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Association of Body Composition with Static Plantar Foot Pressure in Young Adult

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Abstract

Body composition is a key component of health-related fitness. Dual Energy Absorptiometry (DEXA) is the most reliable technique to evaluate body composition. There is evidence suggesting that obesity is linked to foot disorders leading to & an increase in the risk of falls and injuries. Pedobarography is a fast, simple, non-invasive and reliable method used to measure plantar foot pressure. Studies on the association of body composition using DEXA with the static standing plantar pressure are limited.

Purpose: The purpose of the study was to measure the association of fat percentage, Body mass index, type of obesity, fat mass and bone mineral content (BMC) with foot pressure.

Methods: 64 young adults participated in this study including 34 females and 30 males with a mean age of 21.7±2.6 years. DEXA and Pedobarography were used for evaluation.

Results: It was found that with the increase in every 1% in fat percentage, BMI, android type obesity the forefoot pressure increases by 1.070% (p-value 0.06), 1.079% (p-value 0.07) and 1.106% (p-value 0.25). Gynoid type obesity has an inverse relationship with forefoot pressure. With every 1% decrease in the gynoid type obesity value the forefoot pressure increases by 0.971% (p-value 0.97). Also, 39 out of 64 (60%) subjects with higher fat mass and 34 out of 64 (53%) subjects with greater bone mineral density (BMD) on one side had foot pressure dominance on the same side with p-value >0.05.

Conclusion: This study concludes that body composition parameters variably affect the foot pressure in static standing.

Keywords: Dexa; Pedobarography; Fat %; Body Composition; Plantar Foot Pressure

Abbreviations: BMC: Bone Mineral Content; BMD: Bone Mineral Density; DEXA: Dual Energy Absorptiometry.

Introduction

Body composition is a key component of health-related fitness and is often used as a tool for risk assessment. It is a measure of change in physical activity or diet. The assessment of body fat and fat-free mass provides valuable information about the physical and metabolic statuses of humans. In addition, the ability to accurately measure body fat is important because of the established association between high amounts of body fat and a variety of disease processes such as hypertension, diabetes mellitus, coronary artery disease, and hyperlipidaemia [1,2].

Overweight or Obesity is defined as abnormal or excessive fat accumulation that presents a risk to health [6]. In addition to increasing obesity rates observed in numerous populations, it has been found that obesity itself can be a risk factor for a number of other adverse cardiovascular and metabolic diseases [4,5]. Optimal body composition plays a significant role in athletic performance [6,7]. Body composition assessment provides a more sensitive and specific measure of disease risk than body mass index (BMI), and this is of particular relevance for those in the intermediate BMI ranges [8,9]. Several methods are available for estimation percentage body fat, muscle mass, fat mass and free fat Bioelectrical Impedance, Skinfold thickness measurement, DEXA and Underwater Weighing were used variedly. DEXA is one of the most reliable techniques and has the advantage of calculating the Bone Mineral Content (BMC) and Bone Mineral Density (BMD) along with the fat percentage.

Postural stability can be explained as the ability of one's motor control to maintain a standing posture [10,11]. Excessive body weight negatively affects balance. The excessive amount of fat modifies the body structure by adding passive mass to different regions and it influences the biomechanics of activities of daily living, causing functional limitations, and possibly predisposing to injury. Quantitative evidence exists that excessive body weight negatively affects the movement from sitting to standing, walking and balance [12,13]. Gynoid distribution, which is characterized by, body fat deposition predominantly in the lower limbs rather than android pattern, predominantly abdominal fat exerts a greater impact on the feet [14-16].

The foot is exposed to high static and dynamic forces of the load, which can lead to disharmony of muscle strength and load which lead to the appearance of overuse injuries [17,18]. Plantar pressures can provide useful information about the influence of overweight on the musculoskeletal system. The assessment of plantar pressure distribution represents an important clinical tool for understanding the structural and functional implications of being overweight [19-21].

