Journal of Medical Sciences

ISSN 1682-4474

OPEN ACCESS

Journal of Medical Sciences

ISSN 1682-4474
DOI: 10.3923/jms.2019.38.44

Research Article

Assessment of Cervical Proprioception in Participants with Chronic Ankle Instability: A Cross-sectional Study

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Abstract

Background and Objective: Cervical proprioception has an important role in maintaining normal spinal movement, stability and maintaining the balance of the body as a whole. Lateral ankle sprains are considered one of the most prevalent injuries in sports or in daily lives even. The aim of this study was to investigate the effect of chronic ankle instability on cervical active repositioning accuracy. **Materials and Methods:** Thirty subjects of both sexes (16 females and 14 males) were selected and assigned into 2 groups, Chronic Ankle Instability (CAI) group consisting of 7 females and 8 males and control group (9 females and 6 males). Cumberland Ankle Instability Tool (CAIT) was used to determine the severity of functional ankle instability. Cervical proprioception was evaluated by CROM device in the sagittal, frontal and horizontal planes. Manual testing including talar tilt and anterior drawer tests was used to determine the integrity of ankle ligaments to identify subjects with ankle mechanical instability. **Results:** There was a significant effect of chronic ankle instability on cervical reposition error in all cervical movements of the three planes; cervical flexion reposition error ($p = 0.0001$), cervical extension reposition error ($p = 0.0001$), cervical Rt side bending reposition error ($p = 0.0001$), cervical Lt side bending reposition error ($p = 0.0001$), cervical Rt rotation reposition error ($p = 0.\ 0001$) and cervical Lt rotation reposition error ($p = 0.006$). **Conclusion:** There was a relation between CAI and the increase in cervical reposition error compared with healthy subjects. This effect should be considered in the rehabilitation program of patients with CAI.

Key words: Chronic ankle instability, cumberland ankle instability tool, cervical proprioception, cervical reposition error, ankle ligaments, cervical active repositioning accuracy

Received: October 21, 2018 Accepted: November 22, 2018 Published: December 15, 2018

Citation: Heba A. El Gayar, Magda R. Zahran, Olfat I. Ali and Neveen A. Abdel Raaof, 2019. Assessment of cervical proprioception in participants with chronic ankle instability: A cross-sectional study. J. Med. Sci., 19: 38-44.

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Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Proprioception is thought to have an important role in maintaining normal spinal movement and stability. Proprioception impairments could cause a change in the neuromotor system and could affect dynamic spine stabilization and lead to spinal posture instability[1]. Impaired proprioception may be a major risk factor for recurrent injuries even after the restoration of injured muscles and ligaments[2]. Impaired proprioception is thought to be both a result and a cause of injury[3].

Lateral ankle sprains are one of the most common injuries in high school, collegiate and recreational sports[4]. It was stated that up to 40-75% of sufferers continue to report residual disability, which might continue for several years after the inversion sprain[5]. As a result of joint instability over time and movement past its physiological limits, the danger of destroying its articular surface and developing osteoarthritis increases[6,7].

The two hypothesized causes of Chronic Ankle Instability (CAI) have been labeled mechanical instability and functional instability[8]. Mechanical Instability (MI) is defined as ankle movement beyond the physiologic limit of the ankle's range of motion. The term “laxity” is often used synonymously with MI.

The term Functional Ankle Instability (FAI) describes the subjective feeling of giving way or feeling joint instability after repeated ankle sprain traumas. The FAI is thought to be caused by an impairment in ankle proprioception, muscle weakness, prolonged peroneal reaction time, impaired balance control and sensory-motor dysfunctions or a combination of them[5,9].

Researchers have suggested that individuals with FAI had poor postural control and stability as a result of sensory-motor system impairments[10-12].

Altered afferent inputs from the somatosensory system around the ankle and central changes in sensorimotor control following lateral ankle sprain may lead to proximal joint adaptations to compensate for residual symptoms and functional impairments[13].

Ankle instability can have a long-term biomechanical effect on musculoskeletal system[14]. Understanding the pathomechanical and pathophysiological effects of ankle instabilities plays an important role in treating patients with these dysfunctions and preventing further injuries.

There was a significant difference in lumbar proprioception between FAI group and healthy one[15]. Local effect of FAI on ankle proprioception and muscle strength around the ankle and proximal muscles had been reported. The association between CAI and cervical proprioception was not clearly established. Thus, this study was carried out to investigate whether there was an association between CAI and cervical proprioception.

