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Original Article

Comparison of maximum strength, proprioceptive, dynamic balance, maximum joint angle of stability and instability ankle by Cumberland Ankle Instability Tool

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Abstract. [Purpose] The purpose of this study was to investigate the factors of ankle instability by using Cumberland ankle instability tool (CAIT), which have been frequently used as ankle instability tools. The participants were divided into the normal ankle group and the instability ankle group. Maximum strength, proprioception, dynamic balance and maximum rage of joint motion were compared in order to find out factors of instability in the questionnaires. [Participants and Methods] A total of 44 participants were classified into the control (CON) group and the chronic ankle instability (CAI) group according to questionnaire types. Muscle strength, proprioception, dynamic balance and maximum joint angle were measured. The independent t-test was used. [Results] In the case of maximum ankle strength, it showed significance in CON group and CAI group ankle dorsiflexion and plantarflexion. In proprioception, it showed significance in CON group and CAI group. In dynamic balance, it showed significance in anterior (ANT) direction of the CON group and CAI group. Maximum joint angle produced significance in dorsiflexion of CON group and CAI group. [Conclusion] Information on maximum strength, proprioception, dynamic balance of anterior direction, and maximum joint angle of dorsiflexion is available through questionnaire CAIT.

Key words: Cumberland Ankle Instability Tool, Chronic ankle instability, Ankle questionnaire

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INTRODUCTION

Freeman defined a subjective giving way sensation of ankle caused by the repeated ankle sprain as a chronic ankle instability (CAI)[1)]. People with a chronic ankle instability experience lack of ankle muscle strength and sense of position, reduction in reaction time of peroneus, lower balancing ability, and reduction in the range of dorsiflexion in relation with ankle instability[2)]. Kelli et al. reported that weakening of muscle due to frequent damage weakens the functional movement and stability of the ankle joint[3)]. In addition, repeated ankle injury or functional degradation of ankle lowers a sense of postural control[4)], degrades proprioception, and causes a non-alignment of the lower extremity[5)].

According to the existing research that analyzed the cost of ankle instability, the cost of diagnosing and treating a chronic ankle sprain is 318 to 941 dollars per patient[6)]. Considering the consumed cost, there needs to be a way to diagnose the ankle instability in cheaper ways. As a result, self-report survey is recommended as a tool for evaluating the chronic ankle instability[7)].

Recently, Cumberland ankle instability tool (CAIT) is known for its high reliability and validity. CAIT is the first tool to

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score the degree of ankle instability. It is composed of 9 questions and patients with score from 24 to 30 out of 30 are defined to have ankle instability[8].

Thus, this study used CAIT survey on 44 participants, divided them into normal group and ankle instability group, and compared the maximum muscular strength, proprioception, dynamic balance, and the maximum joint range to suggest the type of information that questionnaires give to therapists for x-ray and MRI before therapists treat the patients who visit the hospitals for ankle problems.

PARTICIPANTS AND METHODS

This study targeted on 44 adult males and females majoring in physical therapy at D University located in Daegu, Korea. They were explained about the purpose and procedures thoroughly in the briefing session, and they were selected students who volunteered (Table 1).

The standards of selecting participants were as follows. First, the participants did not get injured within the last three months. Secondly, the participants did not get any injuries on the lower leg within the last three months. Third, the participants did not have any symptoms of concussion or dizziness[9, 10]. After thoroughly explaining the purpose and details of the research, participants were selected who voluntarily agreed on participation according to the ethical principles of Declaration of Helsinki.

Participants were given a self-administered survey, CAIT and participants who got scores over 24 were divided into stability group while participants who got scores lower than 24 were divided into instability group[11]. Then, the stability group's dominant ankle (control group) and instability group's ankle instability (CAI Group) were compared.

After that, participants in each group were measured of muscular strength, proprioception, dynamic balance, and maximum joint angle. Also, the intervention and measurement were performed by a physical therapist with at least five years of clinical experience to enhance the reliability.

