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Relationship between the mobility of medial longitudinal arch and postural control

Tansu Birinci [a,*], Sule Badıllı Demirbas [b]

[a] Istanbul Medeniyet University, Istanbul, Turkey
[b] Yeditepe University, Istanbul, Turkey

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ABSTRACT

Objective: The aim of this study was to analyze the relationship between the medial longitudinal arch mobility and static and dynamic balance.
Methods: A total of 50 subjects (25 female, and 25 male; Mean age: 22.2 ± 1.3 years; BMI: 22.8 ± 3.8 kg/m^2) were included in this study. The relative arch deformity (RAD) was calculated with both 10% and 90% weight bearing (WB). Static balance was evaluated with Single Leg Stance Test and dynamic balance with TechnoBody PK 200WL computerized balance device. Subjects were evaluated for goniometric measurements of lower extremity joints, leg dominance and leg-length discrepancy.
Results: Bipedal dynamic balance was correlated with both feet length at 10% WB and 90% WB. There was a correlation between the dynamic balance on dominant foot and RAD value on the aspect of Medium Speed ($r = -0.32$, $p = 0.02$), Perimeter Length ($r = -0.32$, $p = 0.02$) and Anterior–Posterior Sway ($r = 0.36$, $p = 0.01$). Static balance was unaffected by RAD value when the visual system was eliminated.
Conclusion: Our results suggest that decrease of arch mobility on the dominant foot is associated with posterior sway by causing knee or hip strategy and preventing ankle strategy even in small perturbations. The rate of deviation from the equilibrium point and the degree of total swaying increase when arch mobility decreases.

The foot and ankle is the most distal segment of the human body. It has complex structure and plays an important role in interacting body with the ground in upright posture.[1] The multiple bones of the foot form arches to serve the functions of both stability and flexibility; to contribute to the propulsive mechanism of gait; to support the body weight distribution; to generate energy and to protect the articular surfaces of the feet, ankles and knees. Medial Longitudinal Arch (MLA), consisted by the first metatarsal, the medial cuneiform, the navicular, the calcaneus and the talus, is arguably the most important arch of the foot.[2,3] Height of the MLA is measured with several methods to categorize the foot structure as planus (low arch), rectus (normal arch) and cavus (high arch). Most of these methods try to quantify the arch but some methods are based on observation.[4–6]

The MLA mobility is assessed with using dorsal arch height to calculate relative arch deformation while weight bearing and non-weight bearing stance conditions.[7,8] Such measurements, particularly arch height, have also been associated with the development of lower extremity overuse injuries.[9–11] Actually, quantifying the MLA height is a part of the arch mobility assessment. However, arch mobility has received less attention in the literature. Assuming that an individual with a high arch foot posture would have decreased foot mobility is intuitive and the opposite may not be true for an individual with a low arch foot posture. For example, the individual with a low arch foot posture could indeed exhibit increased foot mobility or have actually decreased mobility as in the case of a rigid pes planus foot deformity.[12]

Considering the fact that the foot is primary shock absorbing structure and provides base of support for muscles and joints of lower extremity chain, biomechanical alterations of the foot may influence postural control strategies. Joint coupling or coordination

* Corresponding author.
E-mail address: tansubirinci@hotmail.com (T. Birinci).
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is influenced by arch mobility. Changes in intersegment coordination can result in the need for compensation.[13] Further, there is some evidence confirming an association between altered postural stability and structure of MLA. Chang et al[14] indicated that alterations of the foot arch impact on both static standing and dynamic athletic activities, in contrast, Cote and associates[15] suggested that foot type has effect on static balance minimally but, its structural abnormalities alter stability limits during dynamic activities. Although the arch structure has received much attention, there has been little focus on the relationship between mobility of the medial longitudinal arch and postural control. Therefore, two purposes of this study were: (1) to identify whether altered dynamic and static balance are related to the mobility of the MLA (2) to examine how MLA mobility changes with gender and anthropometric features. It was hypothesized that the mobility of the MLA has impact on both dynamic and static balance and also women would have flexible arches as compared to men.

Patients and methods

This study was conducted in Yeditepe University during November 2014–January 2015. Fifty subjects were participated in this study after all of them were asked to read and sign an informed consent form, which had been approved by the ethical committee at Istanbul Medipol University Non-interventional Clinical Researches Ethics Committee (Approval Number: 249). Subjects with any musculoskeletal injury of lower extremity history or falling history in the six months before the study, cold or flu at the time of the study, using any drug which affects balance at the time of the study, wearing prescribed foot orthotics, any neurological or specific orthopedic problem, limited range of motion in the lower extremity joints or Body Mass Index (BMI) higher than 30 kg/cm^2 were excluded from the study. Subjects included in the study were aged between 18 and 35 years and without any communication problem. A questionnaire was used to assess socio-demographic information (age, weight, height, chronic diseases, injury of the lower extremities, regular medication).

