RESEARCH ARTICLE

Balance disorder, falling risks and fear of falling in obese individuals: cross-sectional clinical research in Isparta

Sabriye Ercan[1], Zeliha Baskurt[2], Ferdi Baskurt[3], Cem Cetin[4]

Abstract

Objective: To examine the effect of obesity according to gender on balance, posture, the risk of falling and the fear of falling.

Methods: The cross-sectional study was conducted at the Department of Sports Medicine, Suleyman Demirel University, Isparta, Turkey, from December 2016 to June 2017, and comprised individuals aged 40-60 years who were divided into obese and non-obese groups based on their body mass index values. Demographic data was recorded before collecting target data using Tinetti Falls Efficacy Scale, Activities-Specific Balance Confidence Scale, History of Falls Scale, Single Leg Stance Test, Functional Reach Test and the New York Posture Rating Test. SPSS 20 was used for data analysis.

Results: Of the 251 subjects, 129(51.4%) were females and 122(48.6%) were males. The obese group had 125(49.8%) subjects. There was a significant difference between the history of stumbling in obese males and the history of stumbling and falls in obese females ($p<0.05$). A high restriction in activity was determined in obese females because of fear of falling ($p<0.05$). There was impaired posture in all 125(100%) obese individuals and they had all experienced loss of balance. Despite loss of balance and impaired posture in obese males, they did not experience fear of falling and no difference was determined in confidence ($p>0.05$). Fear of falling was high in obese females and confidence in daily activities was low ($p<0.05$). Significant negative relationship was found among body mass index, loss of balance and poor posture ($p<0.05$). No significant relationship was determined in males between obesity and Tinetti Falls Efficacy Scale and Activities-Specific Balance Confidence Scale scores ($p>0.05$).

Conclusion: Obesity causes loss of balance and posture. However, despite functional losses in obese males, as there was no fear of falling and a deceptive sense of confidence, this prevented prediction of the risk of falling.

Keywords: Obesity, Balance, Posture, Risk of fall, Fear of fall. (JPMA 70: 17; 2020).

https://doi.org/10.5455/JPMA.293668

Introduction

Obesity is associated with several diseases such as diabetes mellitus (DM), hypertension (HTN), insulin resistance (IR), arthritis, hyperlipidaemia and heart disease, and is a significant public health problem causing functional losses such as postural balance problems that result in falls.[1,2] Studies have shown that 17.2% of the Turkish population aged >15 years are obese, 34.8% overweight, and when evaluation is made in respect of gender, 20.9% females are obese and 30.4% are overweight compared to 13.7% and 39% males respectively.[3] It has been shown that more than 1 billion individuals worldwide are overweight and 300 million are obese, and the prevalence of obesity is high and rapidly increasing in all populations.[3,4] This makes it necessary to intensify the interventions to reduce the societal effects of diseases related to obesity.

Even though most research conducted on diseases related to obesity have focussed on internal diseases, when the risk factors of falling are examined, which is an important problem in respect of public health, loss of balance related to obesity has been determined to be an independent risk factor for falling.[1,3,5] In respect of gender-specific factors, stroke, nutritional status, education level, eye disease, marital status and arthritis

[1,4]Department of Sports Medicine, Suleyman Demirel University, Isparta, Turkey; [2,3]Department of Physiotherapy and Rehabilitation, Suleyman Demirel University, Isparta, Turkey.

Correspondence: Sabriye Ercan. e-mail: sabriyeercan@gmail.com

have been found to be independent risk factors for a history of falls in males, and stroke, age >85 years, nutritional status, alcohol consumption, use of 5 or more medications, arthritis, diabetes and osteoporosis have been found to be risk factors for falls in females.[6]

Obesity not only increases the risk of falls, but also the fear of falling following postural fluctuations and loss of balance even if there is no history of falls.[7,8] In addition to obesity, risk factors increasing the fear of falling include demographic characteristics, a history of falling, physical health status, morbidities, emotional status, cognitive function and exercise habits.[8]

In demographic terms, the gender factor has been of particular interest to researchers, as it is thought that the correct approach to reduce the risk of falls and the fear of falling could be the development of gender-specific preventative strategies.[6,8]

The current study was planned to examine the effect of body mass index (BMI), balance and posture on the risk of falls and fear of falls, and to determine any differences according to gender. It was hypothesised that obesity could have a negative effect on balance and that in middle-aged individuals, gender could create differences in this status.

