Original Article

The correlation between mechanical low back pain and foot overpronation in patients referred to Hazrat Rasool Hospital

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Abstract

Introduction:
Based on Janda's theory of kinetic chain, dysfunction in one motor segment can affect other segments in the body. The purpose of the study was to determine the correlation between low back pain (LBP) and foot overpronation in patients presenting to Hazrat Rasool Hospital.

Materials and Methods:
In this case control study, 242 subjects were classified into two groups of LBP and healthy. The duration and intensity of LBP, flexibility of trunk, foot overpronation (by Helbing sign and Navicular Drop test) and ankle dorsiflexion range were evaluated. The independent sample t-test and Chi-square test were used for statistical analysis of the data.

Results:
A significant correlation between was observed between foot overpronation and LBP (p=0.001). There were significant relationships between LBP intensity and foot overpronation (p=0.001), between the history of LBP and foot overpronation (p=0.001) and also between foot overpronation and ankle dorsiflexion range (p=0.014).

Conclusion:
The findings of this study indicate significant relationships between the incidence, intensity and duration of LBP in patients with foot overpronation. Furthermore, ankle dorsiflexion range was reduced in the subjects with foot overpronation.

Keywords: Flat Foot, Longitudinal Arc, Navicular, Low Back Pain

Introduction

Low back pain (LBP) is one of the most common disorders of the musculoskeletal system, leading to impaired function and decreased quality of life in many patients. In addition, the disease incurs heavy economic costs on the patients and society. Therefore, many studies have been conducted on the risk factors, prevention and treatment of LBP (1). Unfortunately, LBP has also affected the young population and its prevalence is increasing among children and adolescents.

LBP is the second cause of disability in adults and their visits to the doctor in the

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United States. About 56%, 34%, and 14% of the Americans are hospitalized because of back pain for one day, six days, and one month per year, respectively. Statistics show that there are 149 million working days lost due to LBP in the US that result in 200 million dollars of financial loss (2, 3). LBP is one of the leading causes of absence from work in the UK. About 17.3 million people have LBP in the UK, of whom 3 million suffered LBP for more than a year (4). There are no accurate statistics on the incidence of LBP in Iran. The studies in terms of developing LBP in Iran were cross-sectional on small communities such as employees, workers or pregnant women. A study on the relationship between LBP and physical activity in one of the universities in Iran showed a prevalence of 86.3% (5). Another study on nurses in Isfahan showed that 55.% of nurses had LBP (6).

Attention to the numerous causes of LBP plays an important role in the recovery process (7). Causes of LBP can be classified into mechanical, visceral, inflammatory, infectious, tumors, neuropsychological, and rheumatic diseases (8, 9). Mechanical LBP is the most common type of LBP (97%) in which tissues such as bones, muscles, tendons, ligaments, intervertebral discs, joints, and nerves are damaged (10). Some causes of mechanical LBP are sudden and intense movements, spine trauma, postural and biomechanical disorders of the spine, biomechanical disorders of the lower extremities, weak core muscles, tight back and hip muscles, lower limb length discrepancy, body weight gain, etc. (8, 9).

Biomechanical foot disorders are one of the important factors affecting the incidence of mechanical LBP. Foot overpronation is one of the most common of these disorders mentioned in various medical sources under a variety of titles such as foot hyperpronation, flatfoot, heel valgus, calcaneovalgus, etc. Foot overpronation is known with the reduction or loss of the medial longitudinal arch and is associated with reduced dorsiflexion of the ankle and other disorders such as heel valgus, mild subluxation of the subtalar joint, calcaneal eversion, and forefoot supination (11, 12). The foot has a complex structure and the normal placement of its components form the foot arch. The arch spread the body weight on the entire surface of the foot when walking. It also absorbs the forces exerted on the foot. The reaction force from the ground to the feet increases in people with a fallen plantar arch. In addition, cushioning and absorption of impact forces exerted on the foot are reduced, which can predispose patients to complications such as LBP, sacroiliac joint pain, hip pain, knee pain, etc. (12-15). Common cause of a fallen plantar arch are overweight, lack of physical activity for a long time, aging, standing occupations such as hairdressing and dentistry, heredity, calf and leg muscle weakness, leg muscle tightness, wearing inappropriate shoes for a long time, such as tight shoes, high heels and narrow shoes, fractures in the foot, etc. (12).

