RESEARCH ARTICLE

The Effect of Leg Dominance and Group Difference in Star Excursion Balance Test between Individuals with Chronic Ankle Instability, Ankle Sprain Copers and Healthy Controls

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Abstract

Objectives: To evaluate patients with chronic ankle instability (CAI), copers who had a sprain without instability, and healthy controls using the Star Excursion Balance Test (SEBT). In addition, the reach distance was assessed between the both legs in terms of dominant and non-dominant in all groups.

Methods: A total of 75 subjects (25 healthy, 25 CAI, and 25 Coper) participated. The maximum reach distance in SEBT was assessed in anterior (ANT), postero-medial (PM), and postero-lateral (PL) directions in both legs for each subject. All data were analyzed by SPSS version 21. Tukey post hoc test was used to compare all groups. Paired T-test was used to compare dominant and non-dominant legs in each group.

Results: In 75 subjects have participated in the data collection, no significant differences were reported among all groups for age and BMI measurements. Significant lower reach distance in scores of ANT in the dominant leg of the CAI was demonstrated when compared with the control and the coper groups (P=0.008). No statistical significant difference was determined between the dominant and non-dominant legs in each group (P>0.05).

Conclusion: It seems that relevant strategies for postural control should be taken into account in the rehabilitation setup of individuals with CAI.

Level of evidence: II

Keywords: Ankle, Balance, Dynamic, Postural control, Postural stability, Sprain, Star excursion balance test

Introduction

Lateral ankle sprain (LAS) is known as one of the most spread injuries in lower limbs, especially in populations who are physically active. [1] Some symptoms were detected in individuals with a history of LAS such as pain during activity, swelling, giving way, and repeated injuries last for more than one year and finally, the chronic ankle instability (CAI) was specified. [2] People who have any history of LAS and be able to return to high-level activities such as jumping and pivoting without frequent injury or function loss through an indefinite mechanism that empower them to activity like un-injured.[3] The deficits in dynamic postural control were investigated in subjects with CAI, previously, [2,4-6] and it seems that any disturbances in the dynamic functional tasks might be identified as ankle sprain mechanism. [5,7] In order to assess the postural stability in patients with ankle sprain, various tests were utilized. [5] However, static postural stability was studies in many investigations and the results showed that static balance tests considered as not sensitive enough measurement method to detect fine and small variations

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of postural control and little challenges occurred in the sensorimotor systems. [6] Regarding the literature, the Star Excursion Balance Test (SEBT) was distinguished as a reliable and accessible measurement method to assess the deficits of dynamic postural stability. [8-10]

In numerous studies, CAI patients and healthy counterparts were compared and few researches were considered on copers using static tests more than dynamic ones. [8,11,12] To detect the postural control deficits using static tests more than dynamic ones. [13] Furthermore, the role of leg dominancy was undetermined in postural stability.[14] Since ankle sprain can be associated with a lack of balance during a specific movement and dynamic postural control is considered as the ability to keep balance in order to finish a specific movement. [15] The first purpose of the current study was to evaluate and compare dynamic postural control in people with and without CAI and copers using SEBT as a functional dynamic task. To interpret the unilateral balance test findings in subjects with a history of an ankle injury, the effect of leg dominancy should be considered. [16] Secondly, the maximum reach distance between dominant leg and non-dominant one was evaluated.

Materials and Methods

Demographics of the subjects

In the current case-control study, seventy-five active males and females participants were allocated via a random sampling method using G-Power software. 21 subjects were estimated considering B = 0.80 and α = 0.05. However, in anticipation of any possible dropout in the assessment, 25 cases were included. Using nonprobability accessible convenient sampling, 25 eligible young, active with no history of athletic activities adults per group were tested. The groups were matched based on gender (11 females and 14 males), age, and BMI. A total of 25 CAI patients were matched with 25 copers and also, 25 healthy counterparts. All subjects were recruited by advertisement on the different campuses of the university, hospitals, physiotherapy private centers, and the general community from May 2017 to June 2018 in Tehran province, Iran.

Inclusion criteria of subjects in the CAI group were considered as having a previous severe LAS in the last 3 months, lack of pain or inflammation at the time of assessment, repeated giving way or determined ankle instability confirmed by the available reliable questionnaires to evaluate the instability. [11] The inclusion criteria for copers were considered as having one event of severe LAS within the last year but had returned to their daily activities without any recurrent LAS or giving way. [17] The control group was included if they had no distinguished musculoskeletal lower limb disorder in the past three months.

To exclude subjects in the present study some items were considered as: having previous surgery or fractures in the lower limbs, acute diseases in the lower limbs in the preceding three months, and visual or cognitive disorders.

