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The Relationship between Functional Movement Screen and Ankle Dysfunctions with Chronic Ankle Instability

Ho-Suk Choi[1], Won-Seob Shin[2], Jae-Kwang Shim[1], Sung-Jin Choi[1], Dae-Hyouk Bang[1]

[1]Department of Physical Therapy, Graduate School of Daejeon University, [2]Department of Physical Therapy, College of Natural Science, Daejeon University

Purpose: The purpose of this study was to investigate the correlations between functional movement screen (FMS) and ankle dysfunctions in subjects with chronic ankle instability (CAI).

Methods: This study was a cross-sectional study of 20 participants with CAI. The ankle dorsiflexion range of motion (ROM), Foot and Ankle Disability Index (FADI), center of pressure (COP) path length, and COP velocity for ankle dysfunction were measured in all the subjects. All the subjects underwent the FMS concerned with ankle functions consisted of deep squats, hurdle steps and in-line lunges. The Spearman rank-order correlation coefficient was used to determine relationship between the ankle ROM, FADI, COP and FMS.

Results: The results of the deep squat and in-line lunge exercises revealed a significant correlation with the ankle dorsiflexion ROM, FADI, COP path length, and COP velocity. The hurdle step showed no correlation with the ankle dorsiflexion ROM and FADI but a significant relationship with the COP path length and COP velocity.

Conclusion: The results of this study showed that relationship deep squat and in-line lunge and it is suggested that an assessment tool using ankle dorsiflexion ROM and ankle instability would be clinically effective.

Key Words: Ankle instability, Ankle dysfunction, Functional movement screen

I. Introduction

The ankle joint is responsible for stability and absorbing impacts, and it is one of the important joints in the lower body. It is the most commonly injured joints, both by athletes and non-athletes.[1] The ligaments of the lateral ankle joint are composed of as tissue with a relatively weak structure. As a result, they can be injured during sports and activities where the ankle joint makes an inversion movement, which can cause joint instability.[2]

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Corresponding author Won-Seob Shin, shinws@dju.kr

The easily decreased range of motion (ROM) of ankle dorsiflexion because of lateral ankle sprain.[3] It can affect gait patterns, especially walking and running,[4] and it increases the possibility of re-injury. The reason for the limited dorsiflexion ROM is the restriction of osteokinematics and arthrokinematics.[5] Although the osteokinematic limit of motion can be restored after a lateral ankle sprain, while arthrokinematic limitations was remain. The change in joint movement can affect gait and increase the risk of osteoarthritis.[6,7] One study reported that subjects who exposed to lateral ankle sprain decreased dorsiflexion range.[5] A reported 10% to 30% of these individuals with ankle sprains develop chronic ankle instability (CAI).[8] Despite the frequency of ankle instability, no widely accepted outcomes tool is available to measure ankle function.[9]

The clinical measurement of injury in orthopedic is

concentrated on muscle strength and joint ROM It is often been used to measure of procedure and set a goal of disability in the clinic. The limitations of function and the patient's experience of disability are often ignored,[10] as functional limitation and disability are important to patients.[11] The Functional movement screen (FMS) is a relatively new measurement for both representing various movement factors and forecasting the general risks about musculoskeletal injuries. It can be used to determine functional deficits and musculoskeletal conditions and injuries due to the general asymmetric. It can also be used to modify movement defects verified through personal exercise prescription. It includes seven movement patterns: deep squat, in-line lunge, hurdle step, shoulder mobility, active straight leg raise, trunk stability push-up, and quadruped rotary stability. Ankle joint movement and stability are measured during the deep squat, in-line lunge, and hurdle step.[12] It can measure both the change of disability and functional limitation after therapy in a clinic. Functional deficits and asymmetries that may be predictive of general musculoskeletal conditions and injuries, with an ultimate goal of being able to modify the identified movement deficits through individualized exercise prescription.[12]

It is very important to examine the ankle dysfunction accurately and quickly in the medical environments. Previous studies of ankle dysfunction screening test were using special performances such as single leg jump and sideward lateral cutting movement[13,14] and using tools for ankle instability.[15] Recently there was a study that FMS for ankle has been conducted on healthy subjects.[16] However, there was no study using the FMS in subjects with CAI. Therefore, the purpose of this study was to investigate the correlations with functional movement screen and ankle dysfunctions with CAI.

