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RESEARCH ARTICLE

AN OBSERVATIONAL STUDY SHOWING EFFECT OF OBESITY ON STATIC AND DYNAMIC BALANCE OF HUMAN BODY IN YOUNG ADULTS

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ABSTRACT

The obese young adults are highly prone to frequent fall and extremities fractures as excess weight increases the stress within the bones, joints and soft tissues that leads to body imbalance.In this observational study,effects of obesity on the Static and Dynamic Body balance were studied. Total 200 subjects of both the genders were takenwith 100 in either sexand were divided into three groups 1) normal (BMI< 25) 2) Overweight(25≥ BMI <30) and 3) Obese (BMI≥30) on the basis of BMI."Multidirectional Functional Reach Test (MFRT)", "One leg stand test "and "Dynamic Gait Index Test" were used to test static upper, lower and dynamic body balance respectively. The results by using Mann-Whiteny test showed that there was no significant difference of static and dynamic body balance between males and females related to normal, overweight and obese group (p>0.05).

Comparison of body balance between normal, overweight and obese subjects was done by Kruskal-Wallis test showed no significant difference of static upper body balance between normal and overweight subjects (p>0.05) but there was significant difference between overweight and obese (p<0.05) and also in normal and obese subjects (p<0.05). The same results were also found for static lower body balance (p<0.001).Results showed highly significant difference of Dynamic body balance between normal and overweight subjects also (p< 0.001) and between overweight and obese (p<0.001) and also in normal and obese subjects (p<0.001).

INTRODUCTION

Obesity is a major disease affecting young people because of their hereditary and modern lifestyles. In addition to an overall increase in mortality, obese individuals face a greater risk of mobility impairments .[1,2] Obesity is a risk factor for functional decline in both genders, and the risk increases with body mass.[3,4] Individuals with higher waist circumference and body mass demonstrate difficulty in bending, kneeling, stooping, lifting and carrying.[5,6] Problems in executing these basic physical tasks create limitations in maintaining strength and mobility, as well as in performing basic activities of daily living .[5,6]

In previous studies it is cleared that obesity drastically affect the postural balance by reducing the amount of corrective torque needed to maintain balance.[7] Maintaining balance involves a complex interaction of multiple intrinsic and extrinsic factors. In fact, more than 400 individual risk factors contribute to the incidence of falls in older adults.[8] In surveys of both independent-living and community-dwelling seniors, motor control and balance are the top two underlying factors in the occurrence of falls.[9,10] Compromised balance is also the top contributor to falls as estimated by health care providers.[10] A review of factors cited in related research literature shows the primary contributing factors to falls include: balance deficits, gait impairments and muscle weakness.[9-11] Mobility and balance deficits may be reflected in impaired ability to stand, transfer motion, lean or reach, and respond to perturbation.[8] The efficacy of these motions is measured through variations in centre of pressure (COP) or body sway in static balance tests and postural abnormality during Dynamic Balance tests. Obesity significantly changes the way the body moves by causing changes in anthropometry. Increased body weight and mass modify how the limbs and whole body create and react to forces.[11] Excess adiposity also interferes with the interaction of joints and muscles that are crucial to functional capacity and postural balance.[12] Chambers *et al*. examined the effects of obesity on body segment anthropometry in the obese geriatric population and observed that body mass distribution varied with both obesity and gender.[13]Males with normal weight had greater trunk and upper extremity segment mass as compared to women. However, obese elderly individuals showed a significantly greater trunk segment mass, regardless of gender. This is representative of the increased abdominal fat that is correlated to higher BMI.[14-16]

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Fjeldstad *et al.* have reported that obese subjects have a higher prevalence of falls and ambulatory stumbling or a loss of balance than their non-obese counterparts.[17]Excess weight increases the stress within the bones, joints, and soft tissues, resulting in impaired musculoskeletal function such as abnormal mechanics of the body.[18] These impairments, such as impaired balance, gait, strength, sensory function and neuromuscular function have been identified as strong risk factors for falls. Several studies have found that walking speed, step length, and step frequency to be significantly lower in the obese compared to the non-obese. Additionally, the obese have a longer stance phase and greater period of double support.[19] Spyropoulos *et al* have suggested that obesity compels/demands an individual to walk slowly, take smaller strides, and remain in double support longer in order to maintain balance.[20] Deviations from the obese gait pattern results in instability and loss of balance. Most of people are unaware of bad effect of obesity on balance.