Subjects and Methods

The cross-sectional study was conducted at the Department of Sports Medicine, Suleyman Demirel University, Isparta, Turkey, from December 2016 to June 2017, and comprised individuals who were divided into obese and non-obese groups based on their BMI values. After approval from the institutional ethics committee, the sample size was calculated with 0.20 influence quantity, 80% power and 95% confidence level. The sample was raised using convenience sampling method, and those incuded were individuals aged 40-60 years attending the tertiary level healthcare institution.

Those excluded were individuals with musculoskeletal or neuromuscular problems, those having recently undergone joint surgery, or received treatment for lower back pain. Also excluded were those having any cognitive or psychiatric disease, unstable angina or uncontrolled arterial HTN, severe pulmonary HTN, any other clinical condition that could be exacerbated with physical effort, a recent history of cardiac arrhythmia or myocardial infarction or BMI <18.5 or between 25.1-29.9 kg/m^2.

Informed consent was obtained from the selected subjects. Demographic data was recorded and a detailed medical history was taken from each subject. Height and weight were measured with mechanical adult scales with a height measure (SECA 700, Germany). Obesity detection was done according to the fat ratio or according to the BMI based on the criteria of the World Health Organisation (WHO).[9] The subjects were divided into obese group BMI ≥30 kg/m^2 and the non-obese control group BMI 18.5-24.9 kg/m^2.[9]

After the determination of BMI, target data was collected using Tinetti Falls Efficacy Scale (TFES),[10] Activities-Specific Balance Confidence Scale (ABCS),[11] and the History of Falls Scale (HFS).

TFES evaluates the fear of falling psychometrically, especially in the elderly. The scale consists of 10 items related to simple daily activities, which are answered by the patient on a scale of 0-10. The total points can range from 0-100 with higher points indicating a lower fear of falling. The Turkish version of the Falls Efficacy Scale was used in the study.[10]

ABCS questions the confidence felt during daily activities. The scale consists of 16 items, each of which is scored as a percentage value. Total points can range from 0-1600 with low points indicating lack of confidence and high points, confidence during the activities. Vailidity and reliability studies of the Turkish version of the scale were already available.[11]

HFS is used to obtain the history of falls of an individual within the preceding year.[12] The participants respond to 5 questions and the responses are recorded. The questions are: 1) Have you not undertaken an activity or restricted an activity because of a fear of falling? 2) Have you stumbled within the last year? 3) Have you fallen within the last year? 4) How many times have you fallen in the last year ?, and 5) Have you required medical treatment as a result of a fall or falls?

After the application of the scales, the Single Leg Stance Test (SLST),[13] Functional Reach Test (FRT)[14] and the New York Posture Rating Test (NY-PRT)[15] were applied. To prevent bias in the application of the functional tests, these were applied by a researcher blinded to the previous scale results of the subjects.

SLST is used to evaluate the static balance of an individual and to determine the risk of falling. Balance status was measured 3 times bilaterally in the extremities of the

Table-1: Body composition of participants (mean ± SD).

	Obese W (n=65)	Non-obese W (n=64)	*p*-value	Obese M (n=60)	Non-obese M (n=62)	*p*-value
Age (year)	51.8±6	49.6±4.2	0.1	51.6±5.6	50.4±5.6	0.4
Height (cm)	160.3±5.2	162±6.6	0.3	170.8±6.7	173.1±8.3	0.2
Weight (kg)	86.1±9.1	59.8±7	<0.0001*	98.7±10.8	74.3±7.9	<0.0001*
BMI (kg/m2)	33.9±3.2	23±1.5	<0.0001*	33±2.7	23.3±0.9	<0.0001*

W: women, M: men, cm: centimeter, kg: kilogram, m: meter, SD: standard deviation, BMI= body mass index, *: p<0.05.

Table-2: Characteristics of participants.

