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COMPARISONS OF FOOT POSTURE AND ANKLE AND KNEE STRENGTH BETWEEN ATHLETES WITH AND WITHOUT CHRONIC ANKLE INSTABILITY

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ABSTRACT

This study aims to evaluate foot posture and muscle strength around the ankle and knee joints in athletes with and without unilateral chronic ankle instability (CAI). Forty-one male athletes, aged between 18-36 years, were assigned to two groups; CAI and non-CAI groups. Handheld dynamometer was used to test isometric muscle strength in inverter, evertor, dorsiflexor, plantarflexor, knee flexor and knee extensor. Foot posture was evaluated using the foot posture index (FPI).

The results showed no significant differences in inverter, evertor, dorsiflexor, plantarflexor, knee flexor and knee extensor muscle strength and agonist/antagonist ratios between both groups ($p>0.05$). Subjects in both groups had normal foot posture on both feet. Subjects exhibited no significant differences in FPI score between groups ($p>0.05$). Moderate to high positive correlations were noted among the strength of these muscles ($r=0.61$ to 0.96, $p<0.01$). Additionally, 30% of subjects in CAI groups demonstrated musculoskeletal pain around the knee joint. The results of this study confirmed that all muscles in lower extremity work together, thus alteration of muscle strength of a muscle group might be affected to muscle strength of other joints. Therefore, clinicians should consider it for the assessment and prevention of injuries or for a rehabilitation program for athletes with CAI.

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KEY WORDS: CHRONIC ANKLE INSTABILITY/ FPI-6/ ANKLE STRENGTH/ KNEE STRENGTH

บทคัดย่อ

การศึกษานี้ มีวัตถุประสงค์ เพื่อเปรียบเทียบท่าทางของเท้า ความแข็งแรงของกล้ามเนื้อรอบข้อเท้าและข้อเข่าในนักกีฬาที่มีและไม่มีภาวะข้อเท้าไม่มั่นคง โดยทำการศึกษาในนักกีฬา 41 คนที่มีอายุระหว่าง 18-40 ปี แบ่งเป็น 2 กลุ่ม คือ กลุ่มที่มีภาวะข้อเท้าไม่มั่นคง 20 คน และกลุ่มที่ไม่มีภาวะข้อเท้าไม่มั่นคง 21 คน ผู้เข้าร่วมการศึกษาทั้งหมดจะถูกวัดความแข็งแรงของกล้ามเนื้อ inverter, evertor, dorsiflexor, plantarflexor, knee flexor and knee extensor โดยใช้ handheld dynamometer และตรวจประเมินท่าทางของเท้าโดยใช้ foot posture index

ผลการศึกษาไม่พบความแตกต่างอย่างมีนัยสำคัญทางสถิติของท่าทางของเท้า ความแข็งแรงของกล้ามเนื้อรอบข้อเท้าและข้อเข่า และการเปรียบเทียบความแข็งแรงของกล้ามเนื้อที่ทำงานคู่ตรงข้ามกันของกล้ามเนื้อรอบข้อเท้าและข้อเข่า ระหว่างขาทั้ง 2 ข้างในกลุ่มเดียวกันและระหว่างกลุ่ม ($p>0.05$) นอกจากนั้นพบว่าความแข็งแรงของกล้ามเนื้อรอบข้อเท้าและข้อเข่ามีความสัมพันธ์กัน ($p<0.01$) และ 30% ของนักกีฬาที่มีภาวะข้อเท้าไม่มั่นคงมีอาการเจ็บรอบข้อเข่าในข้างเดียวกัน การศึกษานี้แสดงว่า กล้ามเนื้อของรยางค์ขาทำงานอย่างสัมพันธ์กัน การเปลี่ยนแปลงของความแข็งแรงของกล้ามเนื้อหนึ่งอาจส่งผลต่อกล้ามเนื้ออื่นหรือข้อต่ออื่นได้ ดังนั้นในทางคลินิกควรออกแบบการตรวจประเมิน โปรแกรมการป้องกันและการฟื้นฟูในนักกีฬาที่มีภาวะข้อเท้าไม่มั่นคงให้เหมาะสม

