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Effects of Overweight and Obesity on Postural Stability of Aging Females

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Abstract

Background: Weight gain modifies body geometry by adding mass to different areas of the body.
Objectives: The aim of this study was to determine the effect of body mass index (BMI) groups on postural stability of elderly females in a quiet stance by measuring the center of pressure (CoP) velocity.
Methods: This quasi-experimental study consisted of 77 inactive females over 65 years old (67.7 $\pm$ 3.5) who had come to the Sports Medicine Center (Kiev, Ukraine) in the summer of 2017. All participants were classified into normal, overweight, and obese groups based on BMI. Postural stability was taken in a quiet stance (static situation) on a foam mat with open (OE) and closed (CE) eyes in anteroposterior (AP) and mediolateral (ML) directions by the force platform. Each test was performed two times for 30 seconds, and CoP was recorded at a sampling rate of 200 Hz.
Results: In the AP direction, obese females swayed significantly faster than females with normal weight during OE (1.1 cm/s and 0.84 cm/s, respectively) and CE (1.2 cm/s and 0.88 cm/s, respectively) conditions. In the ML direction, higher CoP velocities in females with normal weight were observed than in obese females under OE conditions (0.55 cm/s and 0.43 cm/s, respectively) and CE (0.76 cm/s and 0.56 cm/s, respectively).
Conclusions: Obesity had a negative influence on postural stability in the AP direction. However, given the expansion of the support base, obese females were more stable than normal-weight females along the ML direction. Study outcomes can be useful for obese people, medical staff, and healthcare decision-makers.

Keywords: Aged, Body Composition, Obesity, Overweight, Postural Balance, Sex Factors, Women's Health

1. Background

Use of the word "globesity" in some reports suggests that weight problems are one of the most important public health issues worldwide (1). According to the latest statistics provided by the World Health Organization, one out of three individuals in the world is overweight and one in ten are obese (2, 3).

Overweight and obesity are defined as abnormal or excessive fat accumulation and are associated with changes in body geometry and posture disorders (4-6). Postural stability is essential for the high-quality performance of activities of daily living (ADLs) in older age (7). Impaired postural stability is strongly associated with a risk of falls, and its complications are getting worse with aging (8, 9). According to World Health Organization projections, the proportion of the global population over 60 years old will rise from 10.0% in 2000 to 21.8% in 2050, and then to 32.2% in 2100 (10). Therefore, studying the effect of human body weight on postural stability of aging could be important. Most studies, managing obesity have concentrated predominantly on the appraisal of postural stability in the anteroposterior (AP) direction (11). Moreover, there are constrained data from the control of the mediolateral (ML) balance in obese adults. The integrity of the postural control system is often looked at by checking the center of pressure (CoP) movement in static conditions (12). The CoP Parameters (for example, CoP velocity) can be categorized as the posture to maintain stability (13). Researchers reported a decrease in postural stability in obese older females, according to high CoP velocity (14, 15). We can assume that there is no inclusive technique for evaluating overweight and obesity that records all conditions. The most widely used "tool" is the body mass index (BMI), which furnishes a helpful evaluation of overweight and obesity at the public level, as it is the same for both genders and adults of all ages (16). Researchers investigated the relation between body anthropometry and balance, and BMI was the only parameter that was correlated with AP sway in quiet upright stance (17). Several studies have shown a close connection between postural instability and obesity (13, 14, 18). However, there are few studies on weight gain and postural control of elderly women (14, 19-21). These studies have also used various parameters to assess postural stability. The average velocity of displacements, as one parameter differs well between test situations, as well as has the smallest standardized interpersonal coefficient of variation, i.e. the smallest reproducibility error (22). However, it has mostly been used as an overall parameter and not in individual directions. For this reason, our study point was to evaluate postural stability in quiet stance (static situation) on aging females with overweight and obesity based on the CoP velocity in different directions.

2. Methods

2.1. Study Population

Sampling in this quasi-experimental study was from the simple type and non-probabilistic. The study participants included 77 sedentary females over 65 years old (67.7 $\pm$ 3.5) who had come to the Sports Medicine Center (Kiev, Ukraine) in the summer of 2017. Participants who did not have a history of regular exercise in the past three months have taken part in this study. The exclusion criteria, as diagnosed by a physician, were a history of falls, neurological diseases, cardiovascular diseases, Parkinson's symptoms, diabetes, musculoskeletal diseases, and any regular exercise experience since three months ago (7, 23, 24). After getting the medical certificate, females who diseased (except obesity) and who were taking medications were excluded from the study.