Pedobarography is a fast, simple, non-invasive and reliable method that enables the measurement of pressure between the foot and the floor during static and dynamic loading. Pedobarography analysis shows the distribution of plantar pressure of the foot and determines certain "hot" and "cold" zones of low and high pressure [17,18]. It can be used for assessment of the effect of treatment, secondly to monitor the progress of individuals or groups of patients by comparison of sequential recordings and for designing and assessment of orthoses. It helps the understanding of weight-bearing foot function in health and diseases and helps to assess new equipment and standardised methodology [17,22]. Thus, the purpose of the study was to evaluate the association between various body composition parameters with static foot pressure in young adults.

Materials and Methods

Sixty-four subjects (30 males and 34 females) participated in the study selected through convenient sampling. All subjects were healthy, between the ages of 18 and 25 years. The nature, purpose, risk and benefits of the study were explained to each participant before obtaining written informed consent. The Institutional Ethical Committee, Guru Nanak Dev University, Amritsar, approved the protocol. The Pedobarography device used was Zebris FDM-SX System (Germany) and the Discovery Wi DXA system (Hologic Inc) was used for evaluating the fat percentage. Calibration for Zebris Win Balance was done prior to each subject tested. DEXA machine was calibrated every 24 hours. The subject's height and weight were measured prior to testing. For the static foot pressure analysis, subjects were asked to stand on the platform with comfortable stance for 20 seconds. The software analyses distribution of pressure in particular areas of the foot shown as 'hot' and cold zones of high and low zones. The load distribution was expressed in percentage [17]. For body composition analysis subjects were asked to lie still with their body carefully centred on the DEXA scanner facing upwards for 7-8 minutes. The software provided data of fat mass, fat-free mass and bone mineral density of the whole body as well as specific parts [14].

Statistical Analysis

The statistical evaluation of the current study was performed using the SPSS software 21 version (IBM, CHICAGO, IL). The results were analysed using the Chi-Square test and by calculating the odds ratio.

Results

The association of forefoot pressure compared to the back foot with various parameters was calculated by using the Odds Ratio with p-value significant at <0.05. The pressure generated at the forefoot increases as the Fat%, BMI, Android type obesity increases. With every 1% increase in these parameters the risk of forefoot dominance increases by 1.070% (p-value 0.06), 1.079% (p-value 0.07) and 1.106% (p-value 0.25) respectively. Gynoid type obesity was inversely proportional to forefoot pressure. With every 1% decrease in gynoid obesity the risk of forefoot pressure dominance increases by 0.971% (p-value 0.71).

Demographic characteristics	Mean ±SD
Age (years)	21 ± 2.60
Height (cm)	165.20 ± 18.30
Weight (kg)	63 ± 10.75
DEXA variables	
Fat %	21.86 ±9.22
Android	78.14 ±9.23
Gynoid	13.77 ±5.92
Trunk Fat %	26.10 ±7.99
Head Fat %	22.30 ±0.36
Lt arm fat %	28.20 ±10.95
Rt arm fat %	27.99 ±10.48
Lt leg fat %	28.73 ±9.56
Rt leg fat %	37.03 ±64.83
Rt total fat (kg)	4.08 ±1.54
Lt total fat (kg)	3.85 ±1.44
Lt arm BMC (kg)	142.73 ±36.66
Rt arm BMC	375.24 ±1611.2
Lt leg BMC	420.04 ±105.74
Rt leg BMC	409.03 ±100.77
Lt rib BMC	86.85 ±18.44
Rt rib BMC	84.02 ±18.97
T spine BMC	109.74 ±22.80
L spine BMC	59.76 ±15.44
Pelvis BMC	267.47 ±87.13
Subtotal	1713.90 ±465.69
Head BMC	462.73 ±143.05
Total BMC	2185.82 ±452.96
Pedobarography average forces (%)	
Lt forefoot	38.17 ±14.19
Lt hindfoot	61.82 ±14.19
Lt foot total	48.79 ±3.17
Rt forefoot	38.42 ±11.51
Rt hindfoot	61.56 ±11.51
Rt foot total	51.20 ±3.17