INTRODUCTION

Ankle sprain is one of the most common injuries affecting athletes and people participating in sports. Eighty five percents of all ankle sprains are caused by inversion and/or plantar flexion trauma, resulting in damage to the lateral ligament complex[1]. The risk of sprain is higher in soccer about 45% and basketball 31%, respectively[2]. After initial lateral ankle sprain, the recurrence rate of athletes has been reported to be 73%, often limiting sport participation[3]. Lateral ankle sprains may further develop into chronic ankle instability (CAI) which contributes to mechanical and/or functional ankle instability. Mechanical ankle instability (MAI) involves joint laxity which is defined as exceeding the range over normal physiological range of motion[4, 5]. Functional ankle instability (FAI) is a condition that occurs a feeling of the ankle “giving way”, during activity where joint motion does not exceed the physiological range but is beyond voluntary control[5]. One of the contributing factors to FAI is strength deficit[5-7]. Previous studies found deficits in inverter[7], evertor[5, 8] and dorsiflexor strength[9]. However, conflicting results of muscle strength deficit were found[7, 10]. Furthermore, a difference of evertor/inverter muscle torque ratio was exhibited between injured ankles and uninjured ankles in subjects with CAI[11]. Therefore, agonist-antagonist ratios were more objectively evaluated and compared for muscle balance around the joint.

During actions, joints of the lower extremity do not work solely but in coordinated patterns. Consequently, the impairment of one level may cause the involvement of more relative joints through the lower extremity kinetic chain. Lateral ankle sprain happening during dynamic activity and static foot posture is a factor related to lateral ankle sprains and CAI[12]. Previous studies evaluated foot posture in a laboratory setting (computerized tomography or radiographs), presenting trends of increased calcaneal varus and high arch in subjects with CAI[13, 14]. These measurements are more accurate than clinical measurements, but are more complicated for clinical evaluation.

Moreover, the knee joint has structural and anatomical linkage to the ankle. Press and Young supported that a history of ankle sprain and hyperpronation of the subtalar joint with increased internal rotation of tibia might lead to increased knee pain[15]. Consequently, prolonged CAI might alter foot posture and cause musculoskeletal problems around the knee joint. Several previous researches had focused only on the ankle joint, and studied in laboratory settings, but the appropriate clinical assessments are still necessary for

detecting musculoskeletal disorders in athletes with CAI. Therefore, this study aims to evaluate foot posture and muscle strength around the ankle and knee joints in athletes with and without CAI.

MATERIALS AND METHOD

Subjects

Subjects were 41 male athletes (football and basketball players), aged from 18-36 years. The subjects were divided to 2 groups; CAI group and non-CAI group. Inclusion criteria for CAI group consisted of a history of unilateral lateral ankle sprains at least twice on the same side in 6 months, having a sensation of giving way in the last 6 months and the Cumberland Ankle Instability Tool (CAIT) score less than 27. Inclusion criteria for non-CAI group were no history of lateral or medial ankle sprain within 6 months and a CAIT score that is equal to or more than 28, and a negative ankle instability test. Exclusion criteria for both groups consisted of having acute inflammatory signs and symptoms of ankle and knee injury within 6 weeks, a history of surgery or injury of a lower extremity, and participation in a rehabilitation program for ankle instability. All subjects signed an informed consent before participation. This study was approved by the Ethical Committee on Human Rights Related to Research, Mahidol University.

Protocol

All subjects completed a questionnaire about their demographic data, musculoskeletal problems and a CAIT questionnaire. The subjects would be evaluated by an ankle instability test (anterior drawer test and talar tilt test). An examiner was blinded about data concerning the questionnaire and group allocation during the evaluation session. Firstly, subjects were palpated for tenderness at complaint area, and had their foot posture using the FPI-6, which is a clinical tool used for observing static foot posture, composed of 6 criteria. Each criterion will be scored on 5 point scale, grade 0 for neutral, with a minimum score of -2 for supination and +2 for pronation, therefore total score ranges from -12 to +12. Intra-rater reliability and inter-rater reliability ICC (2,1) of FPT-6 in the literature were 0.88 and 0.69, respectively[16].

