SPORT TK-EuroAmerican Journal of Sport Sciences

https://revistas.um.es/sportk Online ISSN: 2340-8812

Received: **01/12/2021** Accepted: **24/01/2022.** Published: **05/06/2022**

# Association between unilateral functional ankle instability, limited ankle dorsiflexion range of motion and low back pain

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**ABSTRACT**

There is growing evidence that supports the correlation between incidence of ankle dysfunction and low back pain (LPB). Although the spine and ankle seem like distant regions of the body, they are functionally connected by the lower extremity kinematic chain. The aim of the current study was to investigate the association between functional ankle instability (FAI), limited ankle dorsiflexion (DF) range of motion (ROM) and (LPB). One hundred two subjects with chronic ankle sprain pain participated in this study. The mean ± SD age, weight, height, and BMI of the study group were 43.5 ± 12.96 years, 85.27 ± 14.22 kg, 172.9 ± 8.45 cm, and 28.59 ± 4.72 kg/m². LPB was measured by Visual Analogue Scale (VAS), FAI was measured by the anterior drawer test and DF ROM was measured by the lunge test. All statistical analyses were performed using the Statistical Package for Social Studies (SPSS) version 25 for Windows. There was no statistically significant association between pain and age, pain and BMI, pain, and sex ($p > 0.05$). There was a statistically significant association between pain and drawer test (odd ratio 5.68, $p = 0.02$) and a statistically significant association between pain and DF ROM (odd ratio 1.16, $p = 0.01$). The current study supported previous studies recommending FAI and limited ankle DF ROM as a factor in LPB. The authors suggest conducting similar studies with a larger number of participants and include functional measures scales or questionnaires to increase the validity and generalizability of the results.

**KEYWORDS**

Low Back Pain; Chronic Ankle Instability; Functional Ankle Instability; Lower Limb Kinetic Chain.

## 1. INTRODUCTION

Chronic instability of the ankle is attributable to either mechanical instability or functional instability or a mixture of both (Arnold et al., 2001; Tropp et al., 2002). Mechanical instability results from the anatomical changes that came up after injury such as pathological laxity, synovial changes and degeneration of articular cartilage (Fairbank et al., 1984). Recent evidence revealed that individuals with mechanically unstable ankles exhibited greater ankle displacement in the frontal plane and less displacement in the sagittal plane compared to individuals with FAI (Functional Ankle Instability) (Brantingham et al., 2006; Cholewicki et al., 2005). On the other hand, FAI is related to the neuromuscular control of the ankle and is characterized by impaired joint kinesthesia and disturbed muscle activation patterns, often described by patients as a feeling of ‘‘giving way’’ of the ankle (Rothbart et al., 1988). In patients with FAI, altered afferent input from the ankle is thought to be responsible for adaptive strategies of the whole-body nervous system, resulting in proximal joint adaptations to compensate for impaired lower limb balance (Abdelhaleem et al., 2015).

The theory of motor feed-forward control provides an explanation for the pathomechanism that occurs in FAI. It demonstrates that mechanoreceptors support the information that helps the central nervous system to control the dynamic stability of the ankle. It has been suggested that inaccurate positioning of the ankle joint prior to ground contact during walking may result to ankle sprain and chronic instability (Konradsen et al., 1997).

Ankle instability may make individuals vulnerable to developing low back pain (LBP) (Beckman et al., 1995). Ankle instability induces over load on leg and hip muscles to overcome this dysfunction in the base of support and could results in overload which in turn could be a cause of LBP (Sciascia et al., 2012). Although the spine and ankle are isolated regions, they are functionally connected through the lower limb kinematic chain which works as a transformer that transfer load between both regions.

Katoh et al. (1983) focused on ankle dysfunction as a restricted dynamic range of motion, especially at the sagittal plane and the occurrence of low back pain and concluded that any loss of mobility in the ankle or foot joints could results in abnormalities in gait, which in turn gives rise to over-activation of muscles to compensate for this gait deviation and may induces back discomfort.

To the best of our current knowledge, the literature provides limited studies on the association between LPB, FAI and limited ankle DF ROM. Thus, the association between low back pain and ankle joint dysfunction remains controversial. The current study aims to assess the association between functional ankle instability (FAI), limited ankle dorsiflexion (DF) range of motion (ROM) and low back pain (LPB). The authors hypothesize that LBP is associated with FAI and limited ankle DF ROM.