Subjects were evaluated bilaterally for goniometric measurements of the hip, knee and ankle by using basic goniometer to exclude if there is any limited motion in the lower extremity joints.[16] The leg used to kick a ball was accepted as the dominant side.[17] Leg length measurements included direct measurement of each limb, measuring from the top of the anterior superior iliac spine to the medial malleolus on standing position.[18]

Foot measurements were taken in 2 stance conditions: 10% of weight bearing (WB) and 90% of WB. Subjects were weighed on a standard scale to calculate 10% of their total weight. The foot, which will be measured, was placed on the scale and the other foot was placed on an adjoining surface. Subjects stood with their hands resting on a cane to lower their amount of weight by not leaning to either side until 10% of WB had been achieved. Bony landmarks were used to measure Foot Length (FL), Navicular Height (NH), Dorsum Height (DH), and Truncated Foot Length (TFL) with a ruler (Fig. 1). As reported in the William and McClay's study,[7] FL was measured from the most posterior portion of the calcaneus to the end of the longest toe; NH was measured from the floor to the most anterior-inferior portion of the navicular; DH was measured from the floor to the top of the foot at 50% of foot length; TFL was measured from the most posterior portion of the calcaneus to the center of the first metatarsophalangeal joint. The process was repeated for 90% of WB condition. Arch mobility was assessed with using an equation for calculating relative arch deformity (RAD) modified from that described by Nigg et al[8]

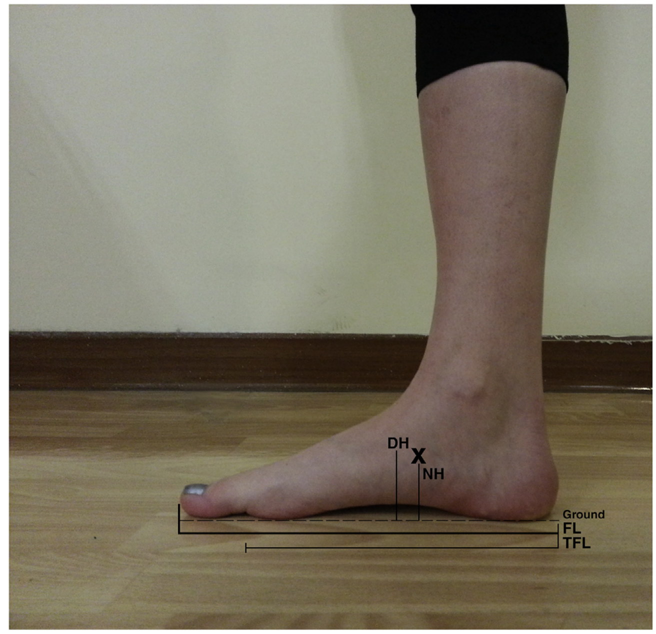

Fig. 1. Bony landmarks of foot measurements (FL; Foot Length, NH; Navicular Height, DH; Dorsum Height and TFL; Truncated Foot Length).

$$RAD = \left(\frac{AHU - AH}{AHU}\right)\frac{10^4}{BW}$$

AHU represents dorsum height at 10% of WB,
AH represents dorsum height at 90% of WB,
Body weight(BW)is expressed in Newton.

Static balance was evaluated with Single Leg Stance Test (SLST). The results with minimum error while eyes opened and eyes closed were recorded out of a total of 3 trials.[19] TechnoBody PK200WL computerized balance device was used for dynamic balance assessment.[20] The subject's barefoot was placed on the balance platform in a standardized position (the maximum point of the medial longitudinal arch was projected on the x-axis and the distance between feet was 8 cm). The test compromises trying to move in a reference circle seen on the computer screen which provides continuous visual feedback to understand the difference between what he/she was feeling on a kinaesthetic level and what is actually happening at motor level.[21] (Fig. 2). Dynamic balance on the right foot, on the left foot and on bipedal stance were tested separately for 30-s and easy mode was used. Test results included 5 parameters; Perimeter length; The total degrees came about during the test time; Area gap percentage; The percentage of the area involved in the drawn with respect to the reference circle; Medium speed; The mean number of covered degrees for a second; Medium equilibrium center-AP; The mean between the values achieved on backward–forward axis; Medium equilibrium center-ML; The mean between the values achieved on medium–lateral axis.[22] All measurements were performed by the same physiotherapist.