Thus obesity is a major risk factor for falls and subsequent injuries. Obese individual should require proper balance exercises accompanying with exercise for weight loss. More research is needed to fully define the structural and functional limitations imposed by overweight and obesity, but available studies suggest that increased body weight does interfere with normal musculoskeletal function through a variety of kinetic and kinematic impairments. These physical adaptations lead to impaired balance, abnormal gait patterns and increased incidence of muscle weakness – the top 3 risk factors for falls in obese .[9-11]

In the present study, we tested the hypothesis, was there any difference of Static upper, lower Body Balance and Dynamic Body Balance between normal, overweight and obese individuals of same age group. Basic anthropometric parameters such as body weight, body height were recorded and BMI was calculated by Quetelet's index. "Multidirectional Functional Reach Test (MFRT)", "One Leg Stand Test "and "DynamicGait Index Test" was used for Static upper, lower and Dynamic Body Balance testing.

MATERIAL AND METHODS

METHODOLOGY

The study was an observational study.The permission to conduct the study was taken from S.G.S.M.C and K.E.M hospital ethical committee. The study was continued for 2 years up to December 2014.

The study was conducted on a tertiary care center of Mumbai, Maharashtra. The students from M.B.B.S, nursing and O.T and P.T. and few individuals from general O.P.D were selected as study subjects with age group between 18-30 years. Total sample size in this study was 200 (100 were female and 100 were male).

Inclusion criteria

- Individual with B.M.I ≥ 18.5.
- Age group between 18-30 yrs.
- Subjects who were able to stand and walk unsupported.
- Subjects having full joint range of motion at shoulder and hip joint.
- No history of vestibular disease, D.M., any peripheral neuropathy, HTN etc.
- No history of long term use of ototoxic or neurotoxic drugs i.e. aminoglycosides, quinine, furosemide etc.

Exclusion criteria

Subjects having any

1. Any contracture in lower limbs.
2. neuromuscular and neurological diseases
3. Any visual loss
4. History of vestibular disease.
5. History of psychological and sleep disorder.
6. History of long term use of ototoxic or neurotoxic drugs i.e. aminoglycosides, quinine, furosemide etc

Equipment's

- Non stretchable inch tape.
- weighing machine.
- Stand stadiometer for height measurement.
- Stop watch.
- Wooden cones and boxes.

Study procedure

All tests were performed at the physiology Laboratory in the department of Physiology S.G.S medical college. The subjects were briefed in detail about the study procedure. The written informed consent was taken prior to the participation in the study. Subjects were asked to sit in the lab comfortably to get accustomed to the new environment. Proper history of diabetes, drugs and any other neuromuscular complains were taken in details. The Height in meters and weight in Kgs were measured and body mass index (BMI) was calculated using Quetelet's index. The subjects were asked to perform tests one by one as follows.

Details of the tests are as follows

Assessment of static and dynamic postural balance:

Subjective assessment of static lower body balance was done by using the one leg stand test and upper body balance by multidirectional functional reach test and dynamic balance by dynamic gait index test.

One Leg Stand test

In the One-Leg Stand test, the subject was instructed to stand with one foot approximately six inches off the ground and count aloud by thousands (One thousand-one, one thousand-two, etc.) until told to put the foot down at the end of 30 seconds.

The subjects were assessed for the following four points-

1. Swaying while balancing
2. Use of arms to balance
3. Hopping
4. Putting foot down.

Score were given according the observation of these points.

