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Biomechanical Correlates of Body Mass Index: The Role of Core Stability and Foot Posture in Young Adults of Swat, Khyber Pakhtunkhwa

Zakir Ullah*[1], Rooh Ullah[2], Usman[3], Asheefa[4], Muhammad Atif[5], Sehrish khan[6], Mariam Shehzadi[7]

1. Assistant Professor, School of health sciences, Peshawar Email: zakirbaryal.9777@gmail.com
2. Lecturer at school of health sciences, Peshawar Email: roohullahhanafi@outlook.com
3. Physiotherapist at Alfarsi physiotherapy center Oman Email: usmankhan6293@gmail.com
4. Physiotherapist at MMC General hospital Peshawar Email: asheefakhan71@gmail.com
5. Lecturer at school of health sciences Peshawar Email: atif64091@gmail.com
6. Lecturer school of health sciences Peshawar Email: Sehrishdr696@gmail.com
7. Lecturer at school of health sciences Peshawar Email: shehzadi0@gmail.com

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Abstract

Background: Body mass index (BMI) is defined as the ratio of weight to height and is expressed in kg/m². High body mass index has been shown to be the cause of different musculoskeletal disorders, which mostly affect the individual especially during walking and ambulation. BMI has also been linked to core stability. Various musculoskeletal disorders have been associated with being the cause of an increase in BMI, but the prime ones are foot disorders such as pronated or supinated foot.
Objective: To determine the effect of BMI on foot posture and core stability in the young adult population.
Method: A total of 316 participants were recruited for the study from the University of Swat, out of which 216 were males and 100 were females. A non-probability convenient sampling technique was used to recruit the subjects, and the study was conducted at the University of Swat. The BMI of participants was measured using a weight and height machine and was expressed in kg/m². The foot posture was measured using the foot posture index (FPI), and it ranges from -12 to +12, whereas core stability was measured by using the anterior plank test.
Result: Out of 316 participants, 181 were in the normal range, 121 were pronated, 10 were highly pronated, and 4 were in the supinated category, while none were in the highly supinated range. The mean age of the participant was 1.71 years. The results of this study revealed that there was a positive correlation between BMI and FPI (left and right), as well as a positive correlation between BMI and core stability.
Conclusion: It was concluded that an increase in BMI can cause a change in the foot posture but does not significantly affect core stability.

Keywords: Body Mass Index, Core Stability, Foot disorders and Foot Posture Index (left and right)

Introduction: People with weight surplus are rapidly increasing in almost every country of the world. The issue of overweight or obesity has been taken into consideration since 1980 to control it but no significant results have been gained. But from the last three decades obesity is increasing in alarming rate in all over the world and specially in Canada and it has increased fourfold since 1985

(1) (2) (3).Obesity control and management has been mostly restricted to weight loss but in broad perspective it not only involves weigh loss but rather contains improving overall health and wellbeing so more researches are needed to be done which should shift the focus from simple weight loss to overall improvement of an individual(4) .Various methods have been used in clinical set up to diagnose obesity but the most prevalent among them is by the use of BMI and waist circumference and simultaneous use of both of them can be a better predictor of obesity (5).In most of the cases obesity and overweight are used synonymously but to be more precise the definition of overweight is the excess body fat in relation to height (6). WHO definition states that obesity is the excessive deposition of fat that effects the normal functioning of human body(7). (8).(9). Medical conditions which arise due to obesity have great impact on the national budget of almost every country and specially in UK and USA obese people have spent more than 30% of their income on medical costs than individuals with normal weight which shows that it greatly impacts resoruces.Another study has also revealed that individuals whose BMI is more than 25kg/m2 has used more medical resources than those whose BMI is below this range(10)

BMI is a universally accepted tool to measure body fat distribution and has been shown by researches that it affect morbidity and mortality(11).For a clinician it is crucial to have knowledge of BMI as this has been linked to development of various diseases and pathologies. Different studies indicates the co relation of BMI to the pathophysiology of various diseases such as the effect of BMI on mesenchymal stromal progenitor cells, those with BMI greater than 30 have 5 times more progenitor cells that those BMI less than 30 (12).(13).The increase in BMI has been shown to affect the cardiovascular system and can increase the risk of blood pressure, lipid profile and can also affect the respiratory system causing hypoventilation(14).Apart from this it also cause problems in the integumentary system causing inflammation to the external layer of the skin, as well as high BMI has been shown to influence the genital system and reproductive system(15). analyzed in 19th century by a mathematician who belonged to Belgium and he stated that people who fall in normal range must have body weight proportionate to the square of the height(16).World Health Organization(WHO) has also categorized obesity on the basis of body Mass Index(BMI)(17).As per the guidelines of World Health Organization(WHO) BMI has been classified as underweight <18.5,Normal 18.5-24.9,overweight 25-29.9 and obese having BMI more than 30(17).