	Obese W (n=65)	Non-obese W (n=64)	*p*-value	Obese M (n=60)	Non-obese M (n=62)	*p*-value
Perceived Health Status (0-5)	3±0.8	3.9±0.8	0.001*	3.3±0.7	3.8±0.7	0.005*
Work status n (%)						
House wife	51 (78.5)	50 (78.1)	0.19	0	0	0.78
Retired	6 (9.2)	5 (7.8)		20 (33.3)	19 (30.6)	
Actively Working	8 (12.3)	9 (14.1)		40 (66.6)	43 (69.4)	
Marital status n (%)						
Married	56 (86.2)	55 (85.9)	0.58	56 (93.5)	62 (100)	0.16
Widowed	8 (12.3)	5 (7.8)		4 (6.5)	0	
Single	1 (1.5)	4 (6.3)		0	0	
Level of education n (%)						
Illiterate	3 (4.6)	0	0.91	0	0	0.88
Literate	4 (6.2)	6 (9.4)		0	0	
Elementary school	26 (40)	29 (45.3)		17 (28.3)	17 (27.4)	
Secondary school	10 (15.4)	6 (9.4)		8 (13.3)	4 (6.5)	
High School	16 (24.6)	17 (26.5)		20 (33.3)	24 (38.7)	
Univertisy	6 (9.2)	6 (9.4)		14 (23.3)	17 (27.4)	
Post-graduate degree	0	0		1 (1.7)	0	

W: women, M: men, *: p<0.05.

individual with eyes open and eyes closed. The result was recorded on the evaluation form as the mean duration in seconds. The test was started with the subject either with or without shoes on a supportive base with the eyes open and arms at the sides of the body. The subject was requested to raise one foot to the level of the other knee at 90O and when the position was taken, measurement was made for a maximum of 30 secs. The test was concluded if the raised foot touched the ground, the position is changed, if the subject bounced on the foot on the ground or if the eyes are opened.[13]

FRT evaluates dynamic balance. The test is applied twice to the subject and the best measurement is used in the evaluation. The subject is positioned next to a wall, the dominant arm is raised to 90O, a fist is made of the hand, and the patient is requested to reach as far forward as possible, following a measure placed at shoulder level, without moving the feet or losing balance. Care is taken that the feet are not moved or raised from the ground. In the test, the distance between the first and the last measurement values is recorded taking the 3rd metacarpophalangeal joint as the reference criteria.[14]

NY-PRT identifies and scores postural impairments that can develop in the posterior of the body (head, shoulders, back, hips, feet and back of the feet) and in the lateral (neck, chest, shoulders, upper back, trunk, abdomen, lower back). The total points can range between 13 and 65 with high points indicating regular posture.[15]

Data was analysed using SPSS 20. Continuous variables were expressed as mean ± standard deviation (SD) and categorical variables as frequencies and percentages. The normality of distribution of continuous variables was tested by Kolmogorov-Smirnov and Shaphiro Wilk tests. Continuous variables were compared using the Student's t-test and the Mann-Whitney U-test where appropriate. Likelihood ratio tests tests were used for comparison of categorical variables. Univariate correlation analysis was performed by Spearman's tests to identify variables that potentially affected obesity. P<0.05 was considered significant.

Results

Of the 260 subjects initially enrolled, 9(3.5%) could not comply with the functional tests, and the final sample

Table-3: Medical resume and habit of participants (n/%).

	Obese W (n=65)	Non-obese W (n=64)	p value	Obese M (n=60)	Non-obese M (n=62)	p value
Presence of chronic diseases (diabetes, hypertension, arthritis, hyperlipidaemia, etc.						
At least one	46 (70.8)	32 (50)	0.13	45 (75)	24 (38.7)	0.005*
No	19 (29.2)	32 (50)		15 (25)	38 (61.3)	
Medications (regular)						
Not using	46 (70.8)	50 (78.1)	0.56	47 (78.3)	62 (100)	0.005*
At least one	19 (29.2)	14 (21.9)		13 (21.7)	0	
Physical Exercise (per week)						
None	51 (78.5)	50 (78.1)	0.96	45 (75)	37 (59.6)	0.39
1-2 times	8 (12.3)	9 (14.1)		14 (23.3)	21 (33.9)	
3-5 times	5 (7.7)	1 (1.6)		1 (1.7)	4 (6.5)	
Everyday	1 (1.5)	0		0	0	
Tobacco use						
Yes	11 (16.9)	23 (35.9)	0.12	31 (51.7)	34 (54.8)	0.74
No	54 (83.1)	41 (64.1)		29 (48.3)	28 (45.2)	

W: women, M: men, *: p<0.05.

