SEX DIFFERENCES IN PROPRIOCEPTION AND BALANCE CONTROL IN INDIVIDUALS WITH CHRONIC ANKLE INSTABILITY

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The study aimed to investigate sex differences in proprioception and balance control in individuals with chronic ankle instability (CAI). A total of 50 CAI participants (26 males and 24 females) were assessed using an isokinetic dynamometer, static balance system, and Y-Balance test. Absolute error, sway velocity and reach distance were used to measure the performance. Results showed compared with males, females had significantly better ankle force sense (plantarflexion: females 1.69±1.13N·m/kg, males 3.37±2.72N·m/kg; dorsiflexion: females 0.99±0.73N·m/kg, males 2.05±1.10N·m/kg) and exhibited smaller sway velocity of center of pressure in static balance. These findings emphasized the importance of sex-specific differences in proprioception and static balance among CAI, especially for males.

KEYWORDS: sex differences, chronic ankle instability, ankle proprioception, balance control.

INTRODUCTION: Ankle sprain is one of the most common sports injuries in physical activity which place a high economic burden on the healthcare system. Up to 40% of ankle sprain may eventually develop chronic ankle instability (CAI) (Hershkovich et al., 2015). The main manifestation of CAI is a prolonged decline in sensorimotor function (e.g., proprioception and balance). Investigators have reported that ankle proprioception and balance control are negatively associated with ankle injuries, which are critical to the quality of life and motor performance of individuals. Therefore, intervention strategies have been developed to improve proprioception and balance control. However, the effectiveness of current interventions varies greatly, such as some therapies can reduce reinjury severity, while others may increase pre-injury exposures.(Doherty et al., 2017). And many factors (e.g., individual physiological characteristics, injury severity) can influence the outcomes of these interventions. Sex difference is one important factor, which is significant in physical fitness and sports performance. In lower limb musculoskeletal injuries, sex differences in knee injuries have been extensively studied. Compared to males, females have a significantly higher incidence of anterior cruciate ligament (ACL) injuries and a slower postoperative recovery process (Hewett, 2000). However, as far as we know, no research relative to sex differences in CAI has been conducted.
Therefore, this study aimed to compare sex differences in proprioception and balance control in individuals with CAI, and provide sex-specific guidelines for rehabilitation programmes for CAI.

METHODS: A total of 50 participants were recruited through social media and posters from a university community, including 26 males (age: 20.8±1.4 years; height: 178.7±4.5 cm; body mass: 73.9±8.5 kg) and 24 females (age: 20.3±1.7 years; height: 164.6±6.8cm; body mass: 57.0±8.3kg). Inclusion and exclusion of patients with CAI according to the International Ankle Consortium's recommendations (Gribble et al., 2014). The injured side was determined as a right ankle or bilateral sprains but the right ankle was more prominent. This definition did not imply an exclusion of left ankle sprains but rather reflected the distribution of injury sides among our voluntary participants. The dominant leg of all included participants was the right leg.

The CON-TREX MJ isokinetic dynamometer (CON-TREX, Switzerland, sampling frequency of 256 Hz) was used for proprioception testing. The ankle position sense tests were performed in a passive positioning-repositioning method, and participants were required to perform three consecutive repetitions of the test after feeling at 15° for 10 seconds. The ankle muscle force sense test consisted of a maximal isometric force test and a test of delivering a force of reproducing a force of 25% MVIC and holding it for 5 seconds, each of which was repeated three times with no advance notice of the results. The static balance testing system (PhysioSensing, Portugal, model: Force Plate) was used for static balance assessment. Participants were asked to stand on a force plate and maintain balance while standing on one leg with eyes open and eyes closed for 10 seconds. The Y-Balance test was used for dynamic balance testing, and the right leg was taken as the supporting leg and the left leg as the pushing leg. The participants reaching as far as possible in three different directions (anterior, posteromedial, and posterolateral) from a single-leg stance position. The reach distance achieved in each direction was recorded to evaluate the participants' postural control ability. Absolute error can reflect proprioception more accurately than mean error, as it was not affected by the positive or negative direction. The center of pressure was selected for static balance as its movement trajectory was an important indicator for evaluating balance control and stability. The reach distance was selected for the Y-Balance test, which can reflect the ability of postural control.

Data were expressed as mean ± standard deviation using Excel and analysed through SPSS 27.0 statistical software. The Shapiro-Wilk test was used to examine the normality of the data distribution. If the data were normally distributed, an independent sample *t*-test was performed; otherwise, the data was log-transformed prior to statistical analysis (Spedden et al., 2020). The significance level was set as $\alpha = 0.05$.