Ankle and foot problems have become a major issue in public health (18).High attention has been given to hip and knee joint in terms of care and treatment of these joints but less attention has been given to ankle joints by rheumatologists and physiotherapists(18).Foot pain affects about 13 to 36% of common community individuals whose age is 45 or more and has greatly impacted the quality of life and physical activities and function(19).Foot is one of the complex structure of human body and with respect to anatomy and biomechanics and allow us to ambulate and transfer energy through lower limb(20).The ankle and foot complex is composed of talonavicular and subtalar joints which play a major role during ambulation and contributes to around 40 to 70% in propelling an individual forward during gait cycle with minimal energy usage of about 7 to 26% of total metabolic cost(21).Increase in heel height has been shown to effectively reduce the pain in the calcaneal region and some of the heel modification and rocker shoes has played a major role in reduction of heel pain(22).Since foot is among the most complex joint of human body therefore problems arising from the abnormalities of foot are complex in nature and are difficult to identify and treat. Approximately it affects one in five people in almost every community and has been related to mobility deficit and poor health. Various causative agents have been identified in causing foot pain and comprise of advancing age, female gender, abnormalities of joints such as OA as well as depression (23, 24).Several criteria have been formulated to differentiate normal foot from abnormal foot. foot posture is defined as the alignment of foot which can either be of low arch, high arch or can be of normal arch(25).Foot posture which is also known as foot type may be responsible for injury of the lower extremity by changing the biomechanics. Change of foot posture form normal to high arch or

low arch is also one of the key factors contributing to the injury of lower limb. It has been concluded that individuals having flat feet have more mobility in the foot in comparison to those having high arch. During running and walking more stress is placed to the soft tissue around the joints of ankle and foot due to more rotation and movement which can cause injury in the person having high and low arch foot. Researchers see the link between foot posture and lower extremity injury through three biomechanical aspects (1)Kinetics (2)Electromyography(EMG) (3)Kinematics (26).The electromyography studies have demonstrated that those having flat feet have more activation of tibialis anterior and posterior than fibularis longus and brevis in comparison to those having normal or high arch feet(27). From the past experience researchers have been unable to deny the fact that foot mechanics plays an important role in causing injuries of the whole kinetic chain and specially of the lower limb .Studies have suggested that hind foot eversion cause internal rotation of tibia which in turn cause transverse rotation at the hip joint disturbing the whole biomechanics of the lower limb causing exercise induced pain and injury of lower limb(28),medial tibial stress syndrome (29)and patellofemoral pain syndrome (30). Feet of an individual whose BMI is high is in constant stress and strain due more weight bearing than normal weight individuals.

During normal walk the weight on the feet is about 1.2 times of the body weight and during running it increases to 2-3 times of the body weight while in those people who are obese or overweight the stress on medial longitudinal arch increase 3 times of the normal weight individuals. one of the easiest and reliable way to measure foot posture is through foot posture index(FPI) (31). Core is defined as a double walled circular structure composed muscles such as transverse abdominus, oblique's (internus and externus), rectus abdominus and pelvic floor muscles. The top of core is made up of diaphragm muscles and the bottom is composed of pelvic floor and hip musculature(32).Core has been a major area of interest for researchers and physical therapist whose primary focus in on sports science(33).Recently core has gained a considerable attention in terms of training and various methods have been used to train the core such as Pilate and ballistic training. There is a belief that the strengthen of the core has a positive effects on stability of athlete and hence helps to improve the athletic performance(34).

Core has a major role in injury prevention. Active and passive elements contribute to core stability. Passive system is composed of vertebral bodies and the discs between them and the capsules and ligaments which play a major role in stabilizing the spine at the end range of movement(35).The active muscular elements contribute to the stability through increasing intra-abdominal pressure, spinal compressive forces and hip and trunk muscle stiffness(36).for proper functional activities of the upper extremity such as throwing and hitting energy is generated in the core and is transmitted to the upper limb(37) there is lack of studies done in young adult population so this study aims to provide knowledge regarding the relation of body mass index with foot posture and core stability in young adults.