2.2. Measurement

Participants performed anthropometric measurements for body height and weight (25). BMI was obtained by dividing body weight (kg) to height (m^2). They were classified according to BMI into 28 women with normal weight (BMI 18.5 - 24, 9 kg/m^2), 25 overweight women (BMI 25.0 - 29.9 kg/m^2), and 24 women with obesity (BMI $\geq$ 30.0 kg/m^2).

2.3. Intervention

Postural stability of each participant was conducted in quite an upright stance (static situation) with open (OE) and closed eyes (CE), randomly by the pressure platform (KistlerInstrumente AG, Winterthur, Switzerland). Each participant was instructed to stand on the force plate and to take a comfortable situation, such as standing at home or at work. Any posture modification, such as an adjusted position at another foot, was not authorized.

2.4. Method Management

The study method has not changed during its implementation. Postural stability evaluation was performed two times for 30 seconds, and CoP velocity was recorded with a sampling frequency of 200Hz. Participants had no working experience with the force platform. This research has been approved by the Ethics Committee [NMAPE, (2017) No. 04112-16] and each participant has signed an informed consent form.

2.5. Data Analysis

Data was been filtered by a fourth order low-pass Butterworth filter with a 7 Hz cutoff frequency using MATLAB software. The averages of two examinations have been used in the statistical investigation. Statistical analysis has been performed using Statistica software (version 10, StatSoft, Inc., Tulsa, OK). The normality of data distribution was not confirmed (Kolmogorov-Smirnov test); thus, for statistical comparisons between the groups, the Mann-Whitney U test ($P < 0.05$) was used. One sample *t*-test has been used to measure averages of parameters. Effect-Size was calculated and interpreted as small for values less than 0.2, large for values more than 0.8, and medium effect size for values between them by Cohen's d and others to evaluate obesity influence on postural stability (26, 27).

3. Results

3.1. Study Population

The personal characteristics of the groups were demonstrated in Table 1.

3.2. Outcomes of Study

All data are entered in Table 2. Measuring the average CoP speed with OE in the ML direction (V_{ML}) has shown a significant difference ($P < 0.05$) in the normal weight, overweight, and obese (large effect) and between overweight females and obese females (large effect). In the AP direction, a significant difference ($P < 0.05$) was observed among females with normal weight, overweight, and females with obesity (large effect) and between overweight and obese females (large effect). In total velocity (V), there is a significant result ($P < 0.05$) in normal weight, overweight, and obesity (large effect) and between overweight and obesity (medium effect). The assessment of average CoP velocity with CE in the ML direction (V_{ML}) showed the significant difference ($P < 0.05$) among normal weight, overweight,

Table 1. The Characteristics of the Groups (mean ± SD)

	Normal Weight	Overweight	Obese
Gender (Female), No.	28	25	24
Age, y	68.1 ± 3.4	67.4 ± 4.5	67.8 ± 2.7
Height, cm	170.2 ± 3.3	170.4 ± 5	169.8 ± 6.4
Weight, kg	60.3 ± 2.6	76 ± 3.2[a]	97.6 ± 4.5[a,b]
BMI, kg/m^2	23.1 ± 4.2	28.1 ± 2.4[a]	36.1 ± 3.6[a,b]
Abdominal circumference, cm	92.6 ± 3.2	103.3 ± 4.5[a]	118.4 ± 8.9[a,b]

[a] Significant difference in comparison with normal weight (P < 0 .05).
[b] Significant difference in comparison to overweight (P < 0.05).

and obese (large effect) and between overweight and obese groups (large effect). In the direction of AP, a significant difference was found (P < 0.05) among normal weight, overweight, and obesity (large effect) and between overweight and obesity (large effect). In total velocity (V), the significant difference (P < 0.05) among females by normal weight, overweight, and obesity and between overweight and obese (large effect) has been found. The significant difference in the circumference of the abdomen between normal weight and obese females in the study was 25.8 cm (32%, P < 0.05).

4. Discussion

Postural stability is the ability to keep balance using the muscles of the ankle, knees, and hip. Balance requires coordinating and integrating data provided by various sensory organs, such as hearing, proprioceptive, and visual (28). Aging process results in degeneration, loss of functionality and obesity (29). By the time age rises, the innate ability of the above organs to get and integration of sensory data decreases (9, 30); on the other hand, the body geometry changes with an abnormal rise of weight (4-6). These cases result in a fall, which is the main cause of death among the elderly. In this way, the study took into account aging females who had an abnormal weight gain.