RESULTS: There were significant differences in height ($p < 0.001$) and weight ($p < 0.001$) demographic characteristics, except age for both males and females. The absolute error of force sense was significantly smaller in the female group than the male group (Table 1) in plantarflexion ($p < 0.001$), dorsiflexion ($p < 0.001$), and eversion ($p = 0.033$). There was no significant difference in position sense between the two groups (Figure 1A) for ankle plantarflexion, dorsiflexion, inversion, and eversion ($p > 0.05$). The static balance test showed that the sway velocity of the center of pressure was significantly smaller in females than in males (Table 2) (one-leg standing with eyes open: medial-lateral, $p = 0.036$, anteroposterior, $p = 0.026$; one-leg standing with eyes closed: medial-lateral, $p = 0.001$, anteroposterior, $p = 0.005$). There was no significant difference in the percentage of reach distance in all three directions or the composite score in the Y-Balance test (Figure 1B) ($p > 0.05$).

Table 1 Mean ± SD data for differences in absolute error of force sense between male and female groups

Absolute error of ankle force sense (N·m/kg)	Male (n = 26)	Female (n = 24)	*p*
Plantarflexion	3.37±2.72	1.69±1.13*	0.001
Dorsiflexion	2.05±1.10	0.99±0.73*	0.001
Inversion	0.90±0.92	0.53±0.37	0.289
Eversion	0.79±0.67	0.43±0.26*	0.033

Table 2 Mean ± SD data for differences in static balance between male and female groups

CoP sway velocity (mm/s)	Male (n = 26)	Female (n = 24)	*p*
OL-EO, ML	23.38±5.23	20.10±5.52*	0.036
OL-EO, AP	24.57±5.55	20.62±6.59*	0.026
OL-EC, ML	59.35±13.33	47.68±10.48*	0.001
OL-EC, AP	65.09±16.59	51.84±14.95*	0.005

Note: * $p < 0.05$. OL-EO: one-leg standing with eyes open; OL-EC: one-leg standing with eyes closed; AP: anteroposterior; ML: medial-lateral; CoP: the center of pressure.

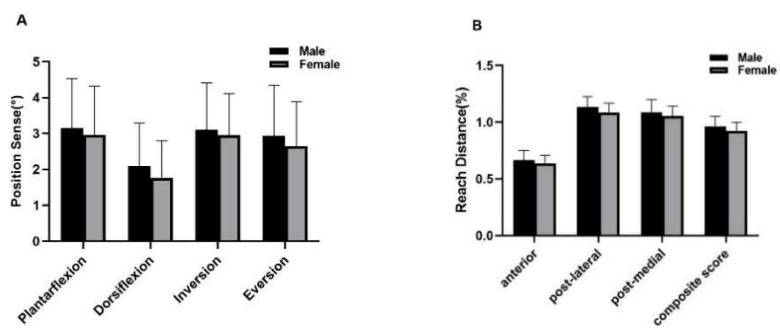

Figure 1: Position sense (A) and the percentage of reaching distance (B) in male and female groups

DISCUSSION: The aim of this study was to investigate sex differences in proprioception, static balance and dynamic balance in CAI. The results showed that compared to males, female patients had smaller absolute error in force sense and smaller center of gravity sway velocity in static balance. The absolute error of muscle force sense was significantly smaller in females than in males. This may be because females have a more sensitive motor nervous system that is better able to perceive information around them and integrate sensation and movement (Wang et al., 2021). Females exhibited smaller sway velocities in both AP and ML directions during one-leg stance with eyes open and closed, indicating that females have better ankle balance control strategies within static conditions. A soldier-based finding may support the current study, which found that females had better static postural stability than males but no significant difference in dynamic postural stability (Sell et al., 2018). Though strength is an important component of maintaining postural stability, the relatively simple task of one-leg

standing may negate this strength advantage, allowing other components required for maintaining postural stability (e.g., visual/auditory information) to dominate. The central nervous system of females may be better able to carry out autonomic control of sensory information around their surroundings (Wang et al., 2021), leading to better performance in one-leg standing compared to males.
Some limitations need to be addressed. First, the female menstrual cycle, which is a significant sex difference, is not taken into account. It should be included in the future research. Second, this study did not classify the injury level of CAI, time since injury, rehabilitation methods, etc., which should be quantified in future work. The lack of detailed classification and quantification may limit the depth of analysis and the specificity of our findings. Future studies are encouraged to incorporate these variables to enhance the outcomes.

CONCLUSION: This study found significant sex differences in proprioception and balance control between males and females in individuals with CAI. Specifically, females showed better ankle force sense and static balance control. Future studies should explore the need for a different intervention by comparing baseline.

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