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Investigation of the Effects of Morphological Structure of the Foot and Ankle Flexibility in Folk Dancers on Foot and Ankle Disorders

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Abstract

This study was conducted to investigate the relationship of morphological structure of foot, and ankle flexibility to foot and ankle disorders in folk dancers. 42 dancers participated in the study. The morphological structures of feet were determined by using footprint analysis method with 4 parameters and ankle flexibility properties were determined by using 4 parameters. Expanded nordic musculoskeletal questionnaire was used to determine foot and ankle disorders. The data were evaluated with Spearman Correlation and Man-Whitney U tests at p <0.05 significance level. When the foot and ankle parameters of unhealthy and healthy volunteers were compared, a statistically significant difference was found between the two groups in the ChippauxSmirak index (CSI), Staheli index (SI) and dorsiflexion (DF°) values in the right foot, and in the CSI and SI values in the left foot. When the relationship of foot and ankle parameters to pain severity and pain frequency in unhealthy volunteers was examined, it was observed that there was a negative correlation between DF° and eversion (E°) values and pain frequency, and between DF°, PF° and E° values and pain severity in the right foot. In the left foot, a negative correlation was found between the DF° values and the frequency of pain. (p<0,05). In this study, some components of the foot morphological structure and ankle flexibility properties were found to have a relationship with foot and ankle disorders. These results can be taken into account in the determination of risk factors and preventive measures in terms of pain, injury and various disorders in the foot and ankle region.

Keywords: Folk Dancers, Foot Morphology, Ankle Flexibility, Foot and Ankle Disorders

Introduction

Dance is a unique combination of art and athletics, while dancers are artistic athletes (Hald, 1992; O'Loughlin et al., 2008). In dance, as in sports, any figure takes place in the human body through intense movements of a collection of interconnected solid segments (Wilson and Kwon, 2008). This intense mobility demands extreme physical demands. For these reasons, the extreme positions that occur while the dancers are performing the figures can cause injuries to the feet and ankles (Kadel, 2006; Rickman et al., 2012).

The foot and ankle are structures that must be understood in the context of dance. It is known that the morphological structure of the foot, which is the end point and the part of the locomotor chain that comes into contact with the ground, is important in activities such as walking and running. Due to this locomotive structure and morphological characteristics of the foot, it allows the performance and stability to be maintained in the athletic art of dance (Kidder et al., 1996; Ledoux et al., 2003; Russell et al., 2008). The ankle joint, on the other hand, is an important component of the normal gait cycle in order for its dynamic and static stabilizers to maintain their structural integrity. From the point of view of the dance world, the ankle becomes even more important given the range of motion and stress applied to the ankle during various dance routines (O'Loughlin et al., 2008).

Dancing is not dangerous, but dancers suffer injuries when the limits are pushed. Foot and ankle injuries constitute the majority of dancers' injuries. Dancers often have to work with pain and injuries in the feet and ankles. For these reasons, it is important to understand the mechanism of injury and its factors beforehand (Macintrye and Joy, 2000; Özkan et al., 2013; Markula, 2015).

Therefore, both in the training sessions combining the development of conditional abilities and technical-tactical elements and demonstrations, it is concluded that the morphological structure of the foot and the flexibility of the ankle are important especially in terms of foot and ankle injuries that may occur due to various reasons.

In this context, in this study, it is aimed to investigate the relationship of morphological structure of foot, and ankle flexibility to foot and ankle disorders in folk dancers. This research is important in terms of determining the relationship between structural changes in the anatomical components of the foot and ankle in dancers, and foot and ankle injuries.

Material and Method

Study Method

This study is descriptive research conducted to investigate the relationship of morphological structure of foot, and ankle flexibility to foot and ankle disorders in folk dancers.

Study Group

42 male students with a mean age of 21.73 ± 2.57 years who are studying at Giresun University State Conservatory Folk Dance Department voluntarily participated in the study. The research was carried out in accordance with the Declaration of Helsinki, with the date and decision number 03.10.2019/14 of Giresun University Faculty of Medicine Ethics Committee.