In terms of biomechanics, the body movement system is a set of kinetic chains working together to make up a motion. Kinetic chains are impaired due to postural disorders, poor physical conditions, repetitive patterns of movement, lack of core stability, reduced flexibility, biomechanical deformations, severe limb movements, etc. Disorders in one part or the entire kinetic chain impairs other kinetic chains of the body, too. Hence, biomechanical foot disorders such as foot overpronation affect the entire lower extremity kinetic chain system and the spine causing severe back pain in some cases (16, 17).

In a study on healthy subjects with mechanical LBP, Brantingham et al. found that a fallen medial arch is more probable in patients with LBP (18).

Babaei et al. investigated the relationship between LBP and foot disorders and found a significant relationship between increasing hallux valgus, hallux rigidus and soleus muscle tightness with chronic LBP, while they found no significant relationship between foot dimensions and LBP. However, they reported that ankle and foot problems and deformities can cause back pain due to their effects on posture, balance, and walk (19).

Unfortunately, one of the prevalent problems associated with LBP, especially in young people, is lack of physicians' attention to complete physical examination and foot examination of the patients. Medical centers mainly just prescribe painkillers and non-steroidal and steroidal anti-inflammatory drugs for patients without performing a thorough physical exam and only with questions about pain regardless of the primary cause of pain and discomfort to treat the symptoms of the patients. While in most cases, the cause of pain still exists and not paying attention to it perpetuates pain and decreases the physical function and quality of life of the patients. It is clear that accurate diagnosis of foot disorders and referring the patients to specialists and using foot orthoses and sports therapy can resolve the root cause of this type of LBP and fully treat the patient.

There are few studies and insufficient evidence about the relationship between mechanical back pain and foot overpronation in Iran. Therefore, the present study tried to investigate the relationship between mechanical back pain and foot overpronation.

Materials and Methods

This was a case-control study. The studied population consisted of two groups of patients with LBP and healthy controls (accompanying people). They were selected through convenience sampling based on inclusion and exclusion criteria, from 2015 to 2016 in the orthopedic and sports medicine clinics of Hazrat Rasool medical complex. This study was approved by the Ethics Committee of Iran University of Medical Sciences (Project No. 8721215095) and written consent was obtained from all participants. The inclusion criteria were: approved mechanical LBP by orthopedists or sports medicine professionals, aged 20-50 years, BMI of 20-25 kg/m^2, and willingness to participate in the study. The exclusion criteria were: a history of traumatic injuries in the spine and lower extremities, skeletal abnormalities in radiography tests, history of surgery on the spine and lower extremities, neuromuscular damage of the spine and lower extremities, history of rheumatoid arthritis disease, history of ligament injuries in the joints of the spine and lower extremities, history of fractures in the spine and lower extremities, history of spondylolisthesis, history of herniated disc and unfinished evaluation programs.

According to the previous study (18) and the power of 80%, the sample size was determined as 120 subjects for each group.

The demographic data of the subjects were recorded and their weight and height were measured. The subjects' weight was measured without shoes and with light clothes with 0.1 kg approximation. Their height was measured without shoes, too. The body mass index was calculated from the related equation. In addition, patients' pain intensity was measured by a Visual Analogue Scale (VAS). VAS is a kind of ruler with a length of 10 cm (Figure 1) scaled from 0 to 10 where 0 means no pain and 10 means very severe and unbearable pain. It is worth noting that the intervals between the numbers are scaled in millimeters and the subjects put the marker on the number corresponding to the intensity of pain. In addition, the patients were asked to rate their pain as numb, tingling, burning and paresthetic; and to express the duration of the pain. The two groups were asked about having exercises (regular exercise at least three times a week) and answers that were recorded as Yes or No.

