Journal of Bodywork & Movement Therapies xxx (2017) 1–5

Contents lists available at ScienceDirect

Journal of Bodywork & Movement Therapies

journal homepage: www.elsevier.com/jbmt

Cross-Sectional study

A comparison of foot kinetic parameters between pronated and normal foot structures during forward jump landing

Hosein Kouhzad Mohammadi [a], Mohammad Mehravar [a], Khosro Khademi Kalantari [b], Sedighe Sadat Naimi [b], Alireza Akbarzadeh Baghban [c], Farshad Okhovatian [b], Asghar Rezasoltani [b], Mohammad Ali Mohseni Bandpei [d, e], Navid Taheri [f, *]

[a] *Musculoskeletal Rehabilitation Research Center, Ahvaz Jundishapur University of Medical Sciences, Ahvaz, Iran*
[b] *Physiotherapy Research Centre, School of Rehabilitation, Shahid Beheshti University of Medical Sciences, Tehran, Iran*
[c] *Proteomics Research Center, School of Rehabilitation, Shahid Beheshti University of Medical Sciences, Tehran, Iran*
[d] *Pediatric Neurorehabilitation Research Center, Department of Physiotherapy, University of Social Welfare and Rehabilitation Sciences, Tehran, Iran*
[e] *University Institute of Physical Therapy, Faculty of Allied Health, University of Lahore, Lahore, Pakistan*
[f] *Department of Physical Therapy, Faculty of Rehabilitation Sciences, Isfahan University of Medical Sciences, Isfahan, Iran*

ARTICLE INFO

Article history:
Received 10 July 2017
Received in revised form
22 November 2017
Accepted 6 December 2017

Keywords:
Pronated foot
Lower limb kinetic
Jump landing

ABSTRACT

Background: Pronated foot is one of the most important factors that may lead to musculoskeletal injuries of the lower extremities. It is known that in a pronated foot, excessive mechanical loads are applied to the lower limb structures, which result in the altered foot biomechanics, including vertical ground reaction forces (VGRFs) and rate of loading (ROL). Therefore, the aim of this study was to determine the changes in foot kinetic parameters in the pronated compared to the normal foot structures.
Methods: In this cross-sectional study, 15 individuals (mean age of 23.27 ± 3.28 years) with asymptomatic pronated feet and 15 normal subjects (mean age of 23.40 ± 3.11 years) were recruited from both genders by using a simple non-random sampling method. VGRF, ROL, and the resultant vector of time to stabilization (RVTTS) were evaluated during the forward jump landing task by using a force plate.
Results: The findings showed that the following parameters were significantly higher in the group of pronated feet than in the normal subjects: VGRF (3.30 ± 0.17 vs. 2.81 ± 0.15, $p = .042$), ROL (0.10 ± 0.01 vs. 0.07 ± 0.006, $p = .020$), and RVTTS (2592.80 ± 141.24 vs. 2114.00 ± 154.77, $p = .030$).
Conclusion: All the measured foot kinetic parameters were higher in the pronated foot subjects than in the normal participants. An impaired movement control and greater forces imposed on the foot region of the pronated foot, compared to the normal foot individuals, were discovered indicating the former group's possible increase of susceptibility to various musculoskeletal injuries.

1. Background

The medial longitudinal arch (MLA) is an important structure of the foot with critical roles in shock absorption and attenuation the forces transferred to the body (Fiolkowski et al., 2003). Therefore, any changes in MLA make individuals more prone to a number of physical injuries (Razeghi and Batt, 2002).

Excessive pronation is a disorder that is resulted by an alteration in the MLA (Cote et al., 2005). This disorder determines with flat MLA and hypermobile midfoot which enforce greater neuromuscular demand for foot stabilization and maintaining upright posture (Cote et al., 2005).

Bone structures, ligamentous supports, and intrinsic and extrinsic foot muscles support the MLA and control foot pronation during walking. Any disturbance in the function of these structures would cause excessive pronation and consequently overuse injuries may result (Headlee et al., 2008).

Theoretically, excessive pronation caused by a general hypermobility of foot joints and the unlocked state of these joints reduce proprioceptive afferents and impair postural control (Tsai et al., 2006). Furthermore, following the higher neuromuscular demand to stabilize the body and maintain the upright posture (Hertel et al., 2002), the postural adjustment can be assigned to the proximal

* Corresponding author. Department of Physical Therapy, Faculty of Rehabilitation Sciences, Isfahan University of Medical sciences, 8175945315, Isfahan, IR Iran.
E-mail address: navidtah@yahoo.com (N. Taheri).

https://doi.org/10.1016/j.jbmt.2017.12.006
1360-8592/

Please cite this article in press as: Mohammadi, H.K., et al., A comparison of foot kinetic parameters between pronated and normal foot structures during forward jump landing, Journal of Bodywork & Movement Therapies (2017), https://doi.org/10.1016/j.jbmt.2017.12.006

joints (hip and knee) of the leg (Cote et al., 2005).

Landing after a jump is a high risk mechanism, exerting forces that can reach values several times larger than the person's weight, depending on the landing technique, which can potentially cause structural injuries (Hargrave et al., 2003; Dufek and Bates, 1991). Most athletes perform jump landing tasks during their sports activities, and since a high percentage (about 70%) of lower extremity injuries occur during sports activities, that led us to hypothesize a high correlation between forces exerted by landing and such injuries (Dufek and Bates, 1991).