To assess postural stability, it is necessary to estimate shifts of the central mass of the human body in static and/or dynamic situations (24). Due to the fact that the CoP mean velocity is a reliable (31) and sensitive (32, 33) measuring of the CoP swing velocity thereby validates the outcomes of this study. The study not only showed a significant difference between the three groups; however, it also confirmed that the large effect size wasn't limited to the CoP fluctuations of women who were overweight and obese, which had OE. Obese females under OE conditions swung significantly faster than normal weight females in the AP direction. This outcome is consistent with data of some researchers who found the greatest significant difference in mean velocity between normal weight and obese females in the direction of AP (12). As shown in the results, abdominal circumferences between normal weight and obese females were significant, therefore, the principal explanation for this discovery could be that obese people often have a protruding belly. The protruding abdomen results in two major physical effects: an anterior position of the center of mass relative to the ankle joint, and higher weight to stabilize the base of the support (8). However, some scientists disagree with these conclusions and consider that excess weight or distribution of fat does not affect the location of CoP (11).

It is well known that by removing the proprioceptive data from the feet and ankles, other systems for maintaining postural stability will be noteworthy (13, 34). Greater pressure values and bigger contact areas observed in obese people have been linked to reductions in the quality and/or quantity of the sensory data originating from plantar mechanoreceptors (13). Changes in data from these receptors raise postural swings and corrective muscular and torsional activity (34). Experimental investigations of normal weight people have verified the decisive proprioception role for the maintaining of postural stability during quiet standing (35, 36), mainly in the AP direction (37).

Another research finding has been shown that there was no difference between the visual and vestibular senses among normal weight, heavy athletic, and obese, and that it was possible that plantar mechanoreceptor sensitivities differed; due to the fact that after removal of vision, these authors observed greater rises in postural sway speed for obese and heavy athletic subjects compared to the control group (38). In contrast, we found under neither vision conditions any significant differences in total mean velocity between normal weight and obese women. Surprisingly, separately in the AP and ML directions, significant differences were found. While in AP the direction of obese women were significantly more affected by vi-

Table 2. Postural Stability Parameters and Significance, with and Without Vision (mean ± SD)

Parameter	Normal Weight (N = 28)	Overweight (N = 25)	Obese (N = 24)	(Effect-Size r)		
				Normal Vs. Overweight	Normal Vs. Obese	Overweigh Vs. Obese
Eyes open						
V_{ML}, cm/s	0.55 ± 0.01	0.5 ± 0.03	0.43 ± 0.02	0.96	0.98	0.93
V_{AP}, cm/s	0.84 ± 0.01	0.93 ± 0.02	1.1 ± 0.01	0.97	0.99	0.97
V, cm/s	1.2 ± 0.03	1.25 ± 0.05	1.31 ± 0.04	0.9	0.89	0.45
Eyes closed						
V_{ML}, cm/s	0.76 ± 0.02	0.77 ± 0.01	0.56 ± 0.05	0.88	0.9	0.96
V_{AP}, cm/s	0.88 ± 0.04	1.18 ± 0.02	1.2 ± 0.03	0.87	0.86	0.8
V, cm/s	1.35 ± 0.04	1.71 ± 0.03	1.57 ± 0.02	0.95	0.9	0.72

Abbreviations: AP, anterioposterior direction; ML, mediolateral direction.

sion and showed higher values than females with normal weight. Obese elderly females showed that their CoP swing velocity was lower than the normal weight group. Reasons for improved stability along ML direction could be of anatomical changes in response to obesity, such as more limitation of range of movement in the lower limbs and torso to the side (39, 40). This is while other epidemiological researchers do not accept these conclusions and believed that BMI doesn't prevent postural instability (6, 14, 41).

In a few investigations, the position of the foot during testing was defined (12-14). The exact measurement of body motion confirmed that width of standing affected the body swing velocity in a quiet situation (40). In our study, the females were asked to stand normally, such as at home or at work, to maintain the most natural conditions. The findings of research showed that the assessment of postural stability in different directions was significantly more susceptible.

4.1. Conclusions

Obesity raises postural swing in anterior and posterior directions. In the ML direction, elderly females with obesity showed lower postural oscillation in comparison to elderly females with normal weight and overweight, which possibly resulted from the expansion of the base of support. These findings will improve our knowledge regarding the postural stability changes in aging females and help to choose more effective strategies or to build better equipment for rehabilitation of them. This research is also advisable for older men.

4.2. Limitation of Study

The impossibility to measure the quite bipedal stance on only one force platform was the research limit; therefore, it was impossible to ascertain stance width (base of support). Aside from this, we were not confronted with any trial restrictions, such as potential bias and the multiplicity of analysis.

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