Data Collection Tools

Determination of Morphological Structure of Foot

Footprint analysis method obtained from the foot plantar pressure was used to determine the foot morphology (Stavlas et al., 2005). The relevant researchers recommend that multiple parameters should be used when evaluating the foot type (Chuckpaiwong et al., 2009). In this study, footprint measurement was performed by footprint metric analysis method using 4 morphometric parameters in order to evaluate foot structure. The footprint method, which measures the sole pressure of the foot, is a very good way of understanding where the load is coming from and which tissues are under extreme mechanical stress (Bek, 2018). Chinesport brand podoscope was used for footprint measurements.

Footprint Measurement and Parameters

Foot plantar pressure images of all volunteers were taken from the podoscope by using a camera in the footprint analysis. Morphometric measurements were made on the images and cm was used as the metric unit. The application was made for both feet as right and left.

Parameters

Foot Index (FI): Obtained by dividing the transverse breadth of the foot by longitudinal length and multiplied by 100. FI=(FB/FL)*100(Moudgil et al., 2008).

Chippaux-Smirak Index (CSI): It is the ratio of the minimum width of the middle arch area of the foot (B) to the maximum width of the metatarsal region (C). CSI=(B/C)*100. (Stavlas et al., 2005).

Staheli Index (SI): It is the ratio of the minimum width of the middle arch area of the foot (B) to the maximum width of the posterior region of the foot (A). SI=B/A (Staheli et al., 1987).

Clark Angle (C°): It is the angle between the line connecting the most medial metatarsal point and the most medial heel region and the line connecting the inner medial arch point (concavity of the arch) and the most medial metatarsal point (Razeghi and Batt, 2002).

Fig 1. Foot İndex Fig 2. CSI and SI Fig 3. C°

Joint Range of Motion Measurement and Parameters

The use of a goniometer has been recommended as an objective measurement method in the determination of joint range of motion. (Menadue et al., 2006). The ankle joint range of motion of the participants were measured in 4 parameters with a Baseline brand 20 cm goniometer.

Dorsiflexion (DF°) and Plantar flexion (PF°): While the volunteer was in supine position, the pivot point of the goniometer was placed in the lateral malleolus. The fixed arm was kept parallel to the lateral midline of the fibula. The movable arm was placed parallel to the lateral midline of the 5th metatarsal bone, and dorsiflexion and plantar flexion measurements were performed (Otman and Köse, 2014).

Inversion (I°) and Eversion (E°): The volunteer was placed in a sitting position at 90 ° with the legs suspended from the knee. The pivot point of the goniometer was placed on the anterior face at the midpoint of the ankle between the malleolar. The inversion and eversion movement angles were measured by placing the fixed arm towards the anterior midline of the leg towards the tuberositas tibia and the movable arm towards the midline of the second metatarsal (Otman and Köse, 2014).

Determination of Foot and Ankle Disorders

Expanded nordic musculoskeletal questionnaire was used to determine foot and ankle disorders of volunteers (Dawson et al., 2009).As a result of the questionnaire, two groups of unhealthy volunteers (n: 21) and healthy volunteers (n: 21) were determined according to the yes-no answer to the question "Have you experienced any foot and ankle disorders in the last 12 months?". The volunteers who answered Yes were divided into two subgroups according to the disorder of both feet or right foot (n: 21) and both feet or left foot (n: 21). According to the questionnaire, in order to determine the frequency of pain experienced in the groups with disorder, they were asked to choose one of the options continuously, occasionally and rarely, and these options were quantitated with 3, 2 and 1 respectively. The severity of the pain, as indicated in the questionnaire, was asked to indicate the pain experienced by a number between 1 and 10. Foot and ankle parameters of unhealthy and healthy volunteers were compared separately for right and left feet. Bilateral asymmetry between foot and ankle parameters was investigated in unhealthy volunteers. The relationship between the frequency and severity of pain and the selected parameters of the painful foot and ankle was examined.