To measure the maximum isometric contraction of the muscle used for dorsiflexion and plantarflexion, this study used a dynamometer (baseline hydraulic manual muscle testers, Fabrication Enterprises Inc). Resistance was applied on the opposite direction of the dorsiflexion and plantarflexion for the maxim voluntary isometric force (MVIF) and its force was measured in kg unit. The measurement angle was set to the maximum voluntary plantarflexion of 45° and dorsiflexion of 25°. The participants were made to keep a posture of sitting on a chair for the anti-gravity status. Also, to prevent the compensation of hip joint during the measurement, the participants were made to cross their two arms on the chest and fix their trunk. The participants practiced each of them three times before the experiment to enhance the adaptability to the experiment. In addition, the break time between each set was put to one minute[12].

This study used a joint position sense test to measure proprioception. For the measurement, this study used a motion biofeedback device Relive (Seoul, Korea). Relive is an inertial measurement tool and it uses earth's magnetic field and sea level to print the absolute angle. Relieve prints the angle between two sensors and the relative angle is measurable by measuring the position of the other sensor with a sensor. This equipment calculates the movement found on a side vertical to set axis (X, Y, Z). The participants were made to stretch knees on a table and put ankles in a neutral position. One sensor is attached to the sole while the other sensor is placed on a horizontal table. The test measured the error angle three times in dorsiflexion and plantarflexion of 10° and 15° respectively to get the mean value (Fig. 1)[13].

This study used modified Excursion Balance Test (SEBT) to evaluate the dynamic balance. Modified SEBT shows a high level of reliability (ICC=0.91) in diagnosing the participants with ankle instability. modified SEBT selects three lines and they are used as the grounds for telling whether the stability and balance have been improved or degraded depending on the

Table 1. General characteristics of the participants

	CON (n=22)	CAI (n=22)
Age (years)	24.90 ± 3.57	25.27 ± 4.49
Height (cm)	169.81 ± 7.33	168.13 ± 7.72
Wight (kg)	67.72 ± 13.12	63.22 ± 11.66

All values are mean ± standard deviation (SD).
CON: control group; CAI: choronic ankle instability.

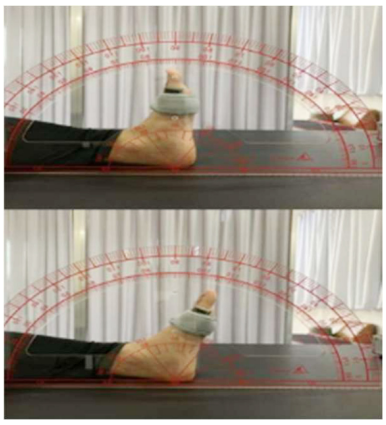

Fig. 1. Joint position sense test.

measurement distance[14]. In the measurement, modified SEBT uses lines indicated on a floor and the name for each direction is called anterior (ANT), posterior-medial (PM), and posterior-latera (PL) in the clock-wise order[15]. The participants were made to put their heels on a designated place and stretch the foot as far as possible while keeping the feet on the ground. The measurer used a tape measure to measure the distance that the participants kept the stretched feet for at least three seconds (Fig. 2).

This study used an angle meter to measure the maximum joint angle. The participants were made to sit straight, bend knee joint by 90°, set lateral malleolus as the axis, and make the stationary arm parallel to the centerline in the lateral fibula while making the moving arm parallel to the centerline in the lateral fifth metatarsal bone. Then, the participants were measured of the maximum range for dorsiflexion and plantarflexion[16].

For the processing of data collected in this study, a commercial statistics program, SPSS ver. 20.0 for Windows, was used to calculate and compare the mean and standard deviation for each variable. For a normal distribution of each measurement item, this study conducted Shapiro–Wilk to get the normal distribution. Also, to find out whether the groups were the equivalence group, this study used independent t-test to test the homogeneity on general characteristics of the participants. This study also conducted independent t-test to compare and analyze between stability ankle group and instability ankle group. The level of significance for all statistical analyses were α=0.05.

RESULTS

The general characteristics of participants were as described in Table 1. There were total of 44 participants.

