



Original Article

# Comparison of maximum strength, proprioceptive, dynamic balance, maximum joint angle between two groups classified through the ankle instability instrument

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**Abstract.** [Purpose] The purpose of this study is to figure out the information obtainable from ankle instability instrument (AII) survey among various factors related to the ankle instability. [Participants and Methods] This study targeted on 34 participants, divided the participants into stability group and instability group based on AII survey results, and measured the maximum isometric contraction, proprioception, dynamic balance, and maximum joint angles. The independent t-test was used. [Results] The maximum isometric contraction showed significance in the plantar flexion while the proprioceptive sense showed significance in both dorsiflexion and plantar flexion. The dynamic balanced showed significance in the anterior direction while the maximum joint angles showed significance in the dorsiflexion. [Conclusion] According to the results, the participants who were classified as ankle instability patients based on AII survey results involved problems in the maximum isometric contraction, proprioception, dynamic balance, and maximum joint angles.

**Key words:** Ankle instability instrument, Chronic ankle instability, Ankle questionnaire

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## INTRODUCTION

The repeated ligament injury involves subjective instability, inflammation, and edema and such symptom is referred to as chronic ankle instability (CAI)<sup>1)</sup>. According to Freeman, also defined the subjective feeling of turning ankle from the repeated ankle sprain as an ankle instability<sup>2)</sup>.

Instability involves the symptoms such as muscular weakness and degradation of balance and coordination because the muscle, ligaments, and tendons that have been supporting around the ankle joints failed to recover to the normal state before the injury. The research also pointed out that such symptoms result in the subjective feelings of ankle joint instability and repeated injuries<sup>3)</sup>.

The research by Hertel, claimed that chronic ankle instability is associated with the weakness of ankle muscles, lack of position sense, reduced reaction time of peroneus muscle, reduced balancing ability, and reduced range of dorsiflexion<sup>4)</sup>. Snyder et al. also reported that the muscular weakening caused by the frequent injuries also weakens the functional movement and stability of the ankle joints<sup>5)</sup>. In addition, the repeated ankle injuries or functional degradation of ankles negatively influence on the postural sense<sup>6)</sup>, damages proprioception, and causes malalignment of the lower extremity<sup>7)</sup>.

In accordance to the researches on cost of ankle instability diagnosis, it costs 318 dollars to 941 dollars per patient to assess and treat the acute ankle sprain<sup>8)</sup>. Meanwhile, once the ankle sprain happens due to the functional instability or other causes, the recurrence rate reaches up to 75%<sup>9)</sup>. Considering the high costs and recurrence rate, it is necessary to come up

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with cheaper ways to assess the ankle instability. In response, self-reported survey is recently recommended as a tool for assessing the chronic ankle instability<sup>10</sup>.

For the ankle instability survey instrument, Docherty et al. assessed the participants who were diagnosed with the chronic ankle instability and participants with lower extremity joint issues and pointed out that 4 point-based cut-off system would be appropriate as the reference point for the chronic ankle instability assessment<sup>11</sup>.

Nevertheless, the previous researches lack consistency due to the varying standards for the chronic ankle instability. For these reasons, it is hard to come up with clear standards to assess the chronic ankle instability. In fact, there is no standardized assessment method for the ankle instability<sup>12</sup>.

While the chronic ankle instability involves numbers of factors including muscular strength, proprioception, dynamic balance, and maximum joint angles, none of the previous researches explained or tested the instability factors implied in the ankle instability instrument (AII) survey. To figure out the meaning of the AII survey, this study measured the muscular strength, proprioception, dynamic balance, and maximum joint angles and tried to find out the instability factors implied in the ankle instability assessment tool.

## PARTICIPANTS AND METHODS

This study recruited through public notice selected total of 34 participants (males 18, females 16) majoring in physical therapy at D University located in Daegu, Korea, who were given explanation on goals and purposes of this study and volunteered under the ethical principles of Helsinki Declaration (Table 1). In the self-reported AII survey (Reliability=0.98) known for its high validity and reliability, the tool to score the degree of ankle instability<sup>13</sup>. It is composed of 11 questions and patients with score of 5 or more out of 11 are defined to have ankle instability. This study divided the participants into ankle stability group and ankle instability group based on the cut off value of 5 to measure the maximum isometric contraction, proprioception, dynamic balance, and maximum joint angles.