Abbreviations: Lt- Left, Rt- Right, BMC-Bone Mineral Content

Table 1: It shows the mean and standard deviation of the demographic data and the various parameters of Pedobarography and DEXA scan

The Fisher's Exact Test value and Pearson Chi-Square (p) value to evaluate the relation between unilateral fat mass and BMC with the left and right foot pressure were calculated using the Chi-Square test with p-value significant at <0.05. The Fisher's Exact test value for the relationship between unilateral fat mass and foot pressure was found to be 1.00 (p-value 0.84). Table 2 shows that 5 out of 15 subjects who had left side fat accumulation higher than right side, had a higher left foot pressure. Whereas, 34 out of 49 subjects with higher right side fat accumulation, were right foot pressure dominant. Total of 39 out of 64 subjects (60%) with higher fat percentage had the same side foot pressure dominance.

The Fisher's Exact Test value for unilateral BMC on foot pressure was found to be 0.79 (p-value 0.73). Table 3 shows that 10 out of 30 subjects who had a higher left side BMC had a higher left foot pressure. 24 out of 34 subjects with higher right-side BMC were right foot pressure dominance. Total of 34 out of 64 subjects (53%) with greater BMC had the same side foot pressure dominance. The mean and standard deviation of the demographic data and the various parameters of Pedobarography and DEXA scan as mentioned in Tables 1-3.

	Higher Left fat mass	Higher Right fat mass
Left pressure dominant	5 (33.3%)	15 (30.6%)
Right pressure dominant	10 (66.7%)	34 (69.4%)

Table 2: Shows the Crosstabulation of fat distribution with left and right foot pressures.

	Higher Left BMC	Higher Right BMC
Left pressure dominance	10 (33.3%)	10 (29.4%)
Right pressure dominance	20 (66.7%)	24 (70.6%)

Table 3: Shows the Crosstabulation of Bone Mineral Content with left and right foot pressures.

Discussion

This study was designed to examine the association between body composition and foot pressure using the Dual Energy X-ray Absorptiometry and Pedobarographic analysis. We hypothesised that there will be an association between various parameters of body composition and Pedographic variables in young adults. The results concluded that when there is an increase in the android type obesity, BMI and fat percentage the forefoot pressure dominates whereas in gynoid type of obesity there was a negative association of increased obesity with forefoot pressure. These results were consistent with the findings of Neri SGR, et al. [14] who observed similar findings in elderly women. The body structure changes with an abnormal rise in weight. Central fat accumulation in the android type of obesity results in two major physical effects: an anterior position of the centre of mass relative to the ankle joint, and higher weight to stabilize the base of support [23]. Excessive weight gain has been shown to induce musculoskeletal adaptations that induce postural and motor alterations [12]. There are a number of mechanisms by which obesity may affect the foot. These include biomechanical changes to foot structure, such as pes planus, and changes to the plantar fat pad, including increased plantar pressures, inadequate muscular strength and power, particularly in activities requiring movement against gravity, and changes to gait [24,25]. Obesity is associated with altered pressures applied to the foot increasing the risk of falls [14]. These findings conclude that fat acts as a passive mass which changes the position of the centre of gravity which leads to disturbed balance.

To our knowledge, this was the first study which aimed to evaluate the association between the distribution of fat and bone mineral content on left and right sides with pressure distribution. The results concluded that 60% of the subjects had dominating foot pressure on the same side on which the fat mass was higher. Whereas, 53% of the subjects had dominating foot pressure on the same side on which the bone mineral content was higher.

Conclusion

In our study including young adults, the static forefoot and backfoot pressure were highly influenced by the type of obesity, BMI and fat %. The influence of unilateral fat mass and bone mineral content on left and right static pressure was influenced in >50% of the samples.

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