II. Methods

1. Subjects

The subjects were 20 subjects who worked at a rehabilitation hospital in the Republic of Korea. The inclusion criteria were recruited within the workplace setting to participate within this study. Subjects were classified as having CAI if they reported having the following: (1) a history of ankle sprain with pain and/or limping for more than 1 day, (2) chronic weakness, pain, or instability that they attributed to the initial injury, (3) giving way in the last 6 months, and (4) having one or more problems the item of FADI.[10] The exclusion criteria were if they reported any of the following: (1) bilateral ankle instability, (2) history of ankle fracture, (3) ankle injury within 3 months of participation, (4) history of anterior cruciate ligament injury, (5) history of balance disorder, or (6) current participation in supervised physical rehabilitation. Participation in the study was voluntary, and the subjects fully understood the content of the study. After providing an explanation of the study's purpose and the experimental method and processes, written informed consent was obtained from all the subjects. The study was approved by the Daejeon University institutional review board. The subjects' characteristics are summarized in Table 1.

Table 1. General characteristics of the subjects

	mean ± SD	%
Gender (person)		
Male	14	34.1
Female	27	65.9
Age (yr)	26.07 ± 2.50	
Weight (kg)	60.32 ± 11.47	
Height (cm)	166.02 ± 7.97	

2. Experimental methods

1) Ankle ROM

Ankle dorsiflexion ROM was measured using a smartphone application Tiltmeter (Intgrasoft HN-Carlos E. Hernandes Peres) during a weight-bearing lunge. The Tiltmeter was placed on the posterior and flat part of the Achilles tendon when the subject stretched. The participant was instructed to lunge forward by bending both knees, to dorsiflexion the ankle as far as possible, keeping the heel on the floor, three times. The reliability had an Intraclass correlation coefficients (ICC) ranged from 0.90 to 0.98.

2) FADI

All the subjects completed the FADI for self-reported

measurement of function. Separate surveys were completed to determine the function of the right and left ankles. The FADI has 22 items. Each item is scored from 0 (unable to do) to 4 (no difficulty at all). $ICC_{2,1}$ for the FADI was 0.89.[18]

3) FMS

The FMS is one evaluation tool that attempts to assess the fundamental movement patterns of an individual. In this study, we evaluated deep squat, in-line lunge, and hurdle step that are related to the stability and mobility of the ankle.[12,16] The intrarater test-retest and interrater reliability of the FMS composite score resulted in an $ICC_{3,1}$ of 0.76 (95% CI: 0.63, 0.85) and an $ICC_{2,1}$ of 0.74 (95% CI: 0.60, 0.83), respectively.[19]

4)Center of pressure (COP)

The subjects' balance was assessed under feet apart as they performed deep squat and in-line lunge on the Wii Balance Board. Their balance was measured three times in each position. For the current study, the sampling for data collection was 50 Hz and 12 Hz (using a low pass filter). Measurements were taken for 15-30 seconds with a 60-second rest between each position. The reliability had an ICC ranged from 0.66 to 0.94, and the pressure points on the COP validity had an ICC ranging from 0.77 to 0.89.[20]

3. Statistical analysis

The descriptive statistics of the means and standard deviations of all the data measured in this study were produced using the SPSS version 18.0 statistical program. Shapiro-Wilk tests of normality were used to determine if the dependent variables were normally distributed. To identify correlations among the FMS, ROM, FADI and COP, Spearman's rank correlation was calculated. Statistical significance was set at $P<0.05$.

III. Results

All results of FMS, ROM, FADI, and COP with the CAI subjects are presented in Table 2.

There was a significant correlation among the FADI, COP velocity, path length and deep squat ($p<0.05$). Both the affected and non-affected ankle dorsiflexion ROM significant correlation with the deep squat score ($p<0.05$). Both the affected and non-affected in-line lunges were related to

Table 2. Descriptive statistics of FMS, ROM, FADI and COP (n=20)

		Mean	SD	Min	Max
DP		2.05	0.78	1	3
HS	Affected	2.68	0.48	2	3
	Non-affected	2.79	0.42	2	3
ILL	Affected	2.53	0.84	0	3
	Non-affected	2.42	0.90	0	3
FADI (%)		97.19	3.29	89.77	99.00
ROM	Affected ankle (°)	28.54	7.02	16.30	33.70
	Non-affected ankle (°)	31.85	5.49	19.50	38.70
COP velocity	DP (cm/s)	6.40	1.14	4.55	8.91
	HS affected (cm/s)	8.06	1.67	5.18	11.83
	HS Non-affected (cm/s)	8.01	1.38	6.06	10.25
COP Path length	DP (cm)	56.36	12.24	34.28	89.07
	HS affected (cm)	71.75	20.57	48.87	118.35
	HS Non-affected (cm)	70.41	14.19	43.85	100.62

