Original Research

Correlation of body mass index with dynamic balance using Y-Balance Test in adults with the Flexible Flat Foot: An Analytical Correlation Research Protocol

Shobha M. Bhave[1,5], Waqar M. Naqvi[2], Arti I. Sahu[3], Sakshi P. Arora[3]

[1]Professor, Physiotherapy School and Centre, Government Medical College, Maharashtra University of Health Sciences, Nagpur, Maharashtra, India, [2]Professor and HOD, Community Health Physiotherapy, [3]Resident, Community Health Physiotherapy, [5]PhD Scholar, Community Health Physiotherapy, Ravi Nair Physiotherapy College, Datta Meghe Institute of Medical Sciences (DMIMSU), Wardha, Maharashtra, India

Abstract

Background: Balance is one of the primary requirements for both static and dynamic activities. Body Mass Index (BMI) is measurement for estimating excess body fat. The Lower Quarter Y-Balance Test (YBT-LQ) is a screening instrument that measures single-leg balance in different directions. Flexible flatfoot is the postural aspect with depressed medial longitudinal arch, pronated subtalar joint and valgus position of calcaneus, evident only in weight-bearing position.

Methods: An analytical correlation study with 255 participants (Purposive sampling) will be taken as per inclusion and exclusion criteria with study duration of 3 years. The BMI, sit to stand Navicular Drop Test (SSNDT), limb length and medial longitudinal arch angle (MLAA) will be measured and compared. The mean score of the Y Balance Test in different categories of BMI will be compared by performing one way ANOVA test. The mean score of the Y Balance Test between two groups in each category of BMI will be compared by Bonferroni t-test.

Conclusion: The study aims the correlation of BMI with the dynamic balance on Y-balanced test in adults with flexible flat foot. The expected outcome of study will concentrate on the significant correlation of Y Balance Test in different categories of BMI.

Keywords: *Balance, BMI, Flexible flat foot, YBT-LQ*

Introduction

Flatfoot is also called as pesplanus or fallen arches [(1)]. Acquired flatfoot develops from injury, illness, prolonged foot stress, obesity, and faulty biomechanics. The foot arch collapses in this postural deformity [(2)]. Flexible flatfoot is stated precisely as the postural aspect of the foot, with depressed medial longitudinal arch, pronated subtalar joint and valgus position of calcaneus under weight-bearing positions [(3)]. The expression "flexible" indicates that while the foot is flat when standing (weight-bearing) and the arch reappears in the non-weight-bearing state. One of the prevalent types of flatfoot is flexible flatfoot. Usually, it commences in childhood or puberty and persists on into adulthood. It ordinarily happens in both feet and advances in severity over the adult years. About 20-30% of the population

Corresponding author:
Waqar M. Naqvi,
Professor and HOD, Community Health Physiotherapy, Ravi Nair Physiotherapy College, Datta Meghe Institute of Medical Sciences (DMIMSU), Wardha, Maharashtra, India.
Email – waqar.naqvi@dmimsu.edu.in
Orcid ID - https://orcid.org/0000-0003-4484-8225

frequently have flat feet reported a high prevalence of flatfoot in 18 to 25 years of young adults. Flatfeet is not dependent on gender [2,3].

The ankle and foot complex plays a significant purpose in keeping erect posture, as further in adjustment on supporting surfaces, in remedying postural sway in single-limb stance, in shock absorption and transition of ground reaction force (GRF) to assist the push-off throughout normal gait [1,4]. Minimal biomechanical alterations and functional variance in the ankle and foot complex, in turn, changes the peripheral sensory input in weight-bearing posture and contact with the surface area (5–7). The abnormalities occurring in the structure of the foot may influence the function in the static and dynamic state, and movement, thus altering the displacement of the body. They may intrude the motion-sensing receptors [8,9]. Since balance necessitates the processing of information from the motion-sensing receptors to estimate the body's position in space, it can affect posture in a complex interaction and affect the complete range of motion (ROM) of the joints required to obtain maximum balance [10,11]. Flat feet bring about variations in foot posture, foot mobility, and load distribution under the foot, which affects dynamic balance required for activities of daily living (ADLs) and optimal performance in the sports activity. Alterations in neuromuscular strategies change the ability to sustain an upright and stable posture, and anticipatory postural control is decreased, frequently making the person susceptible to falls and associated injuries[5,7]. Variations in the structures at the ankle and foot complex make a person susceptible to alterations in weight-bearing, and muscle imbalance in static and dynamic positions leading to compensatory strategies, which usually result in overuse injuries[2].