Then, each subject was randomly measured for muscle strength around ankle and knee joints, including the inverter, evertor, dorsiflexor, plantarflexor, knee extensor and knee flexor by using handheld dynamometer (Lafayette manual muscle test system). For inverter, evertor, knee extensor and knee flexor strength testing, the subject was in a sitting position with the hip and knee flexing at 90°. For inverter and evertor strength measurement, the dynamometer was applied to medial and lateral side of foot, respectively and examiner's hand was placed above the malleoli for stabilization. For knee extensor and knee flexor strength testing, the dynamometer is placed on the anterior and posterior surface of the distal tibia, respectively. For dorsiflexor and plantarflexor strength testing, the subject was in supine with hip flexed at 60° angle; the knee and ankle at a neutral position. The dynamometer was placed on the dorsal and plantar surface of foot, respectively and the examiner's hand was placed above the malleoli for stabilization. The

subjects hold a maximal effort against the dynamometer for 5 second per trial, totally 3 trials for each muscle power group, a 1 minute rest between each trial was given.

Statistical analysis

The parameters of this study, such as the FPI-6 score and ankle and knee muscle strength (kilograms; kg) and agonist-antagonist ratios were compared between groups and sides using two-way ANOVA. If there are significant differences, Bonferron post-hoc comparison would then be used. Descriptive statistics were used to describe musculoskeletal problems. Correlation between ankle and knee muscle strength, FPI-6 score and onset of ankle sprain were tested for normal distribution by using Kolmogorov-smirnov Goodness of Fit test; $p>0.05$. If data is normally distributed, the parameters are investigated using Pearson's product moment correlation. If data is not normally distributed, Spearman's rank order correlation was used. The statistical significant level is set at a probability level of less than 0.05 ($p<0.05$).

RESULTS

Table 1 shows demographic data of the subjects. Subjects in CAI and non-CAI groups showed no significant differences in muscle strength, agonist-antagonist ratios and FPI scores between groups and sides ($p>0.05$). Subjects in both groups presented normal foot posture of both feet. Table 2 presents a comparison of the parameters of the study. Additionally, this study found positive correlations among the muscle strength of those muscles ($p<0.01$), but no significant correlation among scores, onset of ankle sprain and muscle strength was found ($p>0.05$). Table 3 shows correlations among the strength of muscles and onset of ankle sprain and FPI scores in CAI group.

DISCUSSION

The biggest group of CAI subjects had unilateral CAI in the dominant side of totally 14, or 70% of all subjects in the CAI group. A prospective study of Ekstrand and Gillquist found that ankle sprains were more common in dominant legs of athletes, due to the fact that the dominant leg was more exposed to forced inversion during jumping and kicking. When the timing of position of the ankle during landing was unsuitable, the ankle might get a recurrent ankle sprain which might develop to CAI[17, 18].

Table 1 Demographic data of the subjects

Characteristics	Mean ± SD		p-value
	CAI (n=20)	Non-CAI (n=21)	
Age (years)	24.60 ± 4.79	24.00 ± 5.37	0.708
Weight (kg)	67.55 ± 8.37	71.52 ± 7.61	0.434
Height (centimeters)	173.42 ± 6.05	176.48 ± 6.24	0.120
BMI (kilograms/meters^2)	23.07 ± 1.87	22.99 ± 2.47	0.911
Onset of ankle sprain (years)	3.62 ± 3.89	0.84 ± 0.82	<0.01*

* Significant difference at p<0.05

Table 2 Comparisons of muscle strength (kg), agonist/antagonist ratios and FPI scores.