## 2. METHODS

### 2.1. Study design and participants

A cross-sectional study was carried out. One hundred two subjects refereed from an orthopedic surgeon with a diagnosis of ankle sprain and presented with functional ankle instability participated in this study. All subjects were free from any acute injury within the past 3 months. Inclusion criteria: 1. Patients with a history of at least one lateral ankle sprain which occurred at least 6 months prior to enrollment in this study. 2. Patients with a persistent feeling of giving way or instability of the ankle (Marshall et al., 2007). Exclusion criteria: 1. Patients with a history of low back pain. 2. A history of lower extremity surgeries. 3. A surgery or reconstruction on the injured or dominant limb and foot deformities (e.g., pes caves, pes planus…). All subjects were required to sign a consent form before participating in the study and had the right to withdraw from the study at any time. The current study was approved by the ethical committee of the Faculty of Physical Therapy, Cairo University.

### 2.2. Study measurements

2.2.1. Range of motion (ROM) measurement

The lunge Test (LT) was used as a valid and reliable test for measuring the ankle DF-ROM. The LT was applied according to the guidelines of Bennell et al. (1998). First, the unaffected foot was placed forward with the big toe and center of the heel on the tape measure. With both feet fixed, a controlled forward lunge was performed such that the knee flexed as the subject tried to touch it to a vertical line marked on the wall with an adhesive tape (Figure 1). During this movement, the physiotherapist maintained the foot’s alignment on the tape measure secured to the floor, observing the heel to certify contact with the floor, and paid attention to the contact of the knee with the wall. There was no control for supination or pronation.

An attempt was considered successful if the subject was able to touch the knee to the wall while maintaining the proper foot alignment and heel contact with the tape on the floor. As the knee touching the wall correctly, the participant moved the foot further from the wall and performed another forward lunge, once again attempting to touch the knee to the wall. Measurement procedures were repeated three times. Using the tape measure on the floor, this distance was recorded in centimeters to indicate a single value of DF-ROM. The whole process was then repeated with the affected limb. Readings from the affected limb was only used in the statistical analysis.