The flexibility of the trunk was evaluated by the flexion motion and measuring the distance between the tip of the middle finger and the ground. The patient was asked to remove his shoes, stand up, and lean forward as much as possible and to the extent that they do not have pain. Then the distance between the middle finger and the ground was measured with a ruler and recorded in centimeters (Figure 2).

In this study, ankle dorsiflexion range of motion was evaluated on the basis of America Academy of Orthopedic Surgeons guidelines. In this regard, the patients lied prone on the bed and bend their knee to 90 degrees. The examiner put the center of goniometer on the external malleolus so that the fixed axis of the goniometer was along the fibula bone and the moving axis was along the fifth metatarsal bone. The patient was asked to perform the active dorsiflexion motion. The angle of the motion was recorded in degrees (20). The normal dorsiflexion range is 10 to 20 degrees.

The rear view of a flat foot indicates the curving inward of the Achilles tendon which is called the Helbing's sign. In order to confirm the flat foot diagnosis or heel valgus, the patients were asked to stand with parallel feet and the angle of Achilles tendon direction with the vertical line was measured by goniometer and recorded (Figure 3). The angle between the direction of the Achilles tendon and the vertical line is called the Helbing's angle. If it is more than 20 degrees it is a sign of heel valgus and flat foot (21).

In order to test the navicular drop, the subjects were asked to sit on a chair with bare feet and put their feet on a step so that the angle of the hip and knee is 90 degrees of flexion. In addition, during the assessment, the hip was in a neutral position without any lateral or medial rotation. Then the examiner found the navicular tuberosity, which is the outermost bony bump on the inside of the leg and marked it with a marker. Then the distance between the navicular bone jut and the surface of the stair was measured by a caliper and recorded (mm). Then the patients were asked to stand up and the distance between navicular bone jut and the surface of the stair was measured by a caliper and recorded. The difference between the distance of navicular bone and the stair in the standing (weight-bearing) and sitting (no weight) positions was considered as the navicular drop (Figure 4). It should be noted that the natural navicular drop level is 6-8 mm and amounts more than 8 mm are considered abnormal and a sign of reduced medial longitudinal arch (22, 23). Previous studies have validated the navicular drop test in the assessment of the medial arch and reported a good to excellent repeatability for it with the ICC test (0.83 to 0.95) (24-26).

Subjects with foot overpronation (flatfoot) were identified according to the abnormal amounts of Helbing's angle and navicular bone drop, and their prevalence among the study participants was determined.

In order to determine the rigid or flexible type of the medial longitudinal arch reduction, the subjects with reduced medial longitudinal arch were asked to stand up while all their feet sole was on the ground, and once again stand on their toes. If there was no medial longitudinal arch in a weight-bearing condition, but it was visible while standing on the toes, the flatfoot was of the flexible type. Obviously, the medial longitudinal arch is not visible in people with rigid flat foot even when standing on the toes.

The results were analyzed by SPSS software version 18. The measures of central tendency and dispersion of the studied variables were calculated to provide descriptive statistics. At the beginning of the statistical analysis, the demographic variables of participants in both groups were analyzed by the parametric independent t-test. Lack of significant differences in the variables indicated the homogeneity of the study participants in both groups (except in the case of the LBP variable). Since the Kolmogorov-Smironov test suggested the normality of the data, the parametric independent t-test was used for comparing the variables between the two groups. The α level in this study was considered as 0.05 with a power of 80%. The chi square test was used to find the relationships between variables.