Data Analysis

Statistical analysis was performed using SPSS package program. Shapiro Wilk test was used to test the normality of the data.Since the data were not normally distributed, the Mann-Whitney u test (table 1, table 3) was used to determine the difference between the parameters, and the spearman correlation test was used to determine the relationship between the parameters (table 2). Results were evaluated at p <0.05 significance level.

Findings

Table 1. Differences between foot and ankle parameters of unhealthy (n:21) and healthy (n:21) volunteers

Parameters	Right foot and ankle (Mean±Sd)			Left foot and ankle (Mean±Sd)		
	Unhealthy volunteers	**Healthy volunteers**	**P value**	**Unhealthy volunteers**	**Healthy volunteers**	**P value**
FI	38,46±2,05	37,95±1,82	0,753	38,80±1,60	38,42±1,76	0,365
CSI	34,40±6,62	28,37±8,4	**0,021***	34,97±6,30	28,09±8,36	**0,038***
SI	60,44±10,07	48,64±12,65	**0,003***	60,99±9,85	49,44±13,99	**0,016***
C°	48,71±8,63	51,33±14,33	0,399	49,43±9,68	48,00±12,54	0,70
DF°	13,09±10,04	19,71±7,97	**0,038***	14,52±9,26	14,80±6,21	0,970
PF°	64,76±6,82	66,47±5,43	0,340	63,57±7,85	67,57±6,85	0,078
I°	35,76±7,23	33,73±11,67	0,240	36,04±10,33	37,71±6,49	0,219
E°	23,90±12,46	23,38±12,78	0,960	19,48±13,41	20,40±6,65	0,160

Mann-Whitney U test (p<0,05). FI:Foot Index; CSI: Chippaux-Smirak Index; SI: Staheli Index; C°:Clark Angle; DF°:Dorsiflexion; PF°:Plantar Flexion; I°:Inversion; E°:Eversion.

When the foot and ankle parameters of unhealthy and healthy volunteers were compared, a statistically significant difference was found between the two groups in the CSI, SI and DF° values in the right foot, and in the CSI and SI values in the left foot. (p<0,05,Table 1).

Table 2. The relationship between the frequency and severity of pain and the selected parameters of the painful foot and ankle

Parameters			FI	CSI	SI	C°	DF°	PF°	I°	E°
Right foot (n:21)	Pain frequency	r	0,321	-0,294	-0,360	0,234	**-0,509***	-0,376	0,025	**-0,461***
		p	0,156	0,196	0,109	0,307	**0,018**	0,093	0,915	**0,036**
	Pain severity	r	0,308	-0,384	-0,361	0,170	**-0,447***	**-0,659****	-0,287	**-0,559****
		p	0,174	0,086	0,108	0,461	**0,042**	**0,001**	0,206	**0,008**
Left foot (n:21)	Pain frequency	r	-0,020	-0,157	-0,116	0,055	**-0,527***	-0,329	-0,216	-0,267
		p	0,930	0,497	0,616	0,814	**0,014**	0,146	0,346	0,241
	Pain severity	r	0,051	-0,305	-0,058	0,251	-0,403	-0,308	-0,337	-0,324
		p	0,828	0,178	0,803	0,272	0,070	0,174	0,136	0,152

Spearman correlation test (p<0,05). FI:Foot Index; CSI: Chippaux-Smirak Index; SI: Staheli Index; C°:Clark Angle; DF°:Dorsiflexion; PF°:Plantar Flexion;I°:Inversion; E°:Eversion.

When the relationship of foot and ankle parameters to pain severity and pain frequency in unhealthy volunteers was examined, it was observed that there was a negative correlation between DF° and E° values and pain frequency, and between DF°, PF° and E° values and pain severity in the right foot. In the left foot, a negative correlation was found between the DF° values and the frequency of pain. (p<0,05, Table 2).