MATERIALS AND METHODS

This study was conducted at the Faculty of Physical Therapy, Cairo University, during the duration from September, 2017 to December, 2017 to investigate the association between CAI and cervical proprioception.

Design of the study: The study design was an observational cross-sectional one.

Selection of patients: Thirty subjects of both genders (16 female and 14 male) were selected from students of Faculty of Physical Therapy, Cairo University. Their ages were from 18-25 years and their BMIs were less than 25 kg m^{-2}. The CAI group consisted of 15 participants (7 females and 8 males) and the control group included 15 normal individuals (9 females and 6 males). All participants signed an institutionally approved informed consent form prior participating in the study and the experimental research was approved by the ethics committee of the Faculty of Physical Therapy, Cairo University, the approval number is P.T.REC/012/001688. Participants in both groups were assessed by an orthopedist.

Individuals with unilateral CAI who suffered from repeated subjective feeling of giving way or feeling of joint instability after the initial lateral ankle sprain with full weight-bearing and mechanical ankle instability on one ankle joint were included in the study. They were not undergoing formal or informal rehabilitation at the time of the study.

Exclusion criteria: Ankle joint swelling or any rheumatological disorders, ankle surgery in either leg, marked limitation in ankle range of motion, any joint disease or bone fracture or history of neurological disorder in the lower extremities, flat foot, mechanical neck pain, any limitation of cervical ROM, history of whiplash injury or cervical spine surgery, cervical radiculopathy or myelopathy, any non-rheumatologic diseases as multiple sclerosis, rheumatologic condition as mild systemic lupus erythematosus, rheumatoid arthritis, advanced cervical spine degenerative disease, vestibular dysfunction and balance disorder.

Instrumentations and scales

Cumberland Ankle Instability Tool (CAIT): The CAIT is a 9 items questionnaire enables classification of FAI severity according to a score between 0 and 30, where scores greater than or equal to 28 represent no instability and scores less than or equal to 27 represent functional ankle instability. Also, scores less than or equal to 27 have an increasing representation of instability as the scores become lower, with a clear marker from scores less than or equal to 23. The CAIT is a simple, valid and reliable tool to measure the severity of functional ankle instability[16].

CROM device: The CROM device is a type of goniometer designed specifically for the cervical spine and was used to measure CROM.

The CROM device has been evaluated most often, with several studies assessing its reliability on healthy volunteers or symptomatic patients[17-19].

The CROM has three inclinometers, one to measure in each plane and is strapped to the head. One gravity dial meter measures flexion and extension, another gravity dial meter measures lateral flexion and a compass meter measures rotation with its accuracy reinforced by two magnets placed over the subject's shoulders.

Manual testing including talar tilt and anterior drawer tests were used to determine the integrity of ankle ligaments to identify subjects with ankle mechanical instability[20,21]. The grades are: 0 = Hypomobile, 1 = Normal, 2 = Moderate laxity, 3 = Severe laxity[22]. The subjects with a grade of 2 (moderately hypermobile) or 3 (severe laxity) were classified as mechanically instable[22].

Flexibility tests for cervical muscles to exclude any shortening of cervical muscles that cause limitations of cervical ROM.

Procedures: All participants' ages, heights and weight were recorded.

The subjects were given the following instructions as regard to their ankle functional abilities, please tick the one statement in each question that best describes your ankles. Eight of the 9 items ask individuals to describe their instability or "rolling over" of their ankle during sport and daily activities. The other item queries when individuals have pain. Scores range from 0 (worst) to 30 (best)[16].

Assessment of cervical proprioception using a cervical range of motion device

Head reposition accuracy tests: Neutral Head Position (NHP) and Target Head Position (THP) tests: The test procedures were the same as those described by Lee *et al.*[23]. The NHP test measured the subject's ability to actively reposition their head to their self-selected neutral position. The THP test measured the individual's ability to actively reposition the head to a previously demonstrated target position:

- After explaining the testing procedures, the participants were instructed to sit upright with their feet flat on the floor, their back against the chair backrest and facing straight ahead, this position was established as their self-selected "NHP"
- The CROM unit was placed on top of the head and attached posteriorly using the Velcro strap
- The magnetic part of the unit was then placed so that it sat squarely over the shoulders
- The CROM device was calibrated to an NHP

In THP test the subject's head was moved slowly to the pre-determined target position, 50% of the maximum range of motion. The speed of passive neck motion was very slow as higher speeds have been associated with significant differences in vestibular function according to age[24].

The head was maintained in the target position for 3 sec and the subject was asked to remember that position because he or she would be asked to reproduce this position with eyes blindfolded.

