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Evaluation of postural stability in overweight and obese middle-aged men

Mohammadreza REZAEIPOUR*
Department of Physical Education and Sport Sciences, University of Sistan and Baluchestan, Zahedan, Iran

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Background/aim: Weight gain is associated with balance disorders. This study intends to evaluate the postural stability in a natural stance in overweight and obese men by measuring the center of pressure (CoP) velocity in the medial-lateral (ML) and anterior-posterior (AP) directions.

Materials and methods: A total number of 111 men categorized according to body mass index (BMI) into normal weight, overweight, and obese categories underwent a measurement of quiet standing with eyes open (EO) and with eyes closed (EC). Postural stability was assessed using a force platform. The average of CoP velocity was assessed in the two directions.

Results: In the AP direction under EO and EC conditions, obese men swayed significantly quicker than men with normal weight. In the ML direction under EO and EC conditions, a higher velocity of CoP was seen in normal weight men than in obese men.

Conclusion: The results propose a negative influence of obesity on postural stability in the AP direction. In the ML direction, obese men were more stable than normal weight men, probably caused by enlargement of the base of support in a natural stance.

Key words: Age groups, body mass index, central obesity, postural balance, sex factors

1. Introduction

Obesity is one of the most important public health problems in the twenty-first century and it drastically raises the danger of creating numerous medical illnesses. The word 'globesity' in some reports shows the seriousness of this problem at the global level. According to the latest statistical data provided by the World Health Organization, one out of every three people in the world is overweight, and one out of every ten people is obese (1). Excessive body weight with unusual or extreme fat gathering is associated with changes in body geometry and posture (2–4). Some researchers have shown that in obese people body size and shape influence static postural stability by adjusting the location of the center of gravity (5). A center of gravity (CoG) found closer to the anterior edge of the base of support, because of the extra weight of the abdominal cavity, apparently leads to raised ankle torque, which is necessary to maintain balance (5).

In this context, most of the studies addressing obesity have concentrated predominantly on the appraisal of postural stability in the anterior-posterior (AP) direction (6). There are limited data in regards to the control of medial-lateral (ML) balance in obese adults. Postural control system integrity is most often evaluated under static conditions by analyzing the movement of the center of pressure (CoP) (7). The parameters of CoP (i.e. CoP velocity) can be classified as related to postural motion in order to maintain the stability (8). Researchers reported decreased postural stability in obese older men based on increased CoP velocity (9,10). In the literature we can find different approaches for evaluating obesity. We can assume that there is no global method for evaluating obesity and overweight that records all conditions. The most broadly utilized 'tool' is body mass index (BMI), which provides a helpful populace-level estimation of overweight and obesity, as it is the same for both sexes and for all ages of adults (11). Researchers looked at the interrelation between anthropometry of the body and balance, and BMI was the only option that was correlated with AP sway in the bipedal quiet stance (12). Several studies have shown a close relationship between obesity and postural instability (8,10,13). However, there have been few studies about excessive body weight and postural control in middle-aged people (9,10,14,15). These examinations have utilized distinctive parameters to survey postural stability. The mean velocity of displacement as a single parameter distinguishes appropriately between test situations, and it additionally has the smallest standardized interpersonal

* Correspondence: rezaeipour@ped.usb.ac.ir

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coefficient of variation, i.e. the smallest reproducibility error (16). However, it has mostly been used as an overall parameter and not in individual directions. Thus, the point of this investigation was to evaluate postural stability in overweight and obese middle-aged men by measuring CoP velocity in various directions.

2. Materials and methods

A total number of 111 men between 45 and 65 years old (54.7 ± 5.4) participated in our study and were categorized according to BMI (28.7 ± 5.8): 42 normal weight men (BMI 18.5–24.9 kg/m^2), 35 overweight men (BMI 25.0–29.9 kg/m^2), and 34 obese men (BMI ≥30.0 kg/m^2). The BMI ranges and categories corresponded to the international classification scale proposed by the World Health Organization. The group characteristics are provided in Table 1.

Men indicating any diseases (except for obesity) that could affect their balance were excluded from the study. The examination was conducted according to the Declaration of Helsinki and was approved by the institutional research ethics committee. All the participants were informed about this study and provided written informed consent prior to data collection. Each individual initially underwent anthropometric estimation of body weight and height (17). Following these measurements, BMI was calculated in kg/m^2. At that point, postural stability was assessed with a force plate (Kistler Instrumente AG, Winterthur, Switzerland). The individuals stood on the force plate barefoot and were instructed to stand normally as they would at home or at work (Figure). They adopted their preferred stance position with their feet positioned comfortably. Any other foot correction was considered as an adjusted stance and was not allowed.