For the participant exclusion criteria, this study excluded the participants who had any injury, concussion, or dizziness within three months<sup>14, 15</sup>. Also, the intervention and measurement were performed by a physical therapist with at least five years of clinical experience to enhance the reliability.

In measurement of the maximum isometric contraction, this study made the participants sit on a chair and measured the force at 25° of dorsiflexion angle and at 45° of plantar flexion by using the push-pull force gauge. Then, the maximum isometric contraction was measured in kg unit by applying the resistance in direction opposite from the muscle pull direction<sup>16</sup>.

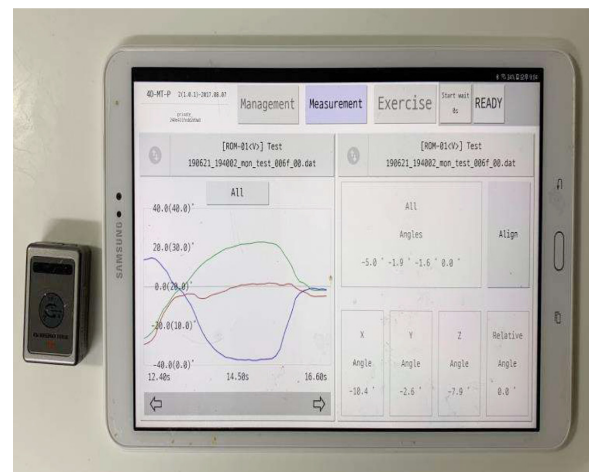
To measure the proprioception, this study used a motion analysis system (biofeedback device Relive, Koreatech co., Seoul, Korea) to measure the joint position (Fig. 1). The participants were made to place an ankle with neutral position on a table. The first sensor was attached on the 3rd metatarsal bone and the second sensor was placed on a horizontal table. The ankle position was measured three times at 10° of dorsiflexion angle and at 15° of plantar flexion to calculate the mean angle error<sup>17</sup>.

For dynamic balance, this study used Star Excursion Balance Test (SEBT). SEBT is a test with high reliability (ICC=0.91) and it measures whether the balancing ability increased or not by setting up three lines and measuring the distance. The three lines indicated on the floor are anterior direction, posterior medial direction, and posterior lateral direction in clockwise order<sup>18</sup>. The participants were instructed to stand in the middle, balance on one leg while reaching as far as possible, and maintain the stretched posture for at least three seconds. Then, measurer measured the spots that participants touched<sup>19</sup>.

**Table 1.** General characteristics of the participants

	Stability group (n=17)	Instability group (n=17)
Age (years)	24.98 ± 3.11	24.23 ± 2.65
Height (cm)	170.21 ± 6.59	168.00 ± 7.75
Weight (kg)	65.27 ± 12.12	63.52 ± 14.62

All values are mean ± standard deviation (SD).



**Fig. 1.** Biofeedback device.

To measure the maximum joint angles, this study used a goniometer. The participants were instructed to sit on a chair and bend knee joint to 90°. After setting lateral malleolus as the axis, the fixed arm was placed parallel to the lateral fibula's center line while the other unfixed arm was placed parallel to 5th lateral metatarsal bone to measure the maximum angles of dorsiflexion and plantar flexion (Fig. 2)<sup>20</sup>. The patients obtains the average of the values of three times of dorsiflexion and plantarflexion with active movement.

This study used statistical software, SPSS ver 22.0 for Windows (SPSS Inc., Chicago, IL, USA), and calculated the mean and standard deviation. This study also conducted an independent t-test for the comparative analysis on ankle stability group and ankle instability group. The significance level for all statistical analyses was  $\alpha=0.05$ .

## RESULTS

Maximum isometric contraction showed significantly lower in the instability group than in the stability group in plantar flexion (Table 2).

Joint relocation showed significantly higher in the instability group than in the stability group in all directions (Table 2).

Dynamic balance showed significantly lower in the instability group than in the stability group in anterior direction (Table 2).

Maximum joint angle showed significantly lower in the instability group than in the stability group in dorsiflexion (Table 2).