Multi directional Functional Reach Test (MFRT): (For detail refer Appendix-1)

In this test

A labeled yardstick was mounted on the wall, at the level of subject's acromion. The subjects were asked to stand sideward next to the wall (without touching).Feet should be at normal stance width and weight equally distributed on feet. Asked to flex shoulder at 90 degrees with extended elbow and fisted hand. For initial measurement note the position of the 3^{rd}metacarpal with yardstick.

For forward reach (F.R), the subjects were asked to lean forward as far as possible without losing balance or taking a step.

A second measurement was taken by using the 3rd metacarpal for reference. Then this measurement was subtracted from the initial measurement.

That was repeated three times for each subject. The average of the three values was taken in each direction and was compared to the normative values of the test.

Same procedure was repeated for backward, and right and leftward leaning/reach of body.

***Dynamic Gait Index test:* -** In this test- the subject was asked to perform tasks step by step during walking following some instructions and his gait and way of walking was observed as follows:

The Tasks were performed with a marked distance of 20 feet and can be performed with or without an assistive device.

Tasks include

- Steady state walking
- Walking with changing speeds
- Walking with head turns horizontally
- Walking with head turns vertically
- Walking while stepping over obstacles
- Walking while around obstacles
- Pivoting while walking
- Stair climbing

Scores were based on a 4-point scale in each task

- 3 = No gait dysfunction
- 2 = Minimal impairment
- 1 = Moderate impairment
- 0 = Severe impairment

Highest possible score was 24 points.

Statistical analysis

Total 200 subjects of both the genders were taken. 100 were males and 100 were females. Males and Females were divided into three groups 1) normal (BMI< 25) 2) Overweight (25> BMI <30) and 3) Obese (BMI>30) on the basis of BMI. Mann Whitney test (non-parametric data) was applied to find out the level of significance of balance between normal males and females and overweight males and females and obese males and females. Kruskal-Wallis test (non-parametric data) was applied to find out the level of significance of balance between non-obese and overweight, overweight and obese, nonobese and obesesubjects and in males and females separately. The level of significance was set at $P<0.05$.

RESULTS

The mean values with standard deviation of different parameters for normal, overweight and obese, males and females are given in Table-2. Results show that there was no significant difference in static upper body balance of normal males and females when MFRT was compared between them.

Table-1 Showing subject's characteristics

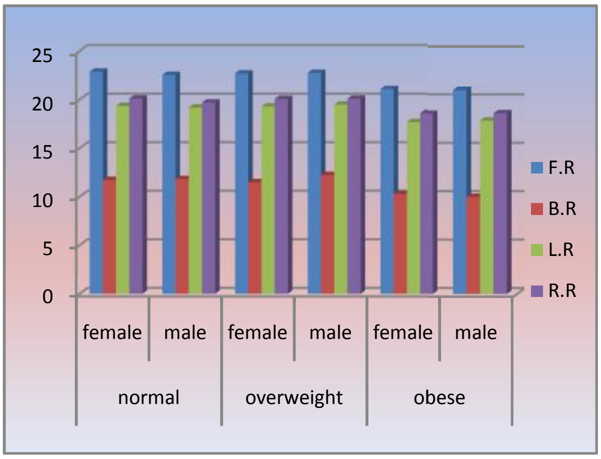
	N	AGE(YRS.) ± S.D.	WEIGHT(Kgs.) ± S.D.	HEIGHT (cms.)± S.D.	B.M.I (kg/m2) ± S.D.
Male (normal)	50	22.91 ±3.46	53.34±4.31	154.75±3.26	22.23±1.35
Female (normal)	50	21.62±2.75	52.10±4.53	154.46±3.45	21.78±1.60
Male (over weight)	26	22.59±3.17	68.59±3.59	155.87±2.01	28.05±1.30
Female (over weight)	32	21.96±2.82	69.57±3.33	156.15±2.24	28.54±1.17
Male (obese)	19	22.05±2.83	77.84±3.07	158.63±3.04	30.93±0.59
Female (obese)	24	22.16±3.00	77.83±3.89	158.58±3.65	30.95±0.88