The World Health Organization, 1997 divided individuals into three categories depending upon body mass: normal (BMI<25 kg/m2), overweight (BMI, 25–30 kg/m2) and obese (BMI>30 kg/m2). BMI is a helpful measurement for estimating excess body fat. It is determined by dividing body-weight by the square of the height (kg/m2) per person[5,6] Balance is linked to the inertial forces acting on the body and the inertial components of body segments. It is stated as the process that keeps the centre of gravity within the body's support base and requires consistent changes with joint positioning and muscular activity[3]. Balance is one of the primary requirements for daily activities, both static and dynamic activities[11]. Balance is a physiological and mechanical state and the desire to move the body within the optimum level of support [11]. Factors that affect balance are sensory information received from the visual, somatosensory, and vestibular systems and motor responses that influence coordination, joint range of motion (ROM) and strength. Dynamic balance is the ability of an object to balance while in motion. Ability to sustain postural stability under dynamic conditions is an essential underlying element of physical activity execution.

The disadvantage presented by obese young adults occurred in dynamic activities, displaying less balance and an increment in the time to achieve these activities[12,13]. It has been recommended that fat mass may be the reason for the outward aspect of a "flat" foot in obese individuals. Bodyweight is considerably correlated to increase loading of the foot, especially the forefoot and midfoot, which infers that obesity enhances the stress applied to the foot directly via raised body weight and indirectly via changes to the foot structure, i.e., a comparatively pronated foot posture [12,14].

The navicular drop test (NDT) has been broadly used as a clinical method to estimate foot mobility. It has also been correlated to lower limb musculoskeletal injuries. Besides, it aided to estimate the amount of foot mobility, particularly pronation in athletes [15].

The Lower Quarter Y-Balance Test (YBT-LQ) is a screening instrument that measures single-leg balance and reaches distances in 3 directions: anterior, posteromedial (PM), and posterolateral(PL). The YBT-LQ was modified from the Star Excursion Balance Test (SEBT) [13,16].

Malik Manoj et al, 2018 studied navicular Drop Gender Differences among College Students in which the correlation of Right ND with left ND and age was significant, but no significant correlation was found between RND and height, weight, foot length and BMI [17]. Mohan Ganesan et al, 2018 found in their study that the individuals with high BMI have impaired dynamic balance control in AP direction reflected through higher COP amplitude and velocity. The COP changes during the double limb stance are unimpaired, both with eyes

opened and closed [18]. There are several studies which suggest that there is a correlation between increasing BMI and dynamic balance as it modifies body geometry and influences the biomechanics of weight-bearing areas of the foot [14,19].

Increase body mass may be a factor resulting in increased static and dynamic plantar pressures, which may cause significant change to the structures of the feet. Also, long-term body mass increase may appear to flatten the medial longitudinal arch of the subject which may change the line of gravity and action of forces on the foot in contact with the ground. Obesity thus may show influence over foot biomechanics and gait pattern [2,16]. However, there has been a significant lag in researches demonstrating a correlation of increased BMI on dynamic balance with individuals with flexible flat feet.

Parvez (2018) stated prevalence of flatfoot in normal working individuals in India according to the age. They stated the prevalence in subjects between 20 – 29 years to be 31.8%, 30 – 39 years to be 42%, 40 – 49 % to be 37.5% and above 50 years to be 37.5% flatfoot. According to gender, the flatfeet were found to have higher incidences in females[20]. Dare NW (2012) analysed prevalence of flatfoot in 510 adults (235 males and 275 females) aged 33±15 years of Bayelsia – Nigeria and they found it to be in 25.3% adults(20.4% in males and 29.5% in females) and incidence of flatfoot was found to be 1:4[21].

The study aims to study the correlation of BMI with the dynamic balance on Y-balanced test in adults with flexible flat foot.