## DISCUSSION

In the dorsiflexion of the ankle stability and instability groups, the participants didn't show significant difference in the maximum muscular strength ( $p>0.05$ ). In the comparison on plantar flexion, the participants showed significant difference in the maximum muscular strength ( $p<0.05$ ).



Fig. 2. Maximum joint angle.

Table 2. Comparison of the stability group and instability group (n=34)

		Stability group (17)	Instability group (17)
Maximum strength (kg)	DFMS	13.54 ± 4.13	12.82 ± 4.14
	PFMS*	23.04 ± 5.94	17.41 ± 6.99
Joint position sense test (°)	DF 10°*	2.07 ± 1.64	3.52 ± 2.06
	PF 15°*	2.25 ± 1.83	4.41 ± 2.23
Dynamic balance (cm)	ANT*	86.41 ± 6.55	82.17 ± 7.36
	PM	83.14 ± 6.62	81.58 ± 10.06
	PL	87.12 ± 6.87	86.11 ± 7.31
Maximum angle (°)	DFMA*	25.98 ± 6.55	22.14 ± 7.88
	PFMA	56.24 ± 9.71	54.05 ± 9.83

\* $p<0.05$ .

DFMS: dorsi flexion maximum strength; PFMS: plantar flexion maximum strength; DF 10°: dorsi flexion 10°; PF 15°: plantar flexion 15°; ANT: anterior direction; PM: posterior medial direction; PL: posterior lateral direction; DFMA: dorsi flexion maximum angle; PFMA: plantar flexion maximum angle.

According to the research by Cho et al., the ankle instability involved the weakened plantar flexor and degraded balancing ability<sup>21</sup>). The research by Kim and Lee also tested the participants with ankle instability and the participants showed the statistically significant increase in muscular strength of plantar after the proprioceptive exercise<sup>16</sup>). According to the research by Eniseler et al, the postural stability decreases when the difference in the maximum muscular strength for the affected and unaffected sides is over 10%, resulting in the frail ankle<sup>22</sup>). Based on these results, the AII survey can be used as an assessment tool for the plantar flexion.

In the plantar relocation test, both dorsiflexion and plantar flexion were significant ( $p < 0.05$ ). Park and Kim pointed out that the group with functional ankle instability showed lower active ankle position sense<sup>23</sup>), and reported that the joint relocation changed more after the ankle sprain<sup>24, 25</sup>). The research by Chun and Choi also examined the ankle instability of the soccer players and showed that the active joint position sense involved significant difference in the dorsiflexion and plantar flexion more than the ankle stability group<sup>15</sup>). Considering these results, the AII survey can be used as an assessment tool for proprioceptive sense of the ankle joint.

In the dynamic balancing test, anterior direction was found out to be significant ( $p < 0.05$ ). One of the preceding researches compared the adults with chronic ankle instability and normal ankle and pointed out that the adults with chronic ankle instability showed shorter reach<sup>26, 27</sup>). According to the research by Baik, anterior direction is highly correlated with the maximum strength of the plantar flexor and range of ankle motion<sup>28</sup>). It is assumed that the anterior direction is affected by the lower maximum strength of plantar flexor and reduced range of ankle motion. Another research also reported that the posterior medial direction is correlated with abduction strength of hip joint while the posterior lateral direction is correlated to extensor strength of hip joint<sup>29</sup>). Since the AII survey does not include questions for assessing the injuries and pains related to the hip joint, it may be hard to assess how the posterior medial direction and posterior lateral direction are affected by the hip joint.

For the maximum dorsiflexion and plantar flexion angle, the maximum dorsiflexion showed significance while plantar flexion didn't show significance. Mattacola and Dwyer pointed at that people with chronic ankle instability show reduced dorsiflexion compared to people without ankle instability<sup>30</sup>). Gilbreath et al. also claimed that the ankle instability involves significantly reduced the dorsiflexion<sup>31</sup>). Since the results of this study showed the same results as the preceding researches, the AII survey can be used as an assessment tool for the dorsiflexion.

As a cross section study, this study categorized the participants by using the AII survey, compared the maximum muscular strength, joint relocation, dynamic balancing, and maximum joint ankle to help in obtaining the information of the ankle status and assessing the patient based on the AII survey.

### *Conflict of interest*

There are no conflicts of interest relevant to this article.

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