Literature review: Obesity, characterized by an elevated Body Mass Index (BMI), is a major global health concern linked to numerous conditions such as diabetes, hypertension, and cardiovascular diseases. WHO has labeled childhood obesity as a top public health issue of the 21st century. The prevalence of obesity is rising not only in developed nations but also in developing countries like Pakistan, where it disproportionately affects women and children due to poor dietary habits and low physical activity levels. If current trends persist, it's estimated that by 2030, 38% of the global population—and up to 85% of the U.S. adult population—may be obese. Epigenetic mechanisms, such as DNA methylation, are believed to play a role in the early development of obesity and its related comorbidities. A meta-analysis indicates that a 5-unit increase in BMI may raise coronary heart disease risk by 29%.

The relationship between BMI and musculoskeletal health, especially foot posture, is significant. Obesity affects gait and increases energy expenditure during walking, which may contribute to

disorders like osteoarthritis and low back pain. High BMI also alters the biomechanics of the foot, increasing stress on ligaments and joints and reducing postural stability. Studies report a correlation between high BMI and conditions like pes planus (flat feet), heel pain, and plantar fasciitis, particularly in non-athletic populations. Increased fat mass can affect the Foot Posture Index (FPI) and lead to decreased medial longitudinal arch due to midfoot overloading.

Core stability, essential for trunk control and postural alignment, is negatively impacted by increased BMI. Research shows that while obese individuals may have stronger core and quadriceps muscles, their endurance is often reduced. Children with higher BMI demonstrate shorter plank and bridging times, suggesting reduced core function. Studies also reveal that increased fat mass impairs load-bearing capacity and postural stability, with gender differences observed in core muscle performance.

In summary, elevated BMI is strongly associated with musculoskeletal changes, altered foot posture, reduced core endurance, and impaired postural stability. These findings emphasize the importance of addressing obesity not only for metabolic health but also for functional and biomechanical well-being.

Methodology

Methods: Cross sectional study done on young adult population of swat**,** non-probability convenience sampling the sample size was calculated by using open epi with a confidence interval of 95%m and sample size was 316. Inclusion Criteria were Both male and female students of the university of swat, KPK, Pakistan, and age 18 to 35 year. Exclusion Criteria were Adults who have pain in their foot and having reduced tactile and thermal sensation as well as having peripheral neuropathy, Participants having patello-femoral pain syndrome, plantar fasciitis and back pain, Presence of any systemic or musculoskeletal condition that has affected the participant within six months and that is affecting activities of daily life and Pregnant females as they may be unable to perform the plank test. Body mass index was calculated using weight and height machine. The weight of participant was divided to the height of the participant in order to calculate BMI. foot posture was calculated using foot posture index (FPI)

Results

Male participants were 216 and 100were females with (59%) and(41%) respectively Individuals categorized as underweight, Normal, overweight and obese based on BMI. Out of 316 individuals 28 were underweight, 179 were Normal,101 were overweight and 8 were obese. Foot nature 62.3% Normal,34.7% Proanted,1.9% Highly pronated,1.1% Supinated and 0 % in Highly supinated category. positive corelation between BMI and FPI (right) with p value being 0.000 were found positive correlation between BMI and core stability.

Discussion

A study conducted in Mumbai in the year 2016 on 40 healthy adult subjects indicate that there is a positive association between BMI and FPI with Correlation co efficient of 0.5 and P value of 0.001 which is in consistent with this study of positive co relation between FPI (right and left) and BMI with p value being 0.000 and 0.001 respectively. The same study shows a negative co relation of BMI and core stability but the results of our study are in consistent with the result of this study and shows a positive co relation between BMI and core stability (38).Another study on older population whose results have concluded obese female have flat feet and obese males tend to present with pronated foot and has also shown that there is a weak positive co relation between BMI and FPI(left and right) and our study is consistent with this study results which also shows a weak co relation of BMI and FPI(39).a study done at school of biomedical engineering Colorado USA indicates the

effect of high BMI on the function of lower extremity specially during walking concluded that as it is increasing the endurance of the muscle is decreased which in turn cause more energy requirement for ambulation as well as there was more probability of causing structural damage and pronation of the foot which is in consistent with our results of increases in foot pronation due to high body mass index (40).

Conclusion

There is a positive co relation between BMI and foot posture index (right and left) which indicates that with increase in obesity there is a possibility of foot pronation and abnormal biomechanical chain of the whole body while BMI was also positively co related with core stability. Therefore proper education is needed to aware the people about the increase in BMI and its consequences on Musculoskeletal system especially on foot.

Limitation

This study conducted in university of swat to see the effects of BMI on foot posture index and core stability was only performed in the age group between 18-35 year while obesity is also observed in age group younger and older than this. Apart from this our study was only restricted to see the effects of BMI on foot posture and core stability.

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