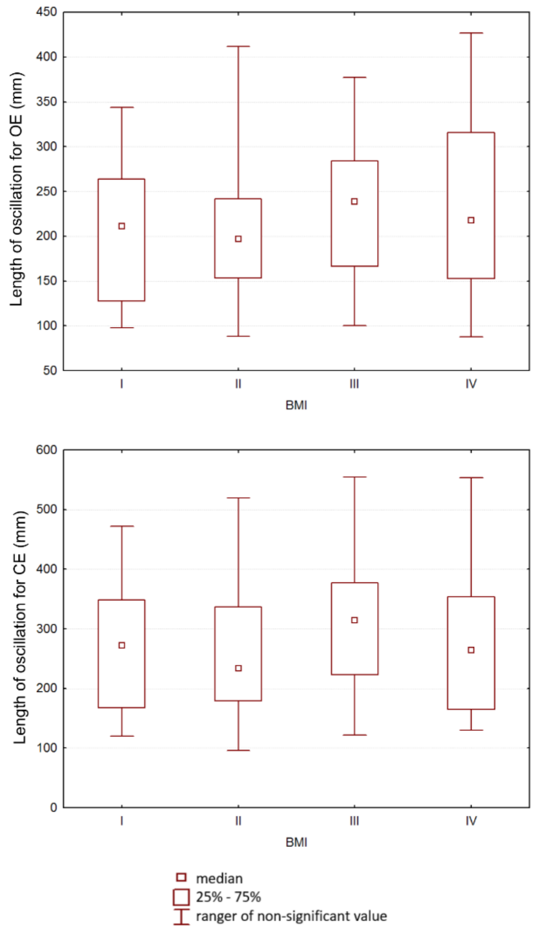

Fig. 3: Length of oscillation in individual categories of BMI.

Discussion

This research study was aimed to find out the relation between BMI and selected stabilometric test parameters in healthy young participants.

The measured values show that the parameter of the confidence ellipse area and the oscillation length at OE and CE are not statistically dependent on BMI.

According to the National Institutes of Health, the correlation between BMI and body fat is obvious, but may vary according to age, gender and participation in certain sports. It is well known that women body stores more adipose tissue, which is concentrated in the lower part of body (hip and buttocks) compared to men. The typical shape of a woman's figure is the Hourglass shape, or triangle (pear) shape figure. In contrast, the male sex concentrates the mass in the upper parts of the body (shoulders, chest). Body-typing (i.e. the quantification and clustering of human body shapes) with inputs from 3D anthropometry was published only recently [7]. This simple approach clearly shows that gender, age, weight and BMI reflect multiple characteristics of the body shape as seen by the metameasures, whereas the former, virtually one-dimensional parameters are not able to comprehensively describe the multidimensional diversity of the body shape [4, 18, 23]. The location of the centre of gravity also plays a significant role, as subjects with a broader upper body (shoulders and back) and a narrower lower body (lower extremities) have a centre of gravity that is shifted in a cranial direction, which may reduce their level of stability. Taller subjects also have a centre of gravity that is shifted upward significantly, which puts them in a less stable position and makes it easier to move them out of a balanced position. All this leads to a change in the vertical and horizontal position of the centre of gravity, which can affect its stability.

Potential factor influencing postural stability is the inaccuracy of the BMI parameter itself, as it does not consider the composition of the mass itself. BMI, given the variables used in its calculation, cannot determine actual fat content and therefore it may provide inaccurate conclusions for individuals who have greater muscle mass (amateur and professional athletes). The calculated higher BMI values for athletes do not function as proof of obesity, and instead are the result of muscle mass [8].

In the future, it would be appropriate to use a method that deals with the distribution of weight within the whole human body, or its specific composition in terms of mass (muscle, fat) and their respective weights and to raise issues of impact on stability.

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Conclusion

The objective of this study was to confirm or refute the initial hypothesis: the higher the mass, the higher the stability. We verified this hypothesis by correlating BMI and postural stability using stabilometry tests on baropodometric platforms. The measurement itself took place in the premises of the Technical University in Kosice. The evaluated set consists of 184 subjects, which is a statistically significant set sufficient to reach relevant conclusions. A total of 184 healthy young subjects participated by performing a bipedal test with their eyes open and closed, where the evaluated parameters were the confidence ellipse area and the length of the oscillation.

The established hypothesis was rejected because of the measured values show that the parameter of the confidence ellipse area and the oscillation length at OE and CE are not statistically dependent on BMI. At the same time other relationships between selected parameters were monitored such as effect of visual perception and gender. After statistical evaluation of the measurements, we found that the elimination of visual perception has an effect on the area of the confidence ellipse area and the length of oscillation in both genders. The presented results show that the elimination of vision (CE) increases the rate of oscillation of the centre of gravity projection, but its oscillations are smaller. However, for the length of the oscillation in individual genders, we can conclude that gender has an effect on this stability parameter. The male population shows higher values compared to women, which correspond to the information that COG of men is located a higher comparing to women, which is based on the results of previous research.

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