Table-4: Answers to the fallen story scale.

	Obese W (n=65)	Non-obese W (n=64)	*p*-value	Obese M (n=60)	Non-obese M (n=62)	*p*-value
Have you not undertaken an activity or restricted an activity because of a fear of falling?						
(Yes, %)	49.2	10.8	0.005*	21.7	11.3	<0.0001 *
Have you stumbled within the last year?						
(Yes, %)	58.5	12.5	0.003*	43.3	11.3	0.01*
Have you fallen within the last year?						
(Yes, %)	50.8	35.9	0.03*	46.7	21	0.05
How many times have you fallen in the last year?$^{\alpha}$						
	1.9±1.1	1.2±0.4	0.03*	1.5±0.7	1.3±0.4	0.5
Have you required medical treatment as a result of a fall or falls? (fracture, bruise, pain)						
(Yes, %)	20	10.9	0.01*	9.7	0	0.3

W: women, M: men, *: p<0.05, α: t-test and only fallen

stood at 251(96.5%) subjects. Of them, 129(51.4%) were females and 122(48.6%) were males. The obese group had 125(49.8%) subjects (Table 1). There was a significant difference in the health status perceived by the obese and non-obese females (p<0.05), while a significant difference was determined in the males in perceived health status, use of medications and the presence of chronic diseases (p<0.05) (Tables 2-3).

Stumbing and a history of falling within the preceding year was significantly higher in obese females (p<0.05). In obese males, a significant difference was seen in respect of history of stumbling (p<0.05). In obese females, the restriction of activity because of fear of falling was significantly high (p<0.05). In males, obesity had no effect on this parameter (Table 4).

Table-5: Results of balance disorder, falling risk and fear of falling (Mean±SD).

	Obese W (n=65)	Non-obese W (n=64)	*p*-value	Obese M (n=60)	Non-obese M (n=62)	*p*-value
NY PRT	45.1±8	52.1±9.8	0.003*	46.9±6.7	53.1±6.9	0.001*
SLST-eye open-R	20.4±8.5	25.5±5.1	0.08	22±8.1	28.3±3.5	0.002*
SLST-eye open-L	18.9±8.5	25.5±5.9	0.006*	21.4±8.1	28.1±5.4	0.002*
SLST-eye closed-R	11.3±8.1	16.68±9.53	0.03*	14.5±8.9	20.9±8.6	0.009*
SLST-eye closed-L	10.2±7.6	15.7±9.9	0.02*	13.5±8.9	19.1±9.7	0.03*
FRT	24.5±10	30.8±11.9	0.03*	26.2±9.9	33.2±11.9	0.02*
Tinnetti's FES	80.8±16.1	92.6±8.5	0.009*	85.2±13.1	85.6±17.8	0.92
Tinnetti's VAS	4.3±2.6	2.3±1.7	0.01*	2.8±2.3	2.1±1.7	0.38
ABC	1145.6±296.3	1399.3±187.9	<0.0001 *	1348±180.7	1392.5±189.4	0.18

W: women, M: men, NY PRT: New York Posture Rating Test, SLST: Single leg stance test, R: right, L:left, FRT: Functional reach test, Tinnetti's FES: Tinnetti's Falls Efficacy Scale, Tinnetti's VAS: Tinnetti's Visual Analoge Scale, ABC: The Activities Specific Balance Confidence Scale, *: p<0.05

Table-6: Correlation of scales and functional tests with body mass index.

