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Relationship between dorsal ankle flexion and medial column flexibility

Relación entre la flexión dorsal de tobillo y la flexibilidad de la columna medial

Noelia Sales Picher[1] and Enrique Sanchis Sales[2]

[1]Graduada en Podología. Universitat de València. Valencia, España. [2]Departamento de Enfermería y Podología. Universitat de València. Valencia, España

Keywords:

Foot posture, medial column, gait, dorsiflexion ankle, Lunge's test, navicular drop, navicular drift.

Abstract

Objectives: Due to its importance during weightbearing activities the study of the ankle joint has recieved much importance in literature. It is very frequent to analyze the range of dorsiflexion of the ankle because it is thought that an incorrect range of motion can affect the function of the lower limb and the foot, to be more concrete, internal longitudinal arch.

Patients and method: To value the dorsiflexion of the ankle we used the Lunge's test. To assess the mobility of the medial column, the navicular was measured using the drop and drift navicular tecniques. Foot posture was studied using the Foot Posture Index.

Results: A total of 57 healthy individuals were included in the study. It's was found a lineal and inverse relation between the ankle flexion and the flexibility of the medial column. However, no relationship was found between the Foot Posture Index and the Lunge test, but relationship was found with the navicular drop and drift.

Conclusion: The present study has found a correlation between the range of ankle dorsiflexion and medial column stability measured clinically, and between foot position and medial column stability in healthy subjects. Finding that the greater the ankle dorsiflexion, there appears to be less flexibility of the medial column.

Palabras clave:

Postura del pie, columna medial, marcha, flexión dorsal de tobillo, test de Lunge, navicular drop, navicular drift.

Resumen

Objetivos: Debido a su importancia durante las actividades de carga, el estudio de la articulación de tobillo recibe gran atención en la literatura. Es muy frecuente analizar el rango de flexión dorsal de tobillo, ya que se piensa que una incorrecta movilidad puede afectar a la función de la extremidad inferior y del pie, más concretamente sobre el arco longitudinal interno.

Pacientes y métodos: Para la valoración de la flexión dorsal de tobillo se utilizó el test de Lunge. Para valorar la movilidad de la columna medial se calculó el desplazamiento y el descenso del navicular mediante las pruebas de navicular drop y navicular drift. Para analizar la postura del pie se utilizó el índice de la postura del pie.

Resultados: Se analizaron un total de 57 adultos sanos. Se encontró una relación lineal e inversa entre la flexión de tobillo y la flexibilidad de la columna medial. Respecto al índice de postura del pie no se observó ninguna relación con el test de Lunge, pero sí que influye en la flexibilidad de la columna medial.

Conclusión: El presente estudio ha encontrado correlación entre el rango de flexión dorsal de tobillo y la estabilidad de la columna medial medida clínicamente, y entre la posición del pie y la estabilidad de la columna medial en sujetos sanos. Se ha encontrado que a mayor flexión dorsal de tobillo, parece existir menor flexibilidad de la columna medial.

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Correspondence:
Noelia Sales Picher
noeliasales1@gmail.com

INTRODUCTION

At present, the study of the tibiofibular joint or ankle joint [AJ] together with the internal column of the foot, continues being of great interest at biomechanical analysis of human gait. The ankle is one of the most complex and important structures in the human body[1-3]. The AJ is formed by the union of the talus with the tibia and fibula[1,4,5]. This joint is characterized by having movements in the three planes of space. The plane with the greatest range of motion is the sagittal plane with 20-30° of dorsiflexion (DF) with knee extended and 30-50° of plantarflexion (PF)[1]. The AJ has a great influence on the gait pattern and seems to be highly correlated with the appearance of certain pathologies such as plantar fasciitis, hallux limitus or rigidus, hallux valgus, metatarsalgia, Achilles tendon tendinopathies, ankle sprains and syndrome of tibial stress among others[3,5-8]. Currently, the evaluation of DF and FP of the AJ is performed routinely in the biomechanical examinations of patients and it is very common to evaluate the range of motion of the AJ in unloading, being rare to do it in loading[3,4-6,9,10]. Numerous studies affirm that it is more reliable to perform a measurement of AJ under load, since it is the best way to assess how this joint behaves during dynamics[3,9,10]. The method or test most used in literature, and which shows a high reliability coefficient for evaluating the DF of AJ at load, is the Lunge test. In literature it has been used to analyze whether there is a relation between the limitation of DF and the etiology of other pathologies in the foot and ankle[3,9,10].