Study design

Ethical approval was received from the ethical committee of the Iran University of Medical Sciences with the registration number IR.IUMS.REC.1395.9211342211. All eligible anxious participants, received written information sheets and signed a consent form and the following questionnaires were completed by subjects suffering from LAS. The following questionnaires were completed: Identification of Functional Ankle Instability (IFAI), Ankle Instability Instrument (AII), Cumberland Ankle Instability Tool (CAIT), Foot and Ankle Ability Measure (FAAM), and finally, Foot and Ankle Outcome Scores (FAOS).[11]

All tests were performed in the rehabilitation laboratory of the Iran Medical University, Tehran, Iran. The participant's weight was registered to detect the variations of the vertical ground reaction force (GRF) during a five-second static stance on the force plate because there was a possibility in the force plate to measure body weight with high precision and also to save time.[2] Maximum reach distance in the SEBT was used to examine the dynamic postural stability. All measurements were performed on barefoot and lasted for two hours with enough rest time between trials. Each outcome was measured and recorded via three trials of tasks made randomly. The injured dominant leg of CAI patients and copers was evaluated and then, compared to healthy subject's dominant leg. In the present study, dominancy was determined if subjects could complete at least two of the three below examinations: a balanced recovery after pushing to the posterior, stepping up onto a box, and high accurate kicking a ball through a goal.[18]

Methods of measurement

SEBT performance

This test was accomplished when a subject was situated in a single-leg stance on the affected dominant leg whereas the opposite leg performed maximum reach distance. The SEBT grid was arranged on the floor with a 1.5-meter measuring tape put ahead from the center of the grid along the following three directions: the anterior (ANT), posteromedial (PM), and posterolateral (PL) directions. [9] The measurements of anterior and posteromedial, anterior and posterolateral were considered 135 degrees. The 90-degree angle was arranged between the posteromedial and posterolateral directions. [13]

The subject was asked to adopt a standing position with hands placed on the hips, the evaluative leg was fixed in the center of the grid and then the subject tried to reach the opposite leg in each direction as remote as possible, touched the big toe, and then returned to a double-legged stance position. The reach distance (in centimeters) was measured from the grid center to the distinguished point of subject's maximum reach. [13]

Before evaluation, three familiarization trials were made. Subjects performed three consecutive trial tasks randomly in each direction with 60 seconds rest period between the trials. Trials were considered unsuccessful. If subjects lost their balance in any way (e. g., moving the stance foot, touching the tape, transferring the weight on the reaching foot, not touching the tape, not going back the reaching foot into the beginning position, and lack of power to keep a unilateral-stance position during the trials. [19] The mean of three successful trials was used for analysis. The normalization of recorded reach distances in all directions was calculated by dividing the reach distance (in centimeters) into leg length. The leg length was determined as a distance from the anterior superior iliac spine to the ipsilateral medial

malleolus in a supine position for each subject.

Statistics

SPSS version 21 (SPSS Inc, Chicago, Illinois 60606, U.S.A.) was used for all analyses. Tukey post hoc test was applied to demonstrate the probable differences among the three groups and paired T-test was employed to analysis the effect of leg dominancy within groups. The value of 0.05 was considered as a level of significance.

Results

The demographic characteristics of all subjects participated in this study were reported in [Table1].

No statistical significant differences were reported among the three groups for their age and BMI measurements.

The results for the Tukey post hoc test are available in [Table 2].

The lower ANT scores were reported in the CAI group (*P=0.008*) compared with copers and controls, but there was not found any significant difference among the three groups in terms of posteromedial (*P = 0.45*) and posterolateral (*P = 0.25*) direction scores.

The results of paired T-test to analysis the three groups for leg dominancy are demonstrated in [Table 3].

Table 1. Demographic characteristics of all subjects

Variables:Mean (SD)	Control group (n=25)	Coper group (n=25)	CAI group (n=25)	*P-value*
Age (year)	31.04 (7.33)	30.28(6.09)	30.84(6.19)	0.99
Height (cm)	172.23(10.39)	173.57(10.50)	171.61(8.01)	0.78
Weight (kg)	71.91(8.99)	72.66(10.08)	74.52(10.66)	0.85
BMI	24.31(2.70)	24.11(1.89)	24.80(3.11)	0.64

BMI: body mass index, CAI: chronic ankle instability, cm: centimeter, kg: kilogram

Table 2. One-way ANOVA Tukey Post hock test for maximum reach distances between the three groups

Dependent variables	Groups	Mean differences	*P-value*	95% confidence interval
AP-SEBT	Healthy vs coper	2.24	0.65	0.31-0.1.25
	Healthy vs CAI	7.81	0.007*	0.28-0.1.33
	Coper vs CAI	5.57	0.04*	0.31-1.45
PL-SEBT	Healthy vs coper	0.55	0.78	0.21-1.31
	Healthy vs CAI	1.44	0.65	0.32-1.20
	Coper vs CAI	02.11	0.69	0.65-0.87
PM-SEBT	Healthy vs coper	1.99	0.67	0.29-1.20
	Healthy vs CAI	2.48	0.55	0.31-1.25
	Coper vs CAI	1.03	0.61	0.55-0.77