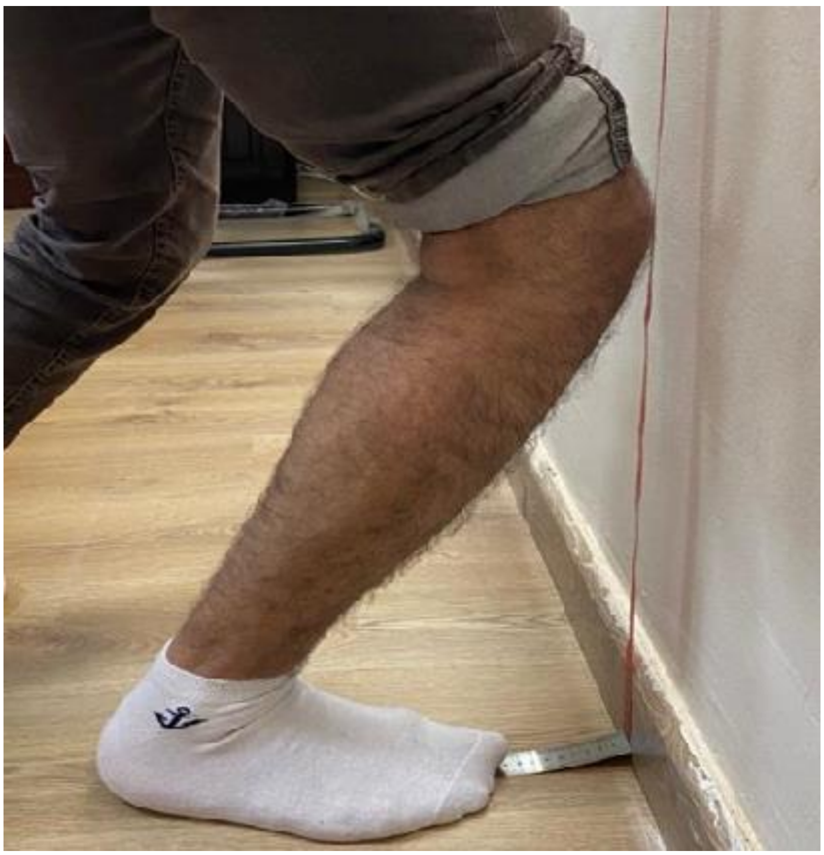

**Figure 1.** Lunge test for the affected lower limb.

2.2.2. Ankle stability test

Ankle anterior drawer test was performed to assess the stability of talocrural joint. The Croy method was used as a standard to determine ankle instability. This method graded the amount of talocrural joint anterior motion on a scale of 0 to 4, with grade 0 as hypomobile, 1 as normal, 2 as mild increased laxity, 3 as moderate increased laxity and 4 as severe increased laxity. In the first analysis, grades of 2 and above were considered “positive” for excessive laxity, whereas grades of 0 or 1 were considered “negative” or “normal” (Croy et al., 2013).

Procedure: The patient is in supine lying or sitting position with the knee flexed to relax the calf muscle and prevent the patient from resisting the examiner. One hand of the examiner stabilizes the distal tibia and fibula while the other hand holds the calcaneus maintaining the ankle in a neutral position (Fig.2). A translatory force is applied on the calcaneus pulling it anteriorly while the tibia and fibula are pushed posteriorly (Van Dijk et al., 1996).

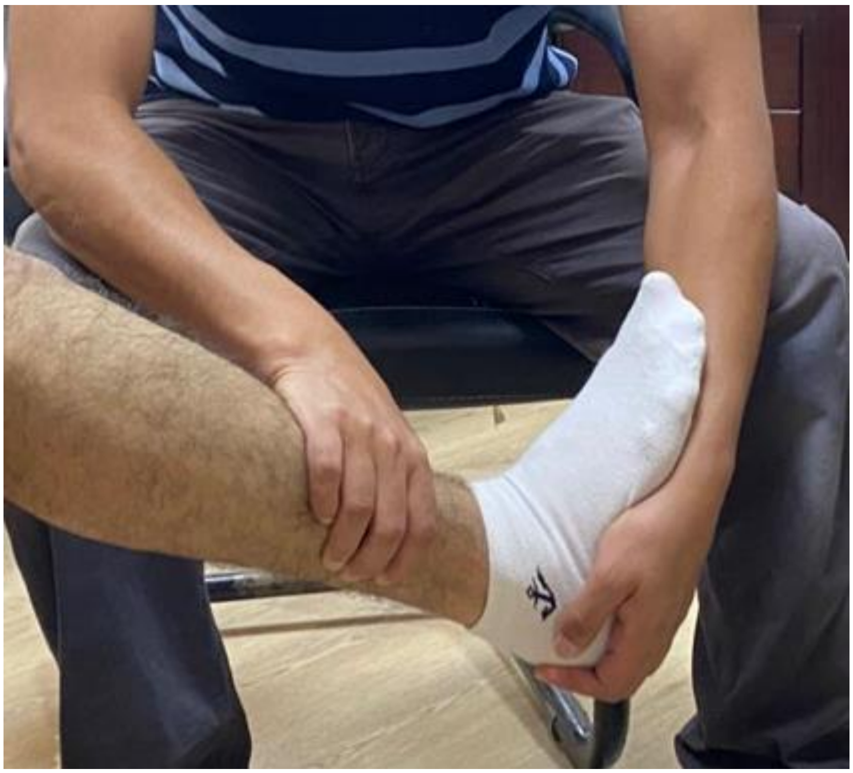

**Figure 2.** Anterior drawer test.

2.2.3. Pain intensity measurement

Low back pain intensity was measured using the Visual Analog Scale (VAS). The subjects who enrolled in the study explained the degree of their low back pain by giving one number which represents the pain intensity. The VAS consisted of numbers from zero to ten, with zero indicating no pain, and ten indicating the maximum pain.

## 2.3. Statistical analyses

Descriptive statistics such as mean, standard deviation, frequencies, percentages and confidence intervals (CI) were used to present the subjects' demographic and measured data. Quantitative variables were summarized using mean and standard deviation, while categorical variables were summarized using frequencies and percentage. Chi-square statistics (Fisher Exact test) were used to examine associations between back pain and subject characteristics. The level of significance for all statistical tests was set at $p < 0.05$. All statistical analyses were performed using the Statistical Package for Social Studies (SPSS) version 25 for Windows.