Another important element to study in biomechanics and human gait is the study of the flexibility of the medial column, which most important element is the internal longitudinal arch [ILA][11]. The medial column is made up of the talus, the navicular, the three wedges, and the first, second, and third metatarsals[1,11]. During gait, the medial column, and especially the ILA, must have the adequate capacity to deform and recover when reactive forces from the ground act on the foot[11]. Therefore, it is necessary to assess the flexibility of the medial column to know its correct motion during walking. In literature, different tests have been described for the assessment of ILA, being the navicular drop [NDrop], navicular drift [NDrift] and arch index tests those that present the highest reliability index for the evaluation of ILA[9,12-17]. There are factors that seem to influence the flexibility of the medial column. Multiple tests have been described to assess this posture, the most widely used at present is the foot posture index [FPI][1,3,18-23]. This study aims to analyze the relationship between AJ range of motion, medial column flexibility and foot posture.

This study aims to focus on the assessment of the DF of the AJ together with the flexibility of the medial column and the posture of the foot. Works such as those of Alfaro Santafé et al.[3], Williams et al.[4], Hall et al.[6], Jung. et al.[7] and Langarika-Rocafort et al.[9] among others, give great importance to both elements in the study of human gait. In addition, an alteration of these factors can be related to the appearance of certain pathologies at the foot level and to an altered gait pattern.

PATIENTS AND METHODS

Study population

An observational, descriptive and cross-sectional study of 57 healthy subjects between 20 and 50 years old was carried out between February and March 2017. The study subjects were students who were academically in the 3rd and 4th year of the Bachelor's Degree in Podiatry in the 2017-2018 at the University of Valencia. Valencia, Spain Only healthy subjects without neuromuscular affectations, without foot or leg injuries that have pain or impede normal mobilization, without surgical history on the foot, and with a normal, pronated and supinated FPI were included. Before participating in the study, all subjects signed an informed consent, and the research was approved by the Bioethics Committee (procedure number: H1512121644041) of the University of Valencia (Valencia, Spain).

Measurement of variables

To obtain the data, the subjects were subjected to a series of biomechanical tests. Anthropometric data were first obtained from each subject such as age, sex, weight and height. All the subjects remained standing in a relaxed position of the calcaneus in support [CRSP]. First, the FPI was performed as described by Redmond et al. in 2006[1], to determine posture on both feet. Subsequently, ankle load bearing DF degrees were calculated for both feet using the Lunge test described by Benell et al.[10] in 1998. DF degrees were measured using a plastic goniometric ruler with a graduated semicircle, as shown in Figure 1. The degrees of inclination of the tibia were quantified with the inclination meter of the system's compass application of the apple IOS operating system found on the Iphone. Subsequently, the NDrop described by Brody et al. in 1982 and NDrift as explained by Menz et al.[16] in 1998 to measure the displacement and descent of the navicular with graph paper to quantify the difference in centimeters between the RCSP and NCSP, as it is shown in Figure 2. All the study data was obtained by an explorer, 4th year student of the Podiatry degree, having been instructed previously to carry out the measurements. The values of the study were obtained from a single measurement.

Data analysis

For data analysis, the statistical program SPSS (version 24.0) for Windows 10 was used. A statistical analysis was performed using the t-student test with a 95 % confidence interval, to compare the means of both sexes. On the other hand, bivariate correlations were performed using the Pearson correlation coefficient between the variables of Lunge test, FPI, NDrop and NDrift to see if there were significant relation between them, statistically significant values were estimated when the *p* value of the correlation test of Pearson was less than or equal to 0.05.