SD: standard deviation, ROM: Ankle dorsiflexion range of motion, FADI: The Foot & Ankle Disability Index Score, COP: Center of Pressure, DP: Deep squat, HS: Hurdle step, ILL: In-line lunge

Table 3. Spearman's rank correlations with functional movement

Test	FADI (%)	ROM-A (°)	ROM-NA (°)	DP COP velocity (cm/s)	HS-A COP velocity (cm/s)	HS-NA COP velocity (cm/s)	DP COP Path length (cm)	HS-A COP Path length (cm)	HS-NA COP Path length (cm)
DP	.408*	.591*	.620*	-.484*	-.083	-.149	-.495*	.126	.116
HS-A	.137	.010	.259	.103	-.041	-.227	-.103	-.445*	-.493*
HS-NA	.252	-.165	-.024	-.283	-.377	-.448	-.212	-.459*	-.431*
ILL-A	.531*	.472*	.526*	-.180	.074	.065	-.577*	-.076	-.139
ILL-NA	.574*	.412*	.491*	-.318	-.067	-.022	-.535*	-.233	-.281

SD: standard deviation, ROM: Ankle dorsiflexion range of motion, FADI: The Foot & Ankle Disability Index Score, COP: Center of Pressure, DP: Deep squat, HS: Hurdle step, ILL: In-line lunge, NA:Non-Affected side, A:Affected side

the affected ankle dorsiflexion ROM, non-affected ankle dorsiflexion ROM, FADI and deep squat COP path length ($p<0.05$). There was a significant correlation between the COP path length and both the affected and non-affected hurdle step ($p<0.05$) (Table 3).

IV. Discussion

Chronical ankle instability was divided into mechanical ankle instability and functional ankle instability.[24] Mechanical ankle instability is determined by a physical examination, such as the talar tilt test and anterior drawer sign.[20] Functional ankle instability is examined by the feelings that appears of functional movement when the ankle was weight-bearing and the experience of repetitive ankle sprain.[27] The functional ability of the ankle joint is defined by the ability of the sagittal and coronal planes and the capacity for coordinated movement. Basic movement measurements are the evaluation of joint flexibility, muscle strength, postural control ability, dynamic balance, and agility of athletes.

The FMS which was performed in this study to assess the performance ability of the subjects and their risk of injury.[12] In this study, the ankle joint dorsiflexion angle was significantly correlated with the deep squat. Deep squats are a good example of closed chain exercises, with changes in dynamic movement, including that of the lower body, when ankle flexion, knee flexion and hip flexion occur at the same time. The difference between three and two points of deep squat scores is the different degree of ankle flexion when it is in closed chain. The results of this study show that the ankle joint dorsiflexion angle is correlated with the Deep squat. A more limited angle in the dorsiflexion deep squat means that the performance is poor. When the deep squat score is 2 points or less, the subject can be considered to have a limited ROM of the ankle and instability.[21]

In a previous study, in-line lunges were a correlated with the FADI-ADL in ankle joints with chronic instability, this study also showed a significant correlation.[22] Also, the results of previous studies had a significant correlation with the ILL and ankle stability.[16] In-line lunges include rotation and lateral movement, and they can be used to evaluate hip and ankle joint movement and stability, quadriceps flexibility, and knee joint stability.[12]

In the section of COP sway distance, the score of deep squat and in-line lunges of one and 2 points subjects was higher than in subjects who received 3 points for the average velocity and path length. After ankle injury, the degree of dorsiflexion decreased, and this can affected static and dynamic balance ability.[23] Changes in balance ability and functional ankle instability can be due to changes in sensory and proprioceptive neuromuscular conditioning,[24] with the most visible variation in balance ability shown during static movements25. They can be considered a factor in increasing the COP path length and average speed. The hurdle step is used to assess the knee-hip extension ability and ankle stability while standing on one leg. In this study, the hurdle step showed ankle dorsiflexion angle and FADI was not related by healthy subjects who did not have a musculoskeletal disease. There was a correlation between the COP velocity and the path length were related to Hurdle step, because it is considered knee joint strength and

posture control ability.[26]

In conclustion, Deep squats and in-line lunges had significant correlation with ankle dorsiflexion ROM and FADI score. These results mean that the use of FMS should be limited for patients who have ankle joint limitation of motion and instability. Further study is needed to assess the clinically effect of FMS for sensitivity to differences between healthy and subjects with CAI, and responsiveness to changes in function scores in those with CAI after rehabilitation training.

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