BMI		SLST-eo-R	SLST-eo-L	SLST-ec-R	SLST-ec-L	NY PRT	FRT	ABC	TVAS	TFES
W	r	-0.3**	-0.3**	-0.2**	-0.2**	-0.3**	-0.2**	-0.3**	0.2**	-0.2**
	p	<0.0001	<0.0001	0.005	0.011	<0.0001	0.004	<0.0001	0.003	0.012
M	r	-0.3**	-0.4**	-0.2*	-0.1*	-0.3**	-0.3*	-0.1	0.1	-0.1
	p	<0.0001	<0.0001	0.047	0.04	0.002	0.03	0.14	0.203	0.09

W: women, M:men, NY PRT: New York Posture Rating Test, SLST: Single leg stance test, eo: eye opened, ec: eye closed, R: right, L:left, FRT: Functional reach test, TFES: Tinnetti's Falls Efficacy Scale, TVAS: Tinnetti's Visual Analoge Scale, ABC: The Activities Specific Balance Confidence Scale, *: p<0.05,**: p<0.01

There was significant postural impairment in all the 125(100%) obese individuals and they had all experienced loss of balance. Obese males had not experienced fear of falling even if they had loss of balance and posture impairment and this had no significant difference to the feeling of confidence (p>0.05). In obese females, the fear of falling was high and the feeling of confidence in daily activities was low (p<0.05) (Table 5).

A significant negative correlation was found between BMI and loss of balance and postural impairment in males (p<0.05). No correlation was determined between BMI and the results of the either TFES or ABCS scores (p>0.05) (Table 6).

Discussion

The study demonstrated that obesity causes loss of balance in middle-aged individuals. While obese females with loss of balance experienced fear of falling, no statistically significant change was determined in obese males in respect of feeling confident and fear of falling. An increase in the prevalence of obesity makes it necessary to take steps to overcome the morbidity and premature mortality associated with obesity. In addition to internal diseases, one of the most important public health problems created by obesity is the risk of falling, which has become an area of interest for many researchers.[16,17] In a study that examined the factors related to falls, there was reported to be a relationship among age, gender and BMI.[5] As the groups in the current study were similar in respect of age, differences in that parameter were not evaluated. However, in parallel with literature,[5,16,17] obesity was determined to increase the incidence of falling in females and the incidence of stumbling in both males and females.

A study examined the effect of obesity on the perception of health, quality of life and risk of falling, and found that the risk of falling in obese individuals aged >65 years was 31% higher than that of non-obese subjects. Those with a history of falls who were not obese were determined to have better health status than the obese subjects with a history of falls.[17] Loss of daily activities following a fall by obese subjects has been found to be at a higher rate compared to non-obese subjects.[2] The use of 4 or more medications per day has been reported to increase the risk of falling of obese individuals by 41%, and diminished quality of life has also been determined in obese individuals.[17] Although the ages of the current study participants were younger than in some previous studies,[2,17] the perception of health was found to be low in obese males and females.

Obesity has a negative effect on health perceptions regardless of age and gender differences. However, in the current study, there was a greater medication history in obese males which suggests that the use of medication creates a greater risk in respect of loss of balance and the risk of falling in middle-aged males. In contrast to the results of the current study, a st udy reported that a history of medication use had a greater effect on females aged >65 years.[6] This could be attributed to the examination of subjects in a different age range.

Falls are often caused by deficits in signals of the neuronal, visual and vestibular systems due to impaired postural stabilisation.[16] In addition to the deficits in these systems, a clear relationship has been identified between the risk of falling and increased postural fluctuation associated with increased BMI.[16] A study of males aged 10-21 years showed a negative correlation between clinical balance points and body weight, BMI and body-fat ratio in obese males. Greater medial and lateral body oscillation was also determined in the obese males compared to the non-obese group.[18] In measurements made with sensor systems in elderly obese individuals aged 65-90 years, it was determined that both, when attempting to maintain balance in areas more distant from the centre of balance and when they reached the centre of balance, were able to stand for a shorter time than those who were not obese.[1]

In a study which examined the change in physical functions according to BMI in individuals aged >65 years, the results of the SLST with "eyes open" were reported to be negatively affected by an increase in BMI.[19] In the current study, static balance was evaluated with SLST, and obesity was found to have a negative effect on both genders. Compared to the earlier study,[19] the shorter time that balance could be maintained in the current study was thought to be due to the inadequate exercise habits of the participants. In addition to static balance, the dynamic balance measured with FRT was worse in obese females than males. Literature has shown a greater increase in postural oscillation, particularly when it was necessary to maintain balance with the eyes closed.[1] This was supported by the current study as balance could be maintained for a shorter time when the eyes were closed in both male and female obese individuals.