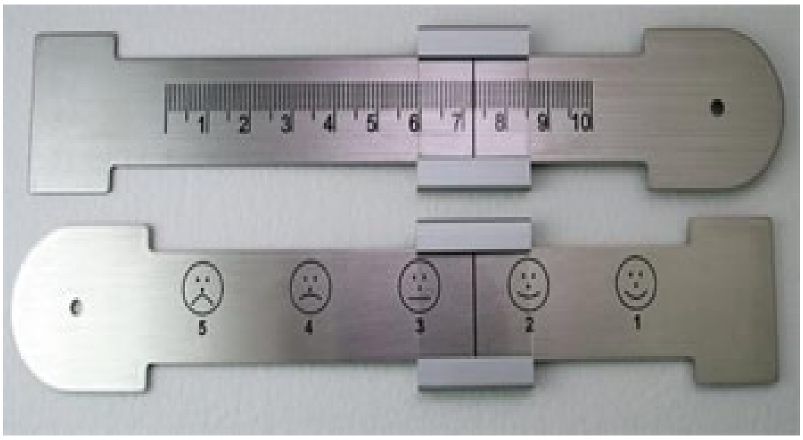

Figure 1

Figure 2

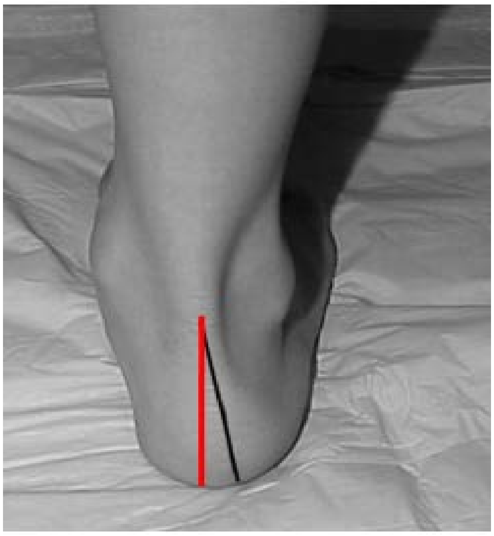

Figure 3

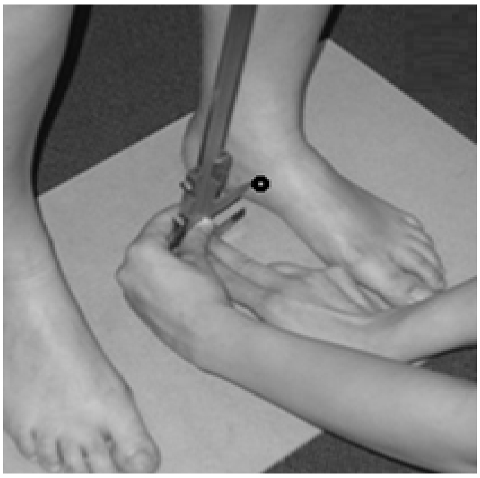

Figure 4

Results

The results of the independent t-test showed that the study groups were homogeneous with respect to age, height, weight and body mass index (Table 1). Regarding gender distribution between groups, there were 64 males and 57 females in the LBP group, and 62 males and 59 females in the control group.

The history of LBP in the patients' group was 4.27±1.91 years and the mean pain intensity was 4.75±1.121 on the 0-10 basis. The type of pain in patients with LBP was, burning (35.5), tingling (19), paresthetic (13.5), and numb (30).

The Helbing's angle and the amount of navicular bone drop were significantly different between the patients with LBP and the healthy controls (P=0.001 and P=0.003). The amount of navicular bone drop and Helbing's angle was higher in patients with mechanical LBP (Table 2). The amount of physical activity in the LBP and the control groups was 35.5% and 49.6#, respectively. The difference was statistically significant (P=0.027) (Table 3). It is worth noting that regarding the incidence of LBP, the Odd Ratio was 0.5650 (confidence interval of 0.9384-0.3348) which indicates a moderate correlation between the incidence of LBP with physical activity.

As Table 4 shows, 8.26% of the control group and 29.75% of the LBP group had flatfoot or foot overpronation. The independent t-test showed a statistically significant difference between the two groups (P=0.001). In the LBP group, 8 patients had rigid flatfoot 28 had a flexible flatfoot. There were 10 cases of flatfoot in the control group of which 3 had rigid flatfoot and 7 had flexible flatfoot, which indicates more prevalence of the flexible flatfoot.