Parameters	CAI group Mean ± SD		Non CAI group Mean ± SD		p-value		
	CAI	Non CAI	Dominant	Nondominant	Group	Side	Groupandside
Inverter	21.93±10.16	22.16±8.81	24.73±11.36	25.01±10.84	0.225	0.913	0.993
Evertor	20.65±9.37	21.72±9.18	24.50±11.34	24.62±10.70	0.142	0.794	0.836
Dorsiflexor	31.43±13.04	32.52±12.94	37.09±14.38	36.20±13.64	0.125	0.973	0.744
Plantarflexor	32.21±13.55	30.70±11.77	35.30±15.50	33.88±14.66	0.316	0.640	0.989
Knee extensor	36.07±16.09	35.04±15.80	39.30±17.33	38.51±16.26	0.362	0.803	0.973
Knee floxor	32.69±14.06	32.65±12.01	39.10±18.32	36.36±17.46	0.153	0.694	0.701
Invertor/evertor	1.08±0.17	1.03±0.16	1.02±0.14	1.02 ± 0.14	0.348	0.514	0.505
Dorsiflexor/plantarflexor	1.03 ± 0.21	1.06 ± 0.16	1.09±0.23	1.11 ± 0.22	0.297	0.616	0.956
Knee extensor/flexor	1.08 ± 0.13	1.06 ± 0.15	1.02 ± 0.14	1.08 ± 0.13	0.753	0.456	0.193
Total FPI scores	5.60 ± 2.26	4.40 ± 2.85	4.95 ± 3.23	4.90 ± 3.94	0.918	0.372	0.409

Table 3 Correlation among the strength of muscles and onset of ankle sprain and total FPI scores in CAI group.

Muscle	Evertor	Dorsiflexor	Plantarflexor	Knee extensor	Knee flexor	Onset of ankle sprain	FPI scores

Inverter	r	0.953	0.866	0.937	0.868	0.718	-0.225	0.176
	pvalue	<0.001*	<0.001*	<0.001*	<0.001*	<0.001*	0.340	0.459
Evertor	r		0.934	0.957	0.875	0.666	-0.262	0.067
	pvalue		<0.001*	<0.001*	<0.001*	<0.01*	0.264	0.778
Dorsiflexor	r			0.912	0.848	0.612	-0.184	0.109
	pvalue			<0.001*	<0.001*	<0.01*	0.438	0.648
Plantarflexor	r				0.926	0.690	-0.265	0.149
	pvalue				<0.001*	<0.01*	0.259	0.531
Kneeextensor	r					0.828	-0.166	0.160
	pvalue					<0.001*	0.483	0.500
Knee flexor	r						0.333	0.243
	pvalue						0.152	0.302
Onsetof	r							-0.090
anklesprain	pvalue							0.706

* Significant difference at $p<0.05$

Comparing isometric muscle strength between CAI and non-CAI groups, significant differences were not found in inverter and evertor between affected and unaffected ankle within the group. Nevertheless, subjects with CAI showed a trend toward decrease in muscle strength. Similarly, previous studies failed to exhibit inverter and evertor strength deficits in unilateral FAI subjects[19-21]. Additionally, conflicting results by Wilkerson, et al. found inverter and evertor strength deficits in FAI subjects[7]. The conflicting results caused by differences of material and method included the position of the subjects during strength examination and type of muscle contraction.

The subjects in the CAI group had a trend toward a decrease of dorsiflexor and plantarflexor strength, but exhibited no significant difference in dorsiflexor and plantarflexor strength between CAI and non-CAI groups. Similarly, McKnight and Armstrong did not find significant difference in dorsiflexor and plantarflexor strength in subjects with CAI compared to healthy subjects[10]. Even so, the mechanism of a lateral ankle sprain affects an injury of lateral ligament and tendons of evertor and dorsiflexor muscle. Because of this, this study examined the maximum force of the evertor and dorsiflexor at one angle in open kinetic chain position. But in most activities in sports, lower limbs were in a closed kinetic chain position consisting of suitable force of muscle around joints, movements of joints and the dynamic stability of joints. Therefore, this study could not detect altered muscle strength of evertor and dorsiflexor in subjects with CAI. Additionally, the results of this study showed no significant difference in knee extensor and knee flexor strength within and between groups, because the knee extensor (quadriceps) and knee flexor (hamstrings) work in a coordinated pattern that operates in an eccentric and concentric contraction with suitable force, and does not generate the maximum

force of muscles during walking, running and sprinting[22, 23]. Therefore, this study did not find an alteration of knee extensor and knee flexor strength in the maximum isometric strength measurement.

This study measured isometric strength and explained it in terms of the agonist-antagonist ratio. The results exhibited no significant difference in the inverter/evertor, dorsiflexor/plantarflexor and knee extensor/flexor ratios between groups and within the group. Previous studies found that subjects with CAI had no significant difference in eccentric/concentric ratio of inverter and evertor muscle when compared to the control group[21]. A conflicting result by Pontaga found that male handball players with recurrent ankle lateral ligament sprains had a significantly lower evertor/inverter muscle torque ratio in inversion position when compared to uninjured ankle[11].