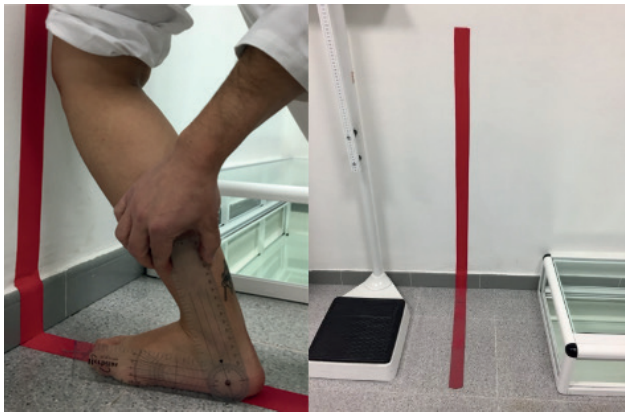

Figura 1. Lunge Test.

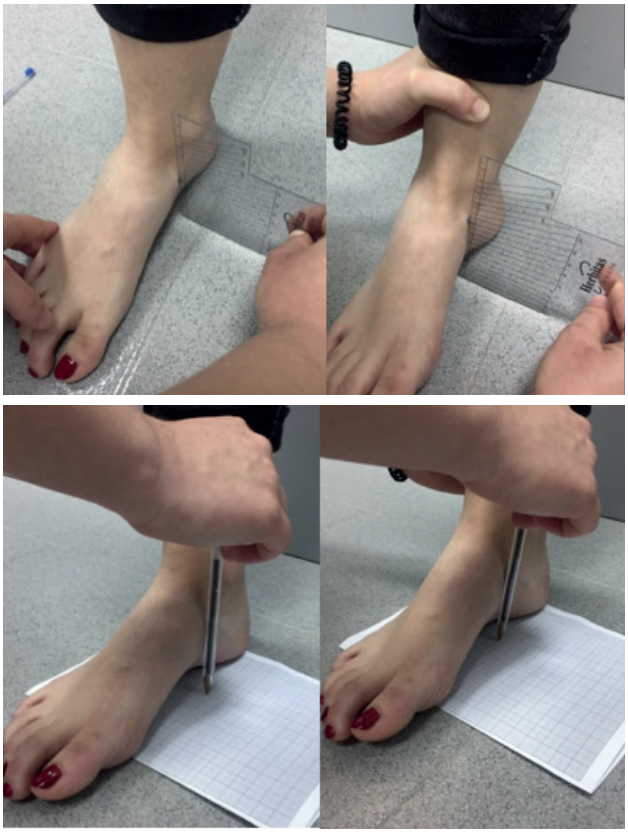

Figura 2. Navicular Drop Test (up) and Navicular Drift Test (down).

RESULTS

A total of 57 subjects were included in the study. Table I shows the anthropometric data taken from the study subjects. Table II shows the frequency and percentages of the qualitative variables of the study, including the results of the FPI. A descriptive analysis of the sample was carried out, 38.59 % of the subjects were men and 61.40 % were women. A total of 114 feet were analyzed in the study, 44.73 % had normal feet, 28.94 % pronated feet and 26.31 % supinated feet.

A statistical analysis of the variables was carried out. First, it was analyzed whether there were significant differences between men and women regarding the FPI, Lunge test, NDrop and NDrift of the right foot (RF) and left foot (LF). It cannot be assumed that there are significant differences between men and women regarding the FPI, Lunge's test, Ndrop and NDrift, the results are reflected in Table II. It was investigated if there is a relation between the FPI, the Lunge test and the NDrop and NDrift using Pearson's correlation coefficient. After the results obtained, reflected in table III, it was observed that there was a low and positive correlation between the FPI and the NDrop of the RF with a $p = 0.003$ ($r = 0.384$; $p < 0.01$) and LF with a $p = 0.016$ ($r = 0.310$; $p < 0.05$). On the other hand, there was a low and positive correlation between the FPI and the NDrif of the RF with a $p = 0.019$ ($r = 0.310$; $p < 0.05$) and with a $p = 0.007$ LF ($r = 0.356$; $p < 0.01$). However, there was no relationship between the FPI variables and the Lunge test with a $p = 0.094$ and with a $p = 0.062$ in LF, ($p > 0.05$) for both feet.