AP-SEBT: anteroposterior star excursion balance test, PL-SEBT: posterolateral star excursion balance test, PM-SEBT: posteromedial star excursion balance test, CAI: chronic ankle instability

Table 3. paired t-test findings within three groups

	Groups	CAI (mean±SD)	coper (mean±SD)	healthy (mean±SD)
AP-SEBT (cm)	dominant side (right)	74.29±7.69	79. 86±8.34	82.10±9.88
	Non-dominant side (left)	75.19±8.12	81.32±9.24	83.46±11.21
	P-value	0.75	0.63	0.79
PM-SEBT (cm)	dominant side (right)	81.34±9.01	82.23±10.21	82.78±11.12
	Non-dominant side (left)	79.43±8.45	81.88±9.76	84.14±9.21
	P-value	0.66	0.66	0.67
PL-SEBT (cm)	dominant side (right)	72.57±8.12	73.60±7.92	75.05±9.32
	Non-dominant side (left)	73.13±9.21	71.15±8.21	77.02±11.11
	P-value	0.68	0.58	0.48

AP-SEBT: anteroposterior star excursion balance test, cm: centimeter, PL-SEBT: posterolateral star excursion balance test, PM-SEBT: posteromedial star excursion balance test CAI: chronic ankle instability

The maximum reach distance between the dominant and non-dominant legs did not show a statistical significant difference in all three groups (*P<0.05*).

Discussion

The current study compared dynamic postural stability among the CAI group, copers, and healthy subjects using SEBT in three directions. The primary result in this study demonstrated less ANT scores in CAI patients when compared with the copers and controls. The result was in agreement with the study findings conducted by Jabber et al, 2018, showed that mean reach distance in the anterior direction has considered to be different among the three studied groups. 15 The result of the study carried out by Chaiyakul et al (2022), demonstrated that the posteromedial direction in the SEBT was lower in the group with repeated ankle sprain compared with the control. [20]

It seems that due to the ankle sprain, the mechanoreceptors of joints, muscles, and ligaments were susceptible to be damaged, and it may affect the afferent messages to the central nervous system and lower extremity's motor control. 18 In addition, because of the proprioception deficit in the ankle joint, patients could not use the ankle joint to control their posture. The current study's results were in agreement with the findings of the previous studies, in terms of changes in SEBT scores, which might be considered a dynamic postural control impairment in CAI patients. [4,5,8,9,19,21,22] A voluntary task named SEPT requires the individual's single limb control in the hip joint, knee, ankle, and foot regions to reach the opposite limb in three different directions. [10] To keep the joint stability, the neuromuscular control that can be evaluated by dynamic postural stability should be measured. [22] Therefore, any changes in the postural control in CAI group is reported to be a critical indicator of ankle joint instability and leads to the ankle sprain recurrences. In addition, lack of a detectable difference between the copers and the controls means that some structural, biochemical, and genetic problems may make individuals prone to experience a recurrence of sprain.[23] Furthermore, in the most recent reviews about dynamic postural control, some differences were demonstrated between CAI patients and coper groups. CAI patients reported more motion deficits or altered motion strategies compared with copers. [7]

To interpret the second aim of the current study, it seems that leg dominancy has an influence on the individual's capability to control his/her posture using SEBT among the three groups. The results demonstrated no significant differences among the CAI group, copers, and healthy subjects. These findings were in agreement with the study carried out by Hoffmann et al. 1998 and Bressels et al. 2007.[14,24]

The biomechanical variations were demonstrated between the dominant and nondominant ankles during physical performances and it can be attributed to some asymmetries exists in the lower extremity anatomy and physiology. Therefore, the asymmetry which was reported in the SEBT might be related to the function of an acute or chronic damage rather than functional leg dominancy.[14]

A lack of clear and exact information on muscle activity and joint function seems to be a potential limitation of the present study. The electromyographic and kinematic assessments of muscles and joints of the lower limbs were not provided in the present study. In addition, most subjects with severe or high-grade ankle sprain participated in the procedure had injuries in their dominant leg. However, more future investigations using electromyography and kinematic evaluations will be needed to include patients with various ankle sprain levels in the data collection.

In conclusion, significantly different findings were reported for dynamic postural stability in CAI patients compared with copers and controls. Therefore, the neuromuscular training of these patients would help decrease recurrent ankle sprain injuries. It can be suggested that neuromuscular control training setup can be applied in CAI patients as a crucial part of their rehabilitation schedules. These findings are particularly helpful to clinicians to use SEBT in the evaluation of lower limb injuries and follow the treatment outcomes.

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