## 3. RESULTS

One hundred two patients with a diagnosis of ankle sprain pain participated in this study. The mean ± SD age, weight, height and BMI of the study group were 43.5 ± 12.96 years, 85.27 ± 14.22 kg, 172.9 ± 8.45 cm and 28.59 ± 4.72 kg/m². Overall, 20 (19.6%) participants had a positive anterior drawer test and 82 (80.4%) had a negative anterior drawer test. The mean ± SD lunge test of the study group was 8.3 ± .7 centimeters. (Table 1).

**Table 1.** Descriptive characteristics of participants

| **Variables** | **N** | **%** |
|---|---|---|
| **Age** | | |
| 20-45 years | 58 | 56.9% |
| 46- 65 years | 44 | 43.1% |
| **BMI** | | |
| Normal weight (18.5–24.9 kg/m²) | 20 | 19.6% |
| Overweight (25.0–29.9 kg/m²) | 45 | 44.1% |
| Obese (≥ 30 kg/m²) | 37 | 36.3% |
| **Sex** | | |
| Males | 51 | 50% |
| Females | 51 | 50% |
| **Anterior with drawer test** | | |
| Positive | 20 | 19.6% |
| Negative | 82 | 80.4% |

Regarding the prevalence of back pain among participants, it was 66.7% with a 95% CI of 57.06- 75.06%. Back pain occurred in 30 (58.8%) of females, 38 (74.5) of males, 18 (90%) of subjects with positive anterior drawer test and 50 (61%) of subjects with negative anterior drawer test. Back pain occurred in 16 (80%) of subjects with normal weight, 25 (55.6%) of subjects with overweight and 27 (73%) of obese subjects. Both age groups showed a high percentage of back pain, 36 (62.1%) of the subjects who were 20-45 years old and 32 (72.7%) of subjects who were 46-65 years old (Table 2).

**Table 2.** The frequency distribution of back pain and its association with the characteristics of the study subjects.

| Variables | Presence of back pain | | $\chi^2$ value | p value |
|---|---|---|---|---|
| | Yes | No | | |
| **Age** | | | | |
| 20-45 years | 36 (62.1%) | 22 (37.9%) | 1.27 | 0.25 |
| 46- 65 years | 32 (72.7%) | 12 (27.3%) | | |
| **BMI** | | | | |
| Normal weight (18.5–24.9 kg/m²) | 16 (80%) | 4 (20%) | 4.76 | 0.09 |
| Overweight (25.0–29.9 kg/m²) | 25 (55.6%) | 20 (44.4%) | | |
| Obese (≥ 30 kg/m²) | 27 (73%) | 10 (27%) | | |
| **Sex** | | | | |
| Males | 38 (74.5%) | 13 (25.5%) | 2.82 | 0.09 |
| Females | 30 (58.8%) | 21 (41.2%) | | |
| **Anterior with drawer test** | | | | |
| Positive | 18 (90%) | 2 (10%) | 6.09 | 0.01 |
| Negative | 50 (61%) | 32 (39%) | | |

*NOTE: $\chi^2$= Chi-squared test; p value = Probability value; p<0.005 = Statistically significant.*

Table 3 presents the association between pain, subject characteristics, ankle stability and DF ROM. There was no statistically significant association between pain and age, pain and BMI and pain and sex ($p > 0.05$). However, there was a statistically significant association between pain and drawer test (odd ratio 5.68, $p = 0.02$) and also a statistically significant association between pain and dorsiflexion ROM (odd ratio 1.16, $p = 0.01$) (Table 3).

**Table 3.** Predictors of back pain in ankle sprain among participants.

| Variables | Univariate analysis | | | Multivariate analysis | | |
|---|---|---|---|---|---|---|
| | Odds ratio | 95% CI | p | Odds ratio | 95% CI | p |
| **Age** | 1.008 | 0.97-1.04 | 0.63 | | | |
| **BMI** | 0.98 | 0.9-1.07 | 0.8 | | | |
| **Sex** | 2.04 | 0.88-4.74 | 0.09 | | | |
| **Anterior drawer test** | 5.76 | 1.25-26.51 | 0.02 | 5.68 | 1.19-26.97 | 0.02 |
| **Dorsiflexion ROM** | 1.16 | 1.03-1.31 | 0.01 | 1.16 | 1.03-1.31 | 0.01 |