Factors such as changes in body-fat distribution, restrictions in joint range of movement (ROM) and changes in the distribution of weight-bearing on the joint cause impairment in normal posture in obesity.[16,20,21] In the current study, the posture evaluation points of the obese individuals were seen to be lower. Changes in body posture created by obesity cause the development of compensation / adaptation mechanisms during the daily life activities (DLAs) of obese individuals.[21-23] These changes in posture form negative effects on the balance and can increase the risk of falling.[16,23]

Obesity causes not only posture deterioration and loss of balance, but also increases the fear of movement and falling following loss of balance. This then diminishes the quality of life of the person. A positive correlation has been shown between fear of movement and increased BMI. This fear is more evident in those who are morbidly obese.[24,25] Together with the fear that is felt, an increasing restriction of activity increases dependence and this situation becomes a vicious cycle.[5,7] In addition to obesity, the fear of falling has also been determined to be related to the balance status, a low educational level, female gender and a low perception of health.[26]

The middle-aged obese females in the current study reported that they experienced a fear of falling and, therefore, restricted their daily activities. However, the same situation was not observed in the male participants. Although the obese male participants experienced loss of balance and were at risk of falling, they had not lost their sense of confidence in daily activities. Similar results were obtained in respect of gender in the functional evaluations, but as the males had a low awareness of the risk of falling, this makes it difficult to assess the negativities brought about by the loss of balance in males. A study presented similar results to those obtained in the current study from an examination of individuals aged 60-88 years. Elderly females were more aware of the characteristics related to function, body composition and health and could better predict the risk of falling.[27] This similarity of results underscores the need for the application of different preventive methods against the risk of falling in males and females.

The strength of the current study was the matched study design, and the use of validated tests and questionnaires. Limitations included its single-centre cross-sectional design, and a small sample size in a relatively limited age range. Also, there could have been deficiencies in the reponses to questions because of recall bias. Besides, parameters that could affect balance, such as muscle strength, were not evaluated.

Conclusion

Obesity created similar losses in balance and posture in both males and females. Balance and posture training must be included in exercise interventions that should be part of multidisciplinary approaches to obesity.

Disclaimer: None.
Conflict of Interests: None.
Source of Funding: None.

References

1. Melzer I, Oddsson LI. Altered characteristics of balance control in obese older adults. Obes Res Clin Pract 2016; 10: 151-8.
2. Himes CL, Reynolds SL. Effect of obesity on falls, injury, and disability. J Am Geriatr Soc 2012; 60: 124-9.
3. Durgun HM, Dursun R, Zengin Y, Özhasenekler A, Orak M, Üstünda? M, et al. The effect of body mass index on trauma severity and prognosis in trauma patients. Ulus Travma Acil Cerrahi Derg 2016; 22: 457-65.
4. Matrangola SL, Madigan ML. The effects of obesity on balance recovery using an ankle strategy. Hum Mov Sci 2011; 30: 584-95.
5. Herrera-Rangel AB, Aranda-Moreno C, Mantilla-Ochoa T, Zainos-Saucedo L, Jáuregui-Renaud K. Influence of the body mass index on the occurrence of falls in patients with type 2 diabetes mellitus. Obes Res Clin Pract 2015; 9: 522-6.
6. Chang VC, Do MT. Risk factors for falls among seniors: implications of gender. Am J Epidemiol 2015; 181: 521-31.
7. Bruce D, Hunter M, Peters K, Davis T, Davis W. Fear of falling is common in patients with type 2 diabetes and is associated with increased risk of falls. Age Ageing 2015; 44: 687-90.