Table-2 Showing mean values of different parameters

Groups	No.	Static Upper Body Balance (MFRT)				lower Body Balance	Dynamic Body Balance
	N	F.R	B.R	L.R	R.R	O.L.S	D.G.I
Male (normal)	100	22.53±2.70	11.8±2.34	19.17±2.58	19.69±2.81	0.75±0.99	22.99±1.13
Female (normal)	100	22.87±2.64	11.72±2.36	19.34±2.41	20.1±2.05	0.74±1.04	22.92±1.22
Male (over weight)	32	22.75±2.64	12.23±2.23	19.47±2.66	20.09±2.72	0.53±0.84	22.84±1.01
Female (over weight)	26	22.69±2.57	11.49±2.42	19.29±2.31	20.06±2.17	0.76±0.76	22.73±0.96
Male (obese)	19	21.07±2.14	10.01±1.79	17.99±1.74	18.66±1.92	2.1±1.1	21.47±0.77
Female (obese)	24	21.08±1.99	10.28±1.86	17.67±2.41	18.6±1.41	1.83±1.34	21.41±0.97

MFRT parameters I.e. - F.R, B.R, L.R and R.R got p-values as 0.3706, 0.806, 0.644, and 0.2447 (p> 0.05). (Shown in Graph-1)

Static upper body balance compared between overweight males and females by MFRT. MFRT parameters I.e. - F.R, B.R, L.R and R.R got the p-vales as 0.8819, 0.1639, 0.5265, 0.919, and 0.5921 respectively (p> 0.05). (Shown in Graph-1)Static upper body balance compared between obese males and females by MFRT. MFRT parameters i.e. - F.R, B.R, L.R and R.R got the p-vales as 0.9999, 0.6332, 0.7319 and 0.9415 respectively (p> 0.05). (Shown in Graph-1)

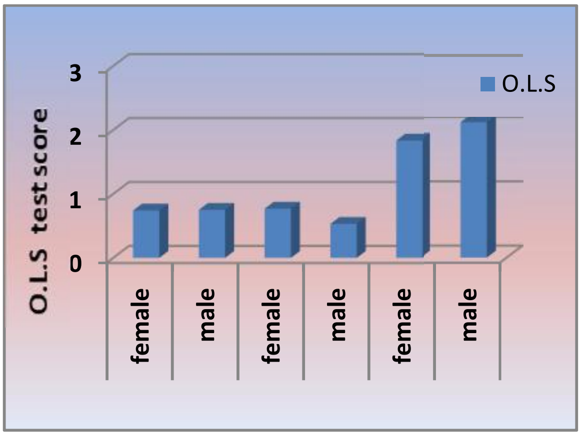


Graph-1 Comparison of Static Upper Body Balance between Males and Females

Static lower body balance also does not show any significant difference between normal males and females when one leg stand test was compared between them as P- value is 0.9448 (p> 0.05). (Shown in Graph-2)

There was no significant difference in static lower body balance between overweight males and females when O.L.S was compared between them. The p-value is 0.1824 (P >0.05). (Shown in Graph-2)

There was no significant difference in static lower body balance between obese males and females when O.L.S was compared between them. The p-value is 0.5382 (P >0.05). (Shown in Graph-2)