*NOTE: CI = Confidence interval; p value = Probability value; p<0.005 = Statistically significant.*

## 4. DISCUSSION

The current study was conducted to investigate the association between FUI, which is a consequence of chronic ankle sprain and the incidence of LBP. The study also investigated the relationship between the incidence of limited ankle dorsiflexion (DF) range of motion (ROM) and the incidence of LBP. All subjects were patients who had experienced lateral ankle sprain 6 months ago and suffers from chronic ankle instability. Statistical analysis revealed no statistically significant association between LBP and age, pain and BMI, LBP and sex (p > 0.05). Simultaneously, there was a statistically significant association between LBP and positive drawer test (odd ratio 5.68, p = 0.02) and a significant association between LBP and DF ROM (odd ratio 1.16, p = 0.01).

Colin et al. (2013) hypothesized the link theory in which the lower limbs joints- ankle, knee, hip works as a link system responsible for force transmission into pelvis and spine during walking, running and jumping. Nadler et al. (1998), in his study confirmed how the lower limb joints work together to transfer forces between the lower kinetic chain and the spine. There is evidence that dysfunction in lower limb joints could lead to spinal dysfunction. One of these evidences comes from Fairbank et al. (1984) who suggested that a disruption in one part of the link system will affect or disrupt other points in the link system.

The literature has shown that previous leg injuries could be a strong indicator for developing low back pain in the future. In the biomechanical study, the isokinetic torque was used to assess the balance between hip internal and external rotators torque in patients with LBP. This study revealed that there is an imbalance between the hip rotator muscles and that imbalance could affect the stability of the lumbopelvic hip complex, which in turn, affects the lower limb kinetic chain. Hip muscles play a critical role in the pelvis's strength and provide a stable base for the spine while subjects practice locomotion activities (Abdelhaleem et al., 2015). Marshall et al. (2009) demonstrated decreased latency of hip muscles in those with FAI, which approves the close relationship between the entire lower limb kinetic chain. There may be more central effects after lower limb ligament injury leading to alterations in the kinetic chain (Marshall et al., 2009).

Freeman et al. (1965) have proposed that mechanoreceptors in the structure that supports the joints (ligaments, tendon and capsules) have the principle role to control the stability of the joints. Disruption of the mechanoreceptor mechanism could result in delayed response of the muscles that support these joint and could also results in inaccurate dynamic control of the ankle joint (Nyska et al., 2003). Furthermore, Cibulka et al. (1988), reported that ankle deformities such as flatfeet which lead to an unleveled pelvis or loss of the ankle full ROM as in stiffness will result in gait deviations. These deviations could decrease the ability of lower limb chain shock absorptions. On the same way Rothbart & Estabrook (1988) concluded that decreased ankle dorsiflexion may be a factor in chronic mechanical lowback pain.

Previous research by Dananberg & Guiliano (1999) revealed that most treatment options for low back pain only treat acute symptoms and are not useful for the long-term management of chronic back pain and that there was no clear treatment for the causes of low back pain. To overcome this lack of research, Dananberg & Giuliano (1999) investigated the effects of custom-made foot orthosis on management of low back pain and they revealed that use of foot orthosis could participate in management of low back pain that resulted from ankle joint dysfunction or loss of full ROM and also could maintain the improvement in back pain for long term. As a result of their research, Dananberg et al. (199) concluded that loss of ankle ROM or mobility is considered a factor involved in the development of low back pain.

The current study supported previous studies recommending FAI and limited ankle DF ROM as a factor in LPB. The authors theorized that abnormalities in the lower extremity kinetic chain may cause abnormal forces to be transmitted through the chain to the spine. These alterations may predispose the individual to the development of LBP. Limitations of the current study include: small sample size, no blinding during implementation and lack of measurement of lower back or ankle activity levels by using scales or questionnaires. The authors suggest conducting similar studies with a larger number of participants and include functional measures scales or questionnaires to increase the validity and generalizability of the results.

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## AUTHOR CONTRIBUTIONS

All authors listed have made a substantial, direct and intellectual contribution to the work, and approved it for publication.

## CONFLICTS OF INTEREST

The authors declare no conflict of interest.

## FUNDING

This research received no external funding.

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