8. Jung D. Fear of falling in older adults: Comprehensive review. Asian Nurs Res (Korean Soc Nurs Sci) 2008; 2: 214-22.
9. World Health Organization. Obesity: Preventing and Managing the Global Epidemic. Geneva: The World Health Organization, Technical Report Series no. 894; 2000.
10. Uz S. Impact on activities of daily living and quality of life of risk factors for falls in geriatric patients. [MSc thesis]. Turkey: Istanbul University; 2008
11. Ayhan Ç, Büyükturan Ö, K?rd? N, Yakut Y, Güler Ç. The Turkish version of the Activities Specific Balance Confidence (ABC) scale: its cultural adaptation, validation and reliability in older adults. Turk Geriatri Derg 2014; 17: 157-63.
12. Fjeldstad C, Fjeldstad AS, Acree LS, Nickel KJ, Gardner AW. The influence of obesity on falls and quality of life. Dyn Med 2008; 7: 4.
13. Jeon BJ. The effects of obesity on fall efficacy in elderly people. J Phys Ther Sci 2013; 25: 1485-9.
14. Jorrakate C, Kongsuk J, Pongduang C, Sadsee B, Chanthorn, P. Effect of yoga training on one leg standing and functional reach tests in obese individuals with poor postural control. J Phys Ther Sci 2015; 27: 59-62.
15. Watson AWS, Mac Donncha C. A reliable technique for the assessment of posture: assessment criteria for aspects of posture. J Sports Med Phys Fitness 2000; 40: 260-70.
16. Hita-Contreras F, Martínez-Amat A, Lomas-Vega R, Alvarez P, Mendoza N, Romero-Franco N, et al. Relationship of body mass index and body fat distribution with postural balance and risk of falls in Spanish postmenopausal women. Menopause 2013; 20: 202-8.
17. Mitchell RJ, Lord SR, Harvey LA, Close JC. Associations between obesity and overweight and fall risk, health status and quality of life in older people. Aust N Z J Public Health 2014; 38: 13-8.
18. Hue O, Simoneau M, Marcotte J, Berrigan F, Doré J, Marceau P, et al. Body weight is a strong predictor of postural stability. Gait Posture 2007; 26: 32-8.
19. Minematsu A, Hazaki K, Harano A, Okamoto N, Kurumatani N. Differences in physical function by body mass index in elderly Japanese individuals: The Fujiwara-kyo Study. Obes Res Clin Pract 2016; 10: 41-8.
20. Emilio EJML, Hita-Contreras F, Jiménez-Lara PM, Latorre-Román P, Martínez-Amat A. The association of flexibility, balance, and lumbar strength with balance ability: risk of falls in older adults. J Sports Sci Med 2014; 13: 349-57.
21. Gilleard W, Smith T. Effect of obesity on posture and hip joint moments during a standing task, and trunk forward flexion motion. Int J Obes (Lond) 2007; 31: 267-71.
22. Heggannavar A, Ramannavar P, Metgud S. Effect of foot posture index associated with body mass index and standing balance in healthy population: an observational study. Int J Physiother Res 2016; 4: 1540-5.
23. Berrigan F, Simoneau M, Tremblay A, Hue O, Teasdale N. Influence of obesity on accurate and rapid arm movement performed from a standing posture. Int J Obes (Lond) 2006; 30: 1750-7.
24. Vincent HK, Lamb KM, Day TI, Tillman SM, Vincent KR, George SZ. Morbid obesity is associated with fear of movement and lower quality of life in patients with knee pain-related diagnoses.PM R 2010; 2: 713-22.
25. Vincent HK, Omli MR, Day T, Hodges M, Vincent KR, George SZ. Fear of movement, quality of life, and self reported disability in obese patients with chronic lumbar pain. Pain Med 2011; 12: 154-64.
26. Thiamwong L, Suwanno J. Fear of Falling and Related Factors in a Community-based study of people 60 years and older in Thailand. Int J Gerontol 2017; 11: 80-4.
27. Smee DJ, Berry HL, Anson JM, Waddington GS. The relationship between subjective falls-risk assessment tools and functional, health-related, and body composition characteristics. J Appl Gerontol 2017; 36: 156-72.