The ground reaction force (GRF) created during landing, which is determined mainly by the jump height, can increase the risk of lower extremity injury by imposing joint stress (Arampatzis et al., 2003; Yeow et al., 2009).

Rate of loading (ROL) is the level of stress imposed on various tissues of lower extremities during landing. A high ROL suggests a poor shock attenuation mechanism and high stress on lower extremities over a short period of time (Hargrave et al., 2003). While loading on the lower extremities during sports activities can enhance their biological resistance, excessive increase in ROL may multiply the risk of micro- and macro-degeneration in the anatomical structures of the lower limbs (Nigg and Bobbert, 1990). The exertion of high impact forces can in fact cause injury and decreased performance (Nigg, 1985). Meanwhile, despite the absence of an established relationship between the magnitude and ROL, the damaging force has been proved to be depended on both (Nigg, 1985).

Time to stability (TTS) is the required time to minimize the GRF at frontal and sagittal planes following a jump landing task. It is an objective method of postural control assessment and a reflector of motor control which depends on not only proprioceptive feedback and preprogrammed muscular patterns, but also muscle reflexes and voluntary responses (Wikstrom et al., 2005). Although anterior/posterior and medial/lateral TTS (APTTS, MLTTS) are usually reported independently, resultant vector TTS (RVTTS) obtains a more general measure of stability.

Few studies have compared kinetic parameters in the pronated foot and normal individuals, during jump landing tasks. Chang et al. (2012) and Choi et al. (2012) reported greater vertical GRF (VGRF) in pronated foot people than in normal individuals. In contrast, Hargrave et al. (2003) and Abasi et al. (2008) did not detect a significant difference in VGRF between pronated foot and normal subjects. In addition, while Choi et al. found higher ROL in pronated foot participants (Choi et al., 2012), Abasi et al. suggested pronated foot to be associated with lower ROL as compared to normal people (Abasi et al., 2008). Nevertheless, Hargrave et al. did not observe a significant difference in ROL between pronated foot and normal individuals (Hargrave et al., 2003). Meanwhile, to the best of our knowledge, no published study has compared TTS, between the two groups.

2. Objectives

Previous research has mainly used one method to confirm pronated foot; in addition, lack of application of tasks with greater perturbations, such as forward jump landing which imposes higher stress in the neuromuscular system, may be another reason for disagreements between previous studies. Regarding contradictory results of previous studies regarding the kinetic parameters of pronated foot compared to normal individuals, the present study aimed to compare kinetic parameters (VGRF, ROL, and RVTTS) in lower extremities of pronated foot and normal individuals, confirmed with MLA and rearfoot to leg (RL) angle methods, during a forward jump landing task.

3. Materials and methods

3.1. Participants

In this cross-sectional study, 30 individuals (15 pronated and 15 normal foot subjects) were recruited according to the inclusion and exclusion criteria. Theses 30 individuals were selected out of 92 volunteers visited following an announcement on the university campus. Inclusion criteria were age between 20 and 30 years old and body mass index (BMI) between 22 and 25 kg/m^2. Individuals with professional athletic activities, scoliosis, discopathy, low back pain and deformities in the knees, history of orthopedic and neurological disorders in the past six months, and the use of any substances that affect postural control in the 48 h prior to tests were excluded from the study.

Different foot structures were determined based on the MLA and RL angles. The MLA angle was considered as less than 134° in pronated and 134–150° in normal foot. Moreover, RL angle was considered as more than 9° in pronated and 3–9° in normal feet.

The study protocol was approved by the Ethics Committee of Ahvaz Jundishapur University of Medical Sciences (Ahvaz, Iran).

All subjects were given written information about the purposes of the study and if they agreed to participate they were asked to sign a consent form. Subjects were also informed that there was no harm in this study and they are free to leave the study at any time.

3.2. Sampling method

The participants were selected from students at the Ahvaz Jundishapur University of Medical Sciences through simple, non-random sampling method. After testing 10 individuals in each group, the sample size was calculated at a 5% level of significance and with a power of 80%, which led to a sample size of at least 15 individuals in each group.

3.3. Data collection

In this study, all measurements were taken by the single investigator and the intra-tester reliability of the procedures for measuring the MLA and RL angles and kinetic parameters were investigated during a pilot study on 10 subjects through two sessions included 3 trials.

MLA and RL angles were measured for dominant foot of each subject. The dominant leg of subjects were determined by dominant leg questionnaire (Mcclay, 2000). The subjects were instructed to relaxed standing on both feet while the distance between two ankle joint centers and the distance between both anterior superior iliac spines was equal. MLA angle is a result of coincidence two lines that connecting the medial malleolus and medial aspect of the first metatarsal head to the navicular tuberosity. Coincidence of the longitudinal bisecting line of the calcaneus and the longitudinal bisecting line of the distal one third of the leg makes an acute angle called RL. If RL angle was more than 9° and MLA angle was less than 134°, the foot is classified as a pronated one. If the RL angle was 3–9° and MLA angle was 134–150° the foot is classified as a normal one (Jonson and Gross, 1997).

The subjects were asked to stand barefoot (Gross and Foxworth, 2003) and cross their hands on their chests. They were then asked to perform 3 double-leg forward jumps using 60% of their maximum efforts with a single leg landing, which had been previously measured and marked on the ground within 3-min intervals. For the determination of their maximum efforts, the subjects were asked to jump forward as far as possible, while maintaining their balances regardless of their jump heights. This way, they only focused on the forward distance. They were