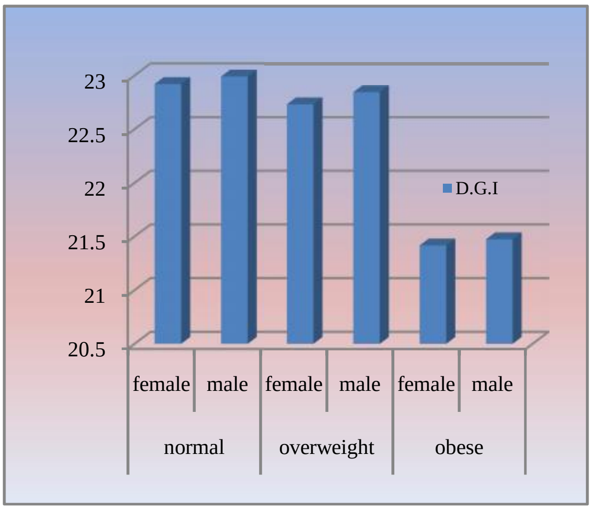


Graph-2 Comparison of Static Lower Body Balance between Males and Females

The dynamic body balance of normal males and females also does not have any significant difference as P- value is 0.6757 (p> 0.05) (shown in). Mann Whitney test was used for this.

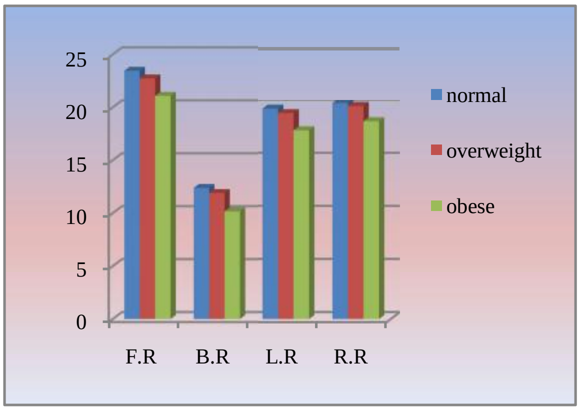
The dynamic body balance of overweight males and females also does not have any significant difference as P- value is 0.5921(p> 0.05). (Shown in Graph-3)Mann Whitney test was used for this.

The dynamic body balance of obese males and females also does not have any significant difference as P- value is 0.8916(p> 0.05). (Shown in Graph-3) Mann Whitney test was used for this.



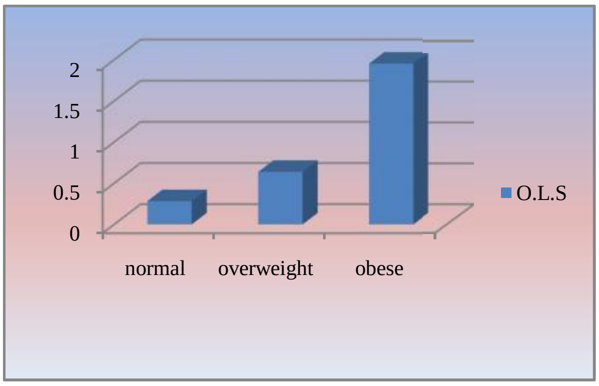
Graph-3 Comparison of Dynamic body balance between males and females

Comparison of static upper body balance between normal, overweight and obese subjects was done by Kruskal-Wallis test. Results showed no significant difference of static upper body balance between normal and overweight subjects (p>0.05) but there was significant difference between overweight and obese (p<0.05) and also in normal and obese subjects (p<0.05). (Shown in Graph-4)



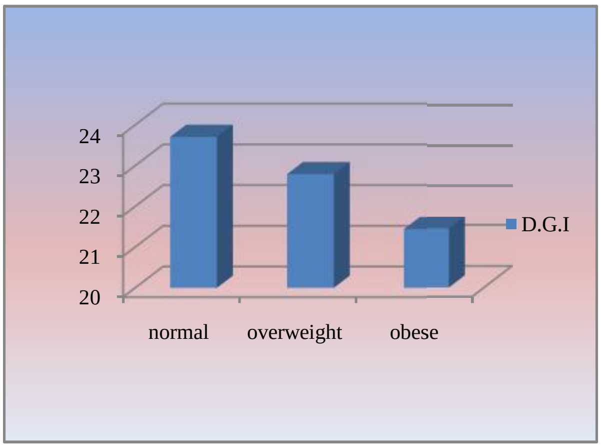
Graph-4 Comparison of static upper body balance between normal, overweight and obese subjects

The Same results were also found for static lower body balance measured by One Leg Stand test score (p<0.001). (Shown in Graph-5) Thus static upper and lower body balance was significantly disturbed in obese than normal and overweight subjects.