The men performed two trials of a quiet stance with eyes open (EO) and with eyes closed (EC), in random order. Each test was performed two times for 30 s, and CoP was recorded at a sampling rate of 200 Hz. None of the individuals had any previous experience with a force plate.

The data were filtered using a fourth-order low-pass Butterworth filter with a cutoff frequency of 7 Hz using MATLAB software (Version R2010b; MathWorks, Inc., Natick, MA, USA). The mean CoP velocity in every direction and total velocity of CoP were computed with similar programming. The mean of the two trials was calculated. The statistical analysis was conducted with SPSS 24 for Windows (IBM Corp., Armonk, NY, USA). The normality of the data distribution was confirmed (Kolmogorov–Smirnov test); thus, for statistical comparisons among the groups, the paired t-test ($P < 0.05$) was used. Effect size was calculated and was interpreted as small ($r < 0.2$), medium ($0.2 < r < 0.5$), or large ($r > 0.8$) according to Cohen to assess the influence of obesity on postural stability (18).

3. Results

All the data are presented in Table 2. For CoP velocity with open eyes, the analysis of mean CoP velocity in two directions (V_{ML} and V_{AP}) indicated significant differences among each of the three groups (large effect). For total velocity (V), a significant difference was observed among all three groups; however, a large effect was observed only between normal weight and obese men. The effect sizes between normal weight and overweight men and among overweight and obese men were medium.

For CoP velocity with closed eyes, the results of swaying in the ML direction showed significant differences in all three groups. However, a large effect was found only between normal weight men and obese men, as well as between overweight and obese men. The effect size between normal weight and overweight was medium. In the AP direction, a significant difference was seen among every one of the three groups; however, a medium effect size was seen between overweight and obese men. The effect sizes between normal weight and overweight men

Table 1. The characteristics of the groups (mean ± SD).

	Normal weight	Overweight	Obese
Sex, men / women, n	42 / 0	35 / 0	34 / 0
Age, years	55.4 ± 5.7	53.3 ± 4.3	55.4 ± 5.8
Height, cm	171 ± 6	172.6 ± 6.7	170.3 ± 5.8
Weight, kg	60.2 ± 3	76.5 ± 4.8*	98 ± 5.4*§
BMI, kg/m^2	23.5 ± 3.6	28.2 ± 1*	35.8 ± 2.7*§
Abdominal circumference, cm	92.4 ± 3.5	100.7 ± 2.7*	115.2 ± 8.5*§

*: Significant difference in comparison with normal weight ($P < 0.001$).
§: Significant difference in comparison with overweight ($P < 0.001$).

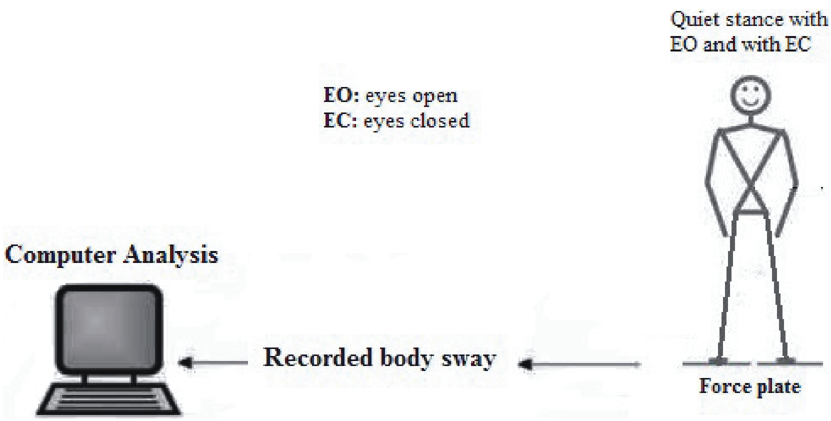

Figure. Schematic image of postural stability measurement.

Table 2. Postural parameters (mean ± SD) and significance, with and without vision.

Parameter		Normal weight (n = 35)	Overweight (n = 30)	Obese (n = 30) Normal vs. overweight	(Effect size r)		
					Normal vs. obese	Overweight vs. obese	
Eyes open	V_{ML} (cm/s)	0.53 ± 0.19	0.48 ± 0.02	0.42 ± 0.02	0.84	0.98	0.88
	V_{AP} (cm/s)	0.8 ± 0.02	0.9 ± 0.02	0.99 ± 0.02	0.96	0.98	0.97
	V (cm/s)	1.18 ± 0.03	1.24 ± 0.02	1.28 ± 0.02	**0.76**	0.89	**0.7**
Eyes closed	V_{ML} (cm/s)	0.71 ± 0.03	0.74 ± 0.02	0.54 ± 0.02	**0.49**	0.95	0.98
	V_{AP} (cm/s)	0.81 ± 0.03	1.11 ± 0.02	1.14 ± 0.02	0.98	0.98	**0.56**
	V (cm/s)	1.4 ± 0.29	1.69 ± 0.3	1.58 ± 1.03	**0.58**	**0.4**	**0. 27**

Significantly different effect size values are shown in bold.

and between normal weight and obese men were large. For total velocity (V), a significant difference was found among all three groups (medium effect).