In addition, a previous study investigated the dorsiflexor/plantarflexor ratio in elite sprinters. Subjects had a dorsiflexor/plantarflexor ratio in concentric and eccentric contraction at 30° /sec and 180° /sec as 0.32, 0.28, 0.38 and 0.34, respectively[24]. However, this study reported conflicting result that plantarflexor strength was equal or less than dorsiflexor strength in isometric contraction. Moreover, this result showed no significant difference in knee extensor/flexor ratio between groups and within the group. The subjects in CAI group had knee extensor/flexor ratio as 1.08 and 1.06 in affected and unaffected sides, respectively. Similarly, the study done by Macintyre and Wessel evaluated extensor/knee flexor ratio in female recreational runners with patellofemoral pain syndrome that showed knee extensor/flexor ratio in concentric and eccentric contraction as 1.02 and 0.87, respectively[25]. This study demonstrated the equality of agonist/antagonist ratio of invertor/evertor, dorsiflexor/plantarflexor and knee extensor/flexor ratios between athletes with and without CAI. It is possible that the athletes were trained in agonist and antagonist muscle strength, and thus isometric assessments using a handheld dynamometer for indication of static stability around the joint in open kinetic chain position could not manifest an alteration of muscle strength and agonist-antagonist ratio of these muscles.

The researcher expected that athletes with prolonged CAI would have an alteration of foot posture. However, subjects showed no significant difference of FPI scores between groups and within the group. Additionally, they also were not clinically significant. It is possible that athletes with unilateral CAI may not be altered in static foot posture. Conflicting results from previous studies showed an increase in calcaneal varus in subjects with CAI and higher arches[13, 14], but these studies measured with computerized tomography or radiography and in open chain position.

No significant correlations were found between FPI score, onset of ankle sprain and the muscle strength in subjects with CAI. It is possible that the onset of ankle sprain may not be affected by foot posture and muscle strength. Willems et al did not find a relationship between inverter muscle strength and ankle sprain in subjects with a history of ankle sprain[21]. In addition, a previous study demonstrated a relationship between peroneal and inverter muscle weakness and CAI[26]. Anyhow, the results showed positive correlations among the strength of muscles. Similarly, a previous study showed a significant relationship between

plantarflexion, dorsiflexion, inversion and eversion average power in subjects with CAI[27]. They suggested that patients with CAI, who had muscle weakness in one direction, should perform muscle strengthening exercise in all muscle directions. Additionally, the study found that the musculoskeletal pain appeared around the knee in affected limb, as 30% of subjects in the CAI group. This finding demonstrates that all muscles in the lower extremity work together during activity. Consequently, alteration of muscle strength in one muscle group might affect the muscle strength of other joints. Therefore, a clinician should consider it for assessment and prevention or a rehabilitation program for the athletes with CAI. Moreover, it is interesting

for future study to design training program for improving muscle balance of the lower extremity during activity. The researcher

recruited subjects during pre-season time, the recruitment was limited. The effect size of this study was perhaps low according to the inadequacy of subjects to detect clinical significance. Future study should control athletes, sporting level, sport types and level of competition. Moreover, future study should consider an assessment for musculoskeletal pain of near structures of ankle joint, severity of pain and investigate musculoskeletal pain that affects performance of sport in athletes with CAI.

CONCLUSION

This study aimed to present appropriate clinical assessments for detecting musculoskeletal disorders in athletes with CAI. The results failed to determine the isometric muscle strength deficit and imbalance of agonist/antagonist of muscle around ankle and knee joint in athletes with unilateral CAI. Additionally, athletes with unilateral CAI performed with normal foot posture in both feet. However, this study found musculoskeletal pain around the knee joint in the affected side. Moreover, a positive correlation among muscle strength around the ankle and knee joints demonstrated that all muscles in the lower extremity work in a coordinated pattern. Consequently, a clinician should consider it for assessment and prevention or when considering a rehabilitation program for the athletes with CAI.

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