Graph-5 Comparison of static lower body balance between normal, overweight and obese subjects

The Dynamic body balance was measured by Dynamic gait index. Comparison of Dynamic body balance between three groups was done by same test i.e. Kruskal-Wallis test. Results showed highly significant difference of Dynamic body balance between normal and overweight subjects also ($p < 0.001$) and between overweight and obese ($p<0.001$) and also in normal and obese subjects ($p<0.001$). (Shown in Graph-6) Thus Dynamic body balance was significantly disturbed in obese than normal and overweight subjects. Overweight subjects also had lower Dynamic gait index than normal subjects. So obesity affects dynamic body balance more early than static body balance.



Graph-6 Comparison of Dynamic Body Balance between normal, overweight and obese subjects

DISCUSSION AND CONCLUSION

Obesity is highly associated with numerous health conditions like hypertension, type 2 diabetes mellitus, cardiovascular disease, osteoarthritis (OA), and respiratory disease.[20-25] In addition, Wearing SC, Hennig EM, Byrne NM, *et al*. in their study found that the obese tend to have higher levels of functional limitation than the non-obese.[26] It was found from our study that the static upper and lower body balance in the obese individuals of both the genders was poorer than that overweight and non- obese of same age group ($P<0.05$). Over weight individuals also have the poorer balance than non-obese which was shown in Graph-4, 5).

Dynamic body balance had highly significant difference between normal and overweight subjects ($p < 0.001$), between overweight and obese ($p<0.001$) and also in normal and obese subjects ($p<0.001$). Thus Dynamic body balance was significantly disturbed in obese than normal and overweight subjects, in overweight than normal subjects. (Shown in Graph-6) Goulding *et al*. found that the balance of obese individuals was poorer and the score of the test was lesser in obese individuals than in non-obese individuals.[27]Hills and Parker and Cynthia Norkins observed that the walking speed of obese individuals was found to be decreased than that of non-obese individuals as the speed was lowering in obese.[28,29]

There was no significant difference in static upper, lower and dynamic body balance of normal males and females ($p > 0.05$). (Shown in Graph-1, 2, 3)

It was found in our study that FRT score in obese females was decreased by 10.53% whereas in obese males, it was reduced by 8.14% when compared to nonobese groups. It indicates that balance in obese females is impaired more than obese males but was not significant statistically. Thus results show obese females have same risk of fall as obese males.

Maffiuletti NA, Agosti *et al*. found that increased obesity has shown to be positively correlated with impaired postural balance even in younger individuals. Postural balance was improved in these individuals following a weight reduction program combined with balance training.[30]

The increase in body mass is associated with changes in many of the components of normal gait. Gait speed has been shown to be slower in obese individuals. Teasdale N, Hue O, Marcotte J et al. found that even overweight children may require more balance control and lower extremity muscle strength than non-overweight children in order to accommodate for the increased body mass.[31] Hills and Parker found that obese subjects displayed a consistently higher double stance period at normal, fast, and slow walking speeds.[28] Francesco M, Manuela G *et al* in their study concluded that obesity modifies the body geometry by adding mass to different regions and influences the biomechanics of activities of daily living.[32] Thus our study is in support of Goulding *et al*., Hills and Parke and Cynthia Norkins *et al*. and we found that overweight and obese subjects were affected by similar postural instability in both genders of same age group. The study concluded that the body balance was more affected in obese group as compared to normal and overweight BMI group in both genders. The Dynamic body balance was highly affected in overweight and obese subjects. Hence doctors should advise the obese patients to take measures for improving body balance in prevention of repeated occurrence of extremities fractures.

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