CAI group showed significantly lower maximum muscular strength in dorsi flexion and planta flexion compared to the control group ($p<0.05$) (Table 2).

CAI group showed significantly higher joint reposition in dorsiflexion and plantarflexion compared to the control group ($p<0.05$) (Table 2).

CAI group showed significantly shorter time in keeping dynamic balance in anterior ($p<0.05$) compared to the control group. While CAI group kept the dynamic balance in posterior medial, posterior lateral for the shorter time than the control group, there was no significant difference ($p>0.05$) (Table 2).

CAI group showed a statistically significant difference in dorsiflexion ($p<0.05$) compared to the control group while not showing a statistically significant difference in plantarflexion ($p>0.05$) (Table 2).

DISCUSSION

This study used a questionnaire with high reliability and validity, classified the stability ankle and instability ankle, and compared the maximum muscular strength, joint reposition, dynamic balance, and maximum angle to figure out the information that questionnaires such as x-ray and MRI give to therapists.

In comparison of the maximum muscle strength in dorsiflexion and plantarflexion, CAI group showed significant lower maximum muscle strength compared to the control group ($p<0.05$). According to the preceding research by Ji et al., junior

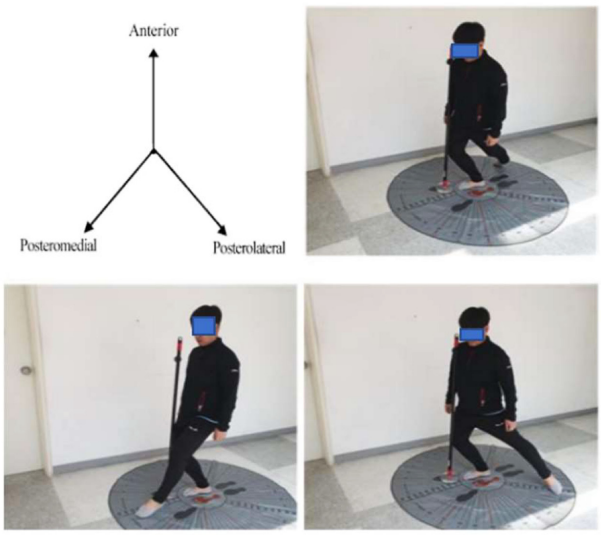

Fig. 2. Dynamic balance.

Table 2. Comparison of the CON group and CAI gorup (n=44)

		CON	CAI
MS (kg)	DFMS*	15.45 ± 4.68	12.77 ± 2.75
	PFMS*	22.54 ± 6.52	18.40 ± 4.86
JPST (°)	DF 10°*	2.27 ± 1.16	3.36 ± 2.10
	PF 15°*	2.72 ± 1.38	4.68 ± 3.98
DB (cm)	ANT*	85.81 ± 5.70	81.95 ± 5.68
	PM	84.77 ± 7.62	81.40 ± 10.36
	PL	88.54 ± 6.99	85.77 ± 11.53
MA (°)	DFMA*	24.68 ± 5.37	19.95 ± 5.37
	PFMA	58.22 ± 9.85	52.95 ± 9.85

*p<0.05.
CON: control gorup; CAI: choronic ankle instability group; MS: maximum strength; JPST: joint postion sense test; DB: dynmaic balance; MA: maximum angle; DFMS: dorsi flexion maximum strenth; PFMS: platar flexion maximum strenth; DF 10°: dorsi flexion 10°; PF 10°: plarat flexion 15°; ANT: anterior direction; PM: posterior medial direction; PL: posterior lateral direction; DFMA: dorsi flexion maximum angle; PFMA: platar flexion maximum angle.

volleyball players with CAI showed weakening of plantarflexion muscle and balance ability ($p<0.05$)[9]. Also, the research by Chun and Choi demonstrated a significant difference in ankle's muscle strength of soccer players in the dorsiflexion and plantar flexion for the isokinetic angular speed of 30°/sec 120°/sec respectively ($p<0.01$)[10]. In the research by Lee et al., CAI with instable ankle showed a significantly lower muscular strength of ankle joint compared to the stable ankle. The preceding researches show that CAIT is capable of providing information on the muscular strength evaluation[17].