The chi-square test showed no significant relationship between the flexibility of the trunk (the distance between the tip of the middle finger and the ground) and flatfoot (P=0.087), while there was a significant relationship between back pain intensity and flatfoot (P=0.001). There was also a significant relationship between the history of back pain and flat foot (P=0.001). In addition, based on the chi-square test, the relationship between flatfoot and ankle dorsiflexion range of motion was significant (P=0.014). In other words, the ankle dorsiflexion range of motion was significantly lower in subjects with flatfoot.

Table 1: Mean and SD of demographic variables in the study groups

Groups / Demographic variables	Patients with LBP		Healthy controls		P-value
	Mean	SD	Mean	SD	
Age (years)	36.44	8.83	36.06	8.35	0.096
Weight (kg)	75.84	8.28	74.71	7.683	0.092
Height (cm)	170.82	9.394	167.95	10.29	0.089
BMI (Kg/m^2)	23.80	1.39	23.11	1.08	0.097

Table 2: Mean and SD in variables of the distance of the middle toe to the ground, ankle dorsiflexion range of motion, Helbing's angle, and navicular bone drop in the studied groups

Variables	Patients with LBP		Healthy controls		P-value
	Mean	SD	Mean	SD	
Are the tip of the middle finger to the ground (cm)	9.04	1.63	9.37	1.67	0.230
Ankle dorsiflexion range (degrees)	14.56	1.27	14.71	2.31	0.072
Helbing's angle (degrees)	24.55	3.25	18.65	2.81	0.001
navicular bone drop (mm)	12.14	1.09	7.78	2.10	0.003

Table 3: Comparison of physical activity in the studied groups

Variable	Patients with LBP	Healthy controls	P-value
Having physical activity	43 (35.5%)	60 (49.6%)	0.027
Lack of physical activity	78 (64.5%)	61 (50.4%)	

Table 4: Comparison of flat foot in the studied groups

Variable	Patients with LBP	Healthy controls	P-value
Flat foot	36 (29.75%)	10 (8.26%)	0.002
Natural foot	85 (70.25%)	111 (91.74%)	

Discussion

The main purpose of this study was to investigate the relationship between mechanical back pain and flatfoot or foot overpronation in patients with LBP referred to the Hazrat Rasool Hospital medical complex in Tehran, Iran. The most important finding of this study was that 8.26% of the control group and 29.75% of the patients with mechanical LBP had flatfoot, indicating a statistically significant difference.

Babaei et al. found a significant relationship between hallux valgus angle increase, hallux rigidus and soleus muscle tightness with chronic LBP. Although they did not examine foot pronation, their results are somewhat consistent with the present study suggesting that the kinetic chain disorders in the footsole have affected the lumbar spine and caused chronic mechanical LBP.

In a retrospective study, Kosashvili et al. (2008) examined 97,279 people of whom 16% had flatfoot. The frequency of LBP in the group without flatfoot was 5%, while it was 10% in those with flatfoot. The difference was statistically significant. It is in line with the present study. This study also showed the increasing prevalence of flexible flatfoot in patients with LBP compared to rigid flatfoot, which was similar to the Kosashvili results (14).

Contrary to the findings of this study, an analytic study by Menez et al. on 1930 people in the US in 2013 found no relationship between the foot conditions and musculoskeletal pain, especially back pain.

The kinetic chain theory of Professor Yanda must be considered in the relationship between foot overpronation and lower back mechanical pain. According to this theory, a disorder in one limb can affect other limbs and joints in the body. Joints away from the area affected by structural or functional disorder usually compensate for the disorder and therefore interfere with the normal pattern of weight bearing and inappropriate distribution of pressure, and chronic damages especially in the musculoskeletal tissues. The structure and function of the ankle and foot when absorbing force and applying pressure have a large influence on the upper parts of the lower extremities and the trunk. Naturally, the foot is the first limb that strikes the ground and while reducing the ground reaction force, prevents the transmission of a lot of the pressure on the rest of the kinetic chain. The pronation motions of the subtalar and mid tarsal joint in three axes when the foot touches the ground supports the femur and tibia against the force by changing the rotational torque. The support protects the lower extremities from damage. However, in the case of a flat foot, the effective performance of foot in meeting these requirements is greatly distorted due to changes in the structure and the arch of the foot (27).