The objectives include- Assessment of dynamic balance using Y-balanced test in normal, overweight and obese adults with flexible flat foot and correlation between the Y Balance score and the groups (Normal to Overweight, Normal to Obese, Overweight to Obese).

Methodology

Study design: An analytical correlation study

Study setting: The study will be carried out at Ravi Nair Physiotherapy College under the Datta Meghe Institute of Medical Sciences University. Permission and approval to carry out the research work shall be obtained from the Head of Institution and Institutional Ethical Committee.

Study duration: The duration of the research study will be three years.

Sampling method: Purposive sampling will be done for the study.

Sample size:

The sample size was estimated out as 255 using n Master version-2 Software based on the pilot study done on 50 subjects having 25 in each group with the following assumptions:

SD in Y Balance Test = 6.97

Mean score of Y Balance Test of flatfeet = 85.61

Relative precision (%) = 1

Desired confidence level (1- α) % = 95

Formula – $n = Z_{1-\alpha/2} \times \alpha^2 / \epsilon^2 \mu^2$

where,

α – Standard deviation

€ - Relative precision

μ - mean

1- α/2 - desired confidence level

Materials:

The study requires weighing machine, stadiometer, marker pen, measuring scale-10 cm scale, chalk, measuring tape and Y Balance kit. Half circle Goniometer, chair , plinth, white card

Eligibility criteria:

The inclusion criteria will comprise adults with age group 20-50 years[22], flexible flat feet according to navicular drop test (Navicular Drop> 10mm)[23], Medial longitudinal arch angle (MLAA) less than 130°, and BMI classification as normal, overweight and obese [5,6]. The exclusion criteria comprise the subjects with unstable/ postoperative ankle joint, Congenital deformities of the foot, Contracture (ankle joint), Pediatric and Geriatric

age group, and subjects with sensory, vascular and neurological problems. Selection of participants after diagnosing as per the BMI classification as normal weight, overweight and obese with Flexible flat foot diagnosed by the Navicular drop test and MLAA.

Recruitment and procedure:

The orthopaedics and health care practitioners working under DMIMSU are invited to refer the prospective patients to our out-patient department (OPD). The individuals fulfilling the inclusion criteria will be included in the study. Purposive sampling will be adapted for the selection of participants until the desired sample size is achieved. The similar criteria study on the effect of BMI (normal, overweight, obese) on Dynamic balance in individuals with flexible flat foot is referred. Written informed consent will be taken from the participants, explaining the study procedures, possible benefits of the study, the right to withdraw from the study and confidentiality in detail, in a language they understand. The pre-participation evaluation form will consist of a personal database, history, chief complaints and duration from the onset of symptoms.

Outcome measures:

1. Primary outcome measure: Y Balance Test is the primary outcome measure, in which the subjects will be asked to keep their non-testing leg in the centre of the grid, and reach in all three directions (anterior, posteromedial and posterolateral) by the great toe of the testing leg as much as he can. The primary investigators will record the distance covered by the subjects in all three directions. The subject will repeat the same procedure using the other leg.

2. Secondary outcome measures: The secondary outcome measures include body mass index (BMI), Sit to stand Navicular drop test (SSNDT), Lower limb length measurement, and Medial Longitudinal Arch Angle (MLAA). BMI is calculated as the bodyweight divided by the square of the height (kg/m2) for each individual. BMI will be classified as normal, overweight, and obese [24]. The SSNDT is useful to diagnose flatfeet. It will be calculated by the difference between the height of navicular from the floor when the subtalar joint is neutral in non-weight bearing (sitting position) and the height of navicular from the floor when in relaxed stance in a full weight-bearing position. The distance of 6-9 mm is considered normal, while less than 6 mm falls under flatfeet criteria [16,25]. Lower limb length measurement is performed in the supine position. Measuring tape will measure the distance between the anterior superior iliac spine and ipsilateral medial malleolus [25]. The MLAA is measured using a goniometer. The centre of the goniometer is placed at the navicular tuberosity, and the ends of the goniometer follow the landmarks on the centre of the medial malleolus and the head of the first metatarsal. The angle between the line from the medial malleolus to the navicular tuberosity and the line connecting the head of the first metatarsal bone and the navicular tuberosity will be measured in degrees. MLAA less than 131º is considered low arch foot.