Measuring a joint position sense is mainly used to examine proprioception[18]. There are various ways to measure the position sense and this study measured the position sense by having the participants reproduce the target angle actively[19]. In the questionnaire-based joint re-position evaluation, CAI group showed a higher significance in dorsiflexion and plantarflexion than the control group ($p<0.05$). In the research by Chun and Choi, soccer players with ankle instability showed significant differences in active joint reposition sense for dorsiflexion and plantarflexion compared to the stable ankle ($p<0.05$)[10]. In comparison of the muscular strength of stable ankle group and instable ankle group after proprioception exercises, the participants showed a statistically significant increase in muscular strength for plantarflexion[12]. Also, while muscular exercise has a direct influence on the ankle muscle strength, there was an intervention of proprioception in muscular function adjustment and joint movement to keep a posture[20]. The preceding results on maximum muscular strength explain about the reason for lower muscular strength in instable ankle in connection with proprioception. This demonstrates that CAIT provides information on proprioception of the ankle joint.

In Y-Balance Test, CAI group showed a significantly shorter ANT compared to the control group ($p<0.05$) while lacking significance in PM and PL ($p>0.05$). According to the Y-Balance Test results of a preceding research, adults with CAI show a significantly shorter stretchable range compared to normal people[21, 22]. This is because adults with CAI try to keep the base of support closer during stretch due to local anatomical limitations or changes in sensorimotor system[23, 24]. In accordance with the research by Freeman, people with functional ankle instability show lower postural balance control of the affected side's lower leg compared to the non-affected side's lower leg[1]. Especially, the muscle activity of soleus and peroneus in the balancing motion[10]. Baek pointed out that ANT holds the correlation between plantarflexion's maximum muscular strength and severity while having a high correlation with movable range of ankle ($p<0.05$)[25]. It is assumed that there exists a significance in distance toward ANT direction because the ankle instability group shows lower muscle strength of plantarflexion and significance in movable range of ankle. Also, a preceding research reported that PM distance is correlated with abduction of hip joint while PL is correlated to extension of hip joint[26]. Thus, because CAIT questionnaire does not include questions for evaluating the injuries or pain related to hip joint, it is difficult to identify the influence on PM and PL precisely.

In CAIT classification, CAI group showed a significant difference in dorsiflexion compared to the control group ($p<0.05$) while not showing a significant difference in plantarflexion ($p>0.05$). The normal moving range of ankle is 10–20° for dorsiflexion and 45–50° for plantarflexion[27]. In the moving range of instability ankle, CAI group showed a remarkable decrease in dorsiflexion[28]. According to Mattacola and Dwyer, people with a chronic ankle instability show a decreased dorsiflexion compared to normal people[29]. The research by Terada et al. also pointed out that there needs to be an intervention method for increasing the moving range of ankle joint for the chronic ankle instability[30]. Thus, an evaluation tool which accurately measures the maximum angle of the ankle joint is crucial.

This study is a cross-sectional study. The objective of this study was to obtain the information on patients by classifying participants into stable ankle group and instable ankle group by using CAIT questionnaire and comparing the maximum muscle strength, joint reposition, dynamic balance, and maximum joint ankle.

In the results, CAIT questionnaire demonstrated that participants would show difference in maximum muscle strength and proprioception. The results also showed the difference in the balance sense for ANT direction in dynamic balance while demonstrating the difference in the maximum dorsiflexion. Such information is a great reference to x-ray and MRI for therapists before treating patients who visited the hospital for ankle problems.

The limitations of this study were firstly, this study could not measure the relative dynamic balance depending on leg lengths of participants. Secondly, this study could not compare the relative muscle strength depending on weights of participants. Thirdly, this study was conducted for a short time and the research results are not enough to be generalized. Therefore, there needs to be further researches with longer application period and additional methods.

Conflict of interest

There are no conflicts of interest relevant to this article.

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