4. Discussion

Aging is associated with degeneration, loss of functional ability, and obesity (19). Therefore, middle-aged men with abnormal weight gain were chosen for this investigation. One limitation of the research was the measurement of bipedal quiet stance on only one force platform, so it was not possible to determine stance width (base of support). Aside from this, there were no trial restrictions such as potential bias, multiplicity of analyses, and so on.

Obese men under the EO conditions swayed significantly faster in the AP direction than normal weight men. This finding was in concordance with data of some other researchers who found the greatest significant difference in mean velocity in the AP direction between normal weight and obese men (age range: 19–58 years) (7). The main clarification for this finding could be related to the fact that obese people frequently have a protruding abdomen. The significant difference in abdominal circumference between normal weight and obese men in our study was 23.35 cm ($P < 0.001$). Researchers assumed two main physical consequences of an abnormal distribution of body fat in the abdominal area: higher mass to stabilize over the base of support, and anterior situating of the CoG relative to the ankle joint (20). On the contrary, in normal weight and obese individuals, no differences were found in the percentages of pressure distribution on the foremost and back foot zones, and the CoP was similarly distant from the tangent line to the inferior border of the posterior heel. Based on these findings, authors have suggested that the CoP location does not seem to be influenced by excess weight or body fat distribution (6).

The great values of pressure and big contact areas observed in obese individuals have been associated with decreases in the quality and/or quantity of the sensory information originating from plantar mechanoreceptors (8). Changes in data from these receptors raise the postural sway and corrective muscle and torsion movement (21). Pilot studies involving healthy (nonobese) individuals have confirmed the decisive role of proprioception in the maintenance of postural stability during quiet standing (22,23), mainly in the AP direction (24). In these conditions, only the proprioception in the lower limbs was involved with sway (25). It is well known that by cutting off the proprioceptive information from the feet and ankles, other systems are imperative in keeping up postural stability. Handrigan et al. found no differences in the visual and vestibular senses among normal weight, very athletic, and obese people (26). They also thought it possible that plantar mechanoreceptor sensitivities differed because of later vision removal. These authors observed greater increase in postural sway speed for obese and athletic subjects compared to the control group (26). In contrast, the present study found no significant differences in total mean velocity between normal weight and obese men under either vision condition (EO vs. EC). Surprisingly, significant differences in both the AP and ML directions have been discovered. While in the AP direction, obese men were significantly more affected by vision and displayed higher values than men with normal weight, in the ML direction, obese men had lower rates of CoP velocity. This observation was in conflict with the data of some other researchers, who found in a group of older women more destabilizing impacts of vision for the obese group in the ML direction (10); however, some researchers have detailed similar outcomes for middle-aged women (9).

In the ML direction under both vision conditions, the obese men in our study achieved lower CoP velocity than the normal weight group. It is well known that the side strategy is significantly better (more stable) than an ankle strategy, which results from a given anatomically more limited movement of the lower limbs and torso to the side. Lateral stability is highly sensitive to foot positioning (27).

In some studies, foot position during testing has been determined (7,8,10). In our study, men were instructed to stand normally, as they would at home or at work, to maintain the most natural conditions. It is thought that standardized foot positioning would have been unnatural for obese men. Observed postural deviations, such as separation of the knees and ankles and flexing of the legs, to achieve a lower CoG were associated with a wider natural stance of individuals with obesity (3). Accordingly, we can assume that the better postural stability among obese men in the ML direction is likely connected to a wider base of support because of overloading of the lower extremities (3). Direct measurement of body movement affirmed that stance width affected the velocity of body sway during a quiet stance (27). The outcomes of the present study suggest that the assessment of postural stability in the two directions was significantly more sensitive.

To conclude, the results of this investigation demonstrated that obesity raises postural sways in the anterior and posterior directions. In the direction of ML, obese men showed less postural swaying compared with normal weight and overweight men, supposedly because of the enlarging of the base of support in a natural stance. These findings help to increase the knowledge about the postural stability of middle-aged men and while preventing the incidence of accidents can also contribute to choosing more effective strategies for rehabilitation or building optimal equipment for older adult men. Investigation in this field is advised for middle-aged females.

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