Statistical Analysis and Data Collection And Management:

Statistical Analysis

The categorical variables will be expressed in frequency and percentages. Continuous variables will be presented in mean ± SD. The categorical variable will be compared by performing the chi-square test. The mean score of the Y Balance Test in different categories of BMI will be compared by performing one way ANOVA test. The mean score of the Y Balance Test between 2 groups in each category of BMI will be compared by Bonferroni t-test. Statistical significance will be set at $p< 0.05$. Data analysis will be done using statistical software STATA version 14.0.

Data Collection And Management

The principal investigators will collect and record Y Balance test score data, and enter in the pre-established spreadsheet for statistical analysis. The collected data will be entered into Microsoft Excel spreadsheet. Testing data will be put into a secure REDCap database. The non-electronic data, such as hard copies of assessment forms, signed consent forms, etc. will be stored securely in the study setting. Electronic data will be stored in DMIMSU's electronic repository as per participant ID. The administrator access rights will lie with the principal investigators (PI). PIs will supervise data collection and documentation. The documentation will be evaluated thoroughly for accuracy. The Excel spreadsheet will be released at the end of the study to an allocation blinded

statistician for conducting the necessary analysis. Checklists are used to prevent missing data due to the improper staff procedure.

Discussion

The study will benefit the subjects with increased BMI along with flexible flat feet to improve their dynamic balance and will prevent the risk of fall and injuries in future. J A do Nascimento et al, 2017 demonstrated that obese subjects exhibited postural alterations, such as head protrusion (47.6%), hyperkyphosis (46.7%) and hyperlordosis (26.7%) [11]. Besides, medial-lateral dynamic displacement, mean time to perform the limits of stability test and timed up and go test (TUGT), and the risk of falls were higher in obese subjects. In a study, Ashwini Chougala et al (2015) witnessed a significant relationship between obesity and flatfoot with a great predominance of flatfoot with high BMI [2]. Dong-Chul Moon et al 2014 demonstrated that short-foot exercise spontaneously raised the dynamic balance in individuals with remarkably pronated feet. The results of the study conducted by Karen P. Cote et al (2005) suggested that postural stability is affected by foot type under both static and dynamic conditions. Shyamala Shree et al(2018) conducted a study on health sciences and nursing students, which demonstrated an overall prevalence of flat foot among obese subjects as 44% [26]. Hannah C. Ded Porto et al, 2012 in their study observed significant biomechanical effects of obesity during conditions of static balance, perturbed balance and dynamic balance during gait [22]. Ajit Dabholkar et al 2012 in their Cross-sectional study compared Dynamic Balance Between Flat Feet and Normal Individuals using Star Excursion Balance Test to find extremely significant mean differences in sit to stand navicular drop test, calcaneum angle, width of the foot, great toe extension range of motion and SEBT was found in individuals with flat feet [27].

Sami S. Al Abdulwahab et al concluded from his study that an overweight BMI influences foot posture alignment and body stability and, BMI should be considered during rehabilitation management for lower extremity injuries and body balance [5]. If we found a positive correlation of dynamic balance with the flexible flat foot so the subjects will be advised to decrease the weight and improve the foot condition (flexible flat foot) by advising foot exercises and shoe modification.

Ethical Approval and Dissemination:

The protocol is designed as per the Declaration of Helsinki. The main findings of the study will be published in a peer-reviewed journal. The subjects participating in the study can access the main findings of the study. The data will be stored in the DMIMSU data repository after the completion of the study a minimum of 5 years, and the results are published.

Patient Consent: Principal Investigators will obtain the informed consent from the patient and one of the relatives on a printed form with signatures and give the proof of confidentiality.

Author's Contribution: SMB and WMN led to the creation and design of the study. SMB wrote the manuscript of this article. SMB and WMN read and approved the final manuscript for publication.

Declaration Of Interests: The authors declare no conflicting interest.

Funding: No direct support will be taken for funding this research from any public and private organizations. The Department of Physiotherapy under Datta Meghe Institute Of Medical Sciences, Deemed to be University, will provide the necessary material for the research.

Conflict of Interest: The authors declare no conflict of interest.

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