Table 3. Investigation of bilateral asymmetry between foot and ankle parameters in unhealthy volunteers

Parameters	Right foot and ankle (Mean±Sd)	Left foot and ankle (Mean±Sd)	P value
FI	38,46±2,05	38,80±1,60	0,285
CSI	34,40±6,62	34,97±6,30	0,725
SI	60,44±10,07	60,99±9,85	0,930
C	48,71±8,63	49,43±9,68	0,641
DF°	13,09±10,04	14,52±9,26	0,462
PF°	64,76±6,82	63,57±7,85	0,751
I°	35,76±7,23	36,04±10,33	0,869
E°	23,90±12,46	19,48±13,41	0,129

Mann-Whitney U test (p<0,05). FI:Foot Index; CSI: Chippaux-Smirak Index; SI: Staheli Index; C°:Clark Angle; DF°:Dorsiflexion; PF°:Plantar Flexion; I°:Inversion; E°:Eversion.

When bilateral asymmetry status of unhealthy volunteers was examined, no difference was found between the parameters (p<0,05, Table 3).

Discussion and Conclusion

According to the results of the study, when the foot and ankle parameters of the unhealthy and healthy volunteers were compared, a statistically significant difference was found between the two groups in the right foot regarding CSI, SI and DF° values. Also, a statistically significant difference was found in the left foot regarding CSI and SI values.

In the chippauxsmirak index (CSI), 0.1-29.99 is considered to be normal values (Echarri and Forriol, 2003). In this study, the CSI values of unhealthy volunteers were found to be 34.40±6,62 in the right foot, 34.97±6,30 in the left foot. On the other hand, the CSI values of the healthy volunteers were found to be 28.38±8,4 in the right foot, and 28.09±8,36 in the left foot. According to these results, it was seen that the foot structures of unhealthy volunteers had low arch structure, healthy volunteers had normal arch structure and there were statistically significant differences between the arch levels of the two groups.

In the study, SI values of unhealthy volunteers were found as 60,44±10,07 in the right foot and 60,99±9,85 in the left foot. SI values of healthy volunteers were 48,63±12,65 in the right foot and 49,44±13,99 in the left foot. In SI values, 30-59 interval is accepted as normal arc and over 59 is considered as low arc (Staheli et al., 1987). The SI values in the study show low arc in both feet in unhealthy volunteers.

Structural effects of arches are known in the absorption of all pressures applied to the human body during stopping and movement and transferring them to the ground. It is emphasized that the measures taken on damaged arch structures increase sports performance and prevent injuries (Huang et al., 1993; Kogler et al.,1996; Prachgosin et al., 2015; Zhao et al., 2017). Tong and Kong (2013) stated that the arch structure of the foot was associated with lower extremity injuries. Menz et al. (2016) emphasized that the flatness of the feet is associated with foot disorders, and interventions that change the abnormal foot posture may play a role in relieving and treating pain. Regarding the relationship between arch structure and foot injuries, it is seen that the relevant literature is similar to this study.

When the relationship of foot and ankle parameters to pain severity and pain frequency in unhealthy volunteers was examined,it was observed that there was a negative correlation between DF° and E° values and pain frequency, and between DF°, PF° and E° values and pain severity in the right foot. In the left foot, a negative correlation was found between the DF° values and the frequency of pain.

In this study results, dorsiflexion angle of the right ankle was significantly lower in the unhealthy group (13,09±2,28) than in the healthy group (19,71±1,74). In addition, when it was examined in terms of pain frequency and pain severity, it was observed that there was a negative correlation between DF values and the frequency and severity of pain. While Wiesler et al. (1996) stated in a study that dancers who had an injury had lower dorsiflexion than healthy dancers, Porter et al. (2002) also emphasized that the increase in achilles tendon flexibility in painful heel syndrome reduces pain. It is seen that similar studies support the results of this study.

The research model used in this study is a relational model based on situation determination. Therefore, the decrease in the joint range of motion of the injured volunteers may be due to the injuries.Researchers have emphasized that decreased flexibility for various reasons will cause new injuries and lead to loss of performance. Especially, dancers need higher ankle flexibility against injury (Abraham et al., 2016; Motta-Valencia, 2006; Rein et al., 2011; Russell et al, 2008).

In this study, some components of the foot morphological structure and ankle flexibility properties were found to have a relationship with foot and ankle disorders. These results can be taken into consideration in determining risk factors and preventive measures in terms of pain, injury and various ailments in the foot and ankle area.

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