In this study, there was no relationship between the trunk and flatfoot flexibility in LBP group, but back pain intensity was considerably and significantly higher in patients with flatfoot. The history of mechanical LBP was significantly higher in patients with flat foot. Moreover, the ankle dorsiflexion range of motion has significantly reduced in patients with flat foot, which might be due to foot sole deformation and reduced flexibility of soft tissues, especially the abnormal position of the Achilles tendon and its rigidity. Naturally, foot range of motion was not reduced in people with LBP and without flat foot. On the other hand, decreased ankle dorsiflexion is a factor that causes mechanical LBP. This was in line with the Brantingham (28). It appears that foot overpronation which leads to decrease or fall of the medial longitudinal arch and reduced ankle dorsiflexion ratio leads to the collapse of the medial longitudinal arch. The foot arches, especially the medial longitudinal arch, create a reactionary effect in the foot and have an important role in absorbing shocks when the foot touches the ground. In people with flat foot, during walking and when taking the foot off the ground, the hindfoot remains in the pronation state and does not change to the supination state, or has a little and very delayed supination, which reduces the absorption of pressure on the foot during weight bearing. This can increase the risk of pain and pain intensity in the central parts of the musculoskeletal system. The findings of this study indicated a statistically significant relationship between flat foot and the intensity of mechanical LBP.

On the other hand, the normal function of the foot depends on the natural position of the bones, joints, ligaments and muscles. Any changes in the structure leads to abnormal functions, exerting intense forces in the joints and tissues of the lower extremities, pelvis, and spine. In this case, the foot cannot absorb the reaction forces from the ground when standing, walking, etc. These changes cause disorders in walking and other kinetic chains of the body. The kinetic chains are impaired due to causes and mechanisms such as postural disorders and improper body status, repetitive patterns of motion, reduced flexibility, fitness, biomechanical deformation, etc. A typical example is the changes in natural foot status in reduced medial arc deformity and mechanical lumbar pain (29).

Another finding of the study was the higher rate of physical activity in healthy controls compared to the LBP group. This indicates the importance of exercise in maintaining a healthy spine, increasing muscle strength and improving body status and posture. Few studies have examined the effects of physical activity on the prevention of LBP in Iran. Most of the available studies have examined the effect of sports therapy on controlling LBP. This was also emphasized in the Bell's review study (30). Vuori et al. had also similar findings and showed that physical activity is effective in the prevention of LBP, but finding the exact intensity of physical activity that would be effective in this regards needs further investigation (31).

One limitation of the study was not examining the effect of type of physical activity on the prevention of LBP. The study was limited to the presence or absence of physical activity. Another limitation of this study was not examining other relevant factors, in particular, lower extremity biomechanical disorders and changes in the soft tissues lengths with LBP. Undoubtedly, body status and posture examination in the LBP group is essential, which was another limitation of this study.

Due to the paucity of studies on the relationship between the kinetic chains in the musculoskeletal system and pain in musculoskeletal disorders, it is recommended that further studies be conducted in this area, particularly with a longitudinal structure with multicenter to complete this study and remove its defects. The examination of the relationship between other joints of the lower extremities and the tightness of foot soft tissue in patients with LBP, as well as examination of the relationship between regular physical activities and back pain can be beneficial in the prevention of spinal pain. However, it should be noted that examination of flat foot, physical activity, the distance of the tip of the middle finger, etc. variables in healthy individuals can be important in predicting LBP.

Conclusion

The results of this study suggest a relationship between the incidence, severity, and duration of LBP in patients with flatfoot. In addition, ankle dorsiflexion range of motion in patients with flatfoot or foot overpronation was lower. The results showed that regular physical activity is effective in the prevention of mechanical LBP.

Acknowledgments

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Conflict of Interest

The authors have no conflict of interest in relation to the writing and publication of this article.

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