In this study, it was observed that there is a low and negative correlation between the Lunge test and the RF Ndrop with a $p = 0.015$ ($r = -0.321$; $p < 0.05$) and the LF with a $p = 0.040$ ($r = -0.273$; $p < 0.05$). On the other hand, a low and negative correlation was found between the Lunge test and the NDrift of RF with a $p = 0.031$ ($r = -0.253$; $p < 0.05$) and the LF with a $p = 0.045$ ($r = -0.287$; $p < 0.05$).

Table I. Descriptive table of the anthropometric data of the 57 subjects

Age (Years)	Weight (Kg)	Size (m)	Total subjects
22,45 ± 4,73	62,63 ± 4,73	1,60 ± 1,26	57

Table II. Descriptive table of the mean and standard deviation of the study variables

Foot	FPI	T. Lunge	NDrop	NDrift
Men Right	2,32 ± 1,359	26,68 ± 9,03	0,43 ± 0,19	0,40 ± 0,18
Women Right	1,91 ± 1,136	29,02 ± 10,58	0,46 ± 0,25	0,32 ± 0,14
Men Left	2,32 ± 1,359	27,54 ± 9,13	0,52 ± 0,054	0,40 ± 0,17
Women Left	1,91 ± 1,136	27,54 ± 7,022	0,54 ± 0,31	0,35 ± 0,16

Table III. Descriptive table of Pearson's correlation coefficient

FPI	T. Lunge	NDrop	NDrift
Right Foot	0,094 > 0,05	0,003 < 0,01	0,019 < 0,05
Left Foot	0,062 > 0,05	0,016 < 0,05	0,007 < 0,01
T. Lunge	**NDrop**	**NDrift**	
Right Foot	0,015 < 0,05	0,031 < 0,05	
Left Foot	0,040 < 0,05	0,045 < 0,05	

DISCUSSION

The objective of the present study was to analyze whether there is a relation between the AJ range of dorsiflexion, the flexibility of the medial column and the posture of the foot. The ankle and medial column has great importance for the proper motion of human gait. It is necessary an appropiate range of joint mobility to carry out a correct dynamics of the human body. In the biomechanical examination, unloading ankle DF is normally assessed, but recent studies describe the Lunge test as a test with high intra- and inter-rater reliability[3,4,6,9]. Another widely used test to classify the type of foot that the patient has, in load is the FPI.

The assessment of the load bearing ankle DF has been one of the most relevant aspects of the present study together with the analysis of the flexibility of the medial column. This is because the ankle DF has great importance in load activities, and its study has great importance in literature. Some authors, such as Cejudo et al.[6], Alfaro Santafé et al.[3], Hall et al.[4] and Langarika-Rocafort et al.[9] reflect the importance of assessing the ankle under load since it is the best way to observe how this joint behaves dynamically. In these studies, the Lunge test is named as the most reliable method or test for assessing the DF of AJ on load.

Another important aspect for the dynamics and load-bearing activities of the foot is to observe how the posture of the foot influences the flexibility of the medial column, if there is a correlation between both parameters since different authors indicate how the posture of the foot can affect the flexibility of the internal column predisposing the subject to suffer certain conditions such as plantar fasciitis, posterior tibial dysfunction, myositis of the abductor hallucis, among others[3,5,7,24]. In this study, a correlation was found between the FPI and the NDrop, which reflects the existence of a low and direct linear relation between both parameters, this implies that the higher the value of the FPI, the more decrease there is of the navicular, therefore, the more pronated the foot, the greater its descent from the navicular. This study is in agreement with recent research by Cowley and Marsden[18] and Kothari et al.[19], that although it was found a correlation between both parameters, it was not statistically significant. These authors indicate in their studies that the low relationship existing may be due to the fact that during the assessment of the FPI parameters, the soft and bony parts of the foot are taken into account, while in the case of the NDrop only the navicular is analyzed, so as there are a greater number of parameters in the FPI, as a whole these do not have to significantly influence the NDrop. This research is also in agreement with the study by Langley et al.[20], but in this case the author indicates that the NDrop by itself should not be used for the classification of the foot, but should be related to the FPI. On the other hand, the study by Peláez Menacho et al.[21] contradicts what was found in this research, since no relationship was found between the FPI and the NDrop, explaining that what is mentioned in the study by Cowley and Marsden[18] may influence, that is, it may happen that a relationship is lack between the FPI and the NDrop because the variables analyzed are different. Kothari et al.[19] in their study found no significant relationship between NDrop and FPI. Regarding the relation between the FPI and NDrift, this study reflects that there is a low and direct relation between both, this implies that the higher the FPI of the foot, the greater the value of the NDrift, which translates into greater pronation of the foot, the greater is the navicular displacement between the PRCA and PNCA position. A similarity has been found with the research found by Kothari et al.[19]. There are few recent publications that evaluate and use the NDrift, so it is difficult to compare the results with other relevant investigations.

No statistically significant differences were found in the FPI between men and women. Other authors such as Cowley and and Marsden[18] and Jimenez-Cebrian et al.[22] also state that sex does not influence foot posture. Results obtained for the Lunge test with with respect to NDrop and NDrift reflect a statistically significant relationship. Our results are in line with the results published by Chimenti et al.[24]. For them, the DF of the AJ and the NDrop are related. Subjects with a low range of ankle DF present a decrease in the height of the ILA and an increase in the descent of the navicular. A possible mechanism that explains everything mentioned above is that the lower the DF of the AJ, the greater the pronation of the subtalar joint and this can be translated as a greater flattening of the ILA, which can cause a descent of the navicular. It seems that a decrease in the ankle DF can influence the stiffness of the medial column, which is less rigid. Regarding the relation between the Lunge test and the NDrift, the present study has found a statistically significant relation, being able to affirm that there is a linear and inverse relationship between both parameters; no recent studies have been found analyzing of both variables and relate them to each other. Therefore, a comparison of this study with others of scientific relevance cannot be made.

The findings of the present study describe biomechanical parameters of the lower limb that may be useful for performing biomechanical examinations in the office. In the case of the Lunge test, it can be used as a complementary test for the evaluation of the AJ in unloading, since there may be a change with respect to this joint, depending on whether the subject is in unloading or in static standing. In addition, the assessment

of the joints both in loading and unloading allows to know the physiological changes that the foot undergoes. The results of this study seem to explain the clinical findings that we find in pathologies that affect the medial column, such as plantar fasciopathy, or posterior tibial dysfunction, among others.

The sample of the following study belongs to the adult population and the vast majority are young people without the presence of pathologies, which is why they cannot be generalized for the pediatric and geriatric population, and in individuals who present some pathology of the lower limb (sprains, hallux valgus, plantar fasciitis ...). Therefore, it would be interesting to carry out this type of study in older people to see if aging is a factor that influences the DF of AJ and the flexibility of the internal column. It should also be performed with people with foot and ankle pathologies to see if there is a correlation with the appearance of pathologies such as plantar fasciitis and hallux rigidus. Another limitation present in the study has been that the sample size is small, so it may happen that there is no predominance of one type of foot in both men and women. For future research work, it is possible to continue analyzing the biomechanical behavior of the ankle joint and the medial column in a larger sample size than the present study, and also perform an analysis in subjects with pathologies at the foot level and in the pediatric and geriatric population.

In conclusion, the present study has found a correlation between the ankle dorsiflexion range and the medial column stability measured clinically, and between the foot position and the medial column stability in healthy subjects. Finding that the greater the ankle dorsiflexion, there appears to be less flexibility of the medial column. The biomechanical behavior of the ankle joint and the medial column should be further investigated due to its relation with human gait, as well as the effectiveness of the different tests described to analyze these parameters.

CONFLICT OF INTERESTS

The authors have no relevant conflicts of interest with this article.

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