Afterward, the participant returned to the neutral position and then was given the verbal instruction of reproducing the target position as accurately as he or she could. When the subjects reached the reference position the subject's relocation accuracy was measured in degrees with CROM device.

The THP repositioning tests were performed in the 6 directions (flexion, extension, right side bending, left side bending, right rotation, left rotation). Three trials were undertaken in each direction of movement and the mean of these trials (mean error) was used for analysis. No feedback about repositioning performance was given during the testing and all tests were administered by the same investigator. The entire procedure took approximately 15 min for each subject.

Statistical analysis: Descriptive statistics and t-test were conducted for comparison of mean age, weight, height and BMI between both groups. Chi-squared (χ^2) test was conducted for comparison of the distribution of sex between both groups and MANOVA was conducted for comparison of repositioning error between both groups.

The level of significance for all statistical tests was set at $p<0.05$. All statistical tests were performed through the statistical package for social studies (SPSS) version 19 for windows (IBM SPSS, Chicago, IL, USA).

RESULTS

Comparing the general characteristics of the subjects of both groups revealed that there was no significance difference between both groups in the mean age, weight, height or BMI (p>0.05) (Table 1).

There was no significant difference between both groups in sex distribution (p = 0.46).

Effect of chronic ankle instability on cervical proprioception: Multivariate analysis of variance (MANOVA) was carried out to investigate the effect of chronic ankle instability on cervical reposition error. There was a significant effect of chronic ankle instability on cervical reposition error (p = 0.0001) (Table 2).

Comparison of cervical reposition error of CAI and control groups

Flexion reposition error: The mean±SD flexion reposition error of CAI group was 7±1.7 while that of control group was 1.39±0.31. The mean difference between both groups was 5.61. There was a significant increase in flexion reposition error in the CAI group compared with control group (p = 0.0001) (Table 3).

Extension reposition error: The mean±SD extension reposition error of CAI group was 5.49±1.95 while that of control group was 1.26±0.52. The mean difference between both groups was 4.23. There was a significant increase in extension reposition error in the CAI group compared with control group (p = 0.0001) (Table 3).

Right side bending reposition error: The mean±SD right side bending reposition error of CAI group was 4.02±1.62 while that of control group was 1.22±0.42. The mean difference between both groups was 2.8. There was a significant increase in right side bending reposition error in the CAI group compared with control group (p = 0.0001) (Table 3).

Left side bending reposition error: The mean±SD left side bending reposition error of CAI group was 4.08±1.62 while that of control group was 1.22±0.42. The mean difference between both groups was 2.86. There was a significant increase in left side bending reposition error in the CAI group compared with control group (p = 0.0001) (Table 3).

Right rotation reposition error: The mean±SD right rotation reposition error of CAI group was 4.62±1.66 while that of control group was 1.5±0.4. The mean difference between both groups was 3.12. There was a significant increase in right rotation reposition error in the CAI group compared with control group (p = 0.0001) (Table 3).

Left rotation reposition error: The mean±SD left rotation reposition error of CAI group was 4.76±1.42 while that of control group was 1.43±0.35. The mean difference between both groups was 3.33. There was a significant increase in left rotation reposition error in the CAI group compared with control group (p = 0.006) (Table 3).

Table 1: Demographic data of the participants

	$\bar{X}$±SD					
Parameters	CAI	Control group	MD	t- value	p-value	χ^2
Age (years)	20.13±0.74	21.06±2.28	-0.93	-1.5	0.14	
Weight (kg)	63.40±8.37	63.33±7.75	0.07	0.02	0.98	
Height (cm)	170.33±8.96	169.73±5.27	0.6	0.22	0.82	
BMI (kg m^{-2})	21.76±1.38	21.92±1.91	-0.16	-0.26	0.79	
Sex						
Females	7.0 (47%)	9.0 (60%)			0.46	0.53
Males	8.0 (53%)	6.0 (40%)				

$\bar{X}$: Mean, SD: Standard deviation, MD: Mean difference, t-value: Unpaired t-value, p-value: Probability value, χ^2: Chi-squared value

Table 2: MANOVA for the effect of chronic ankle instability on cervical reposition error

MANOVA Group effect	
F-value	p-value
77.27	0.0001

Table 3: Comparison of mean value of cervical reposition error of CAI and control groups

	$\bar{X}$±SD				
Parameters	CAI	Control group	MD	F- value	p-value
Flexion	7.00±1.70	1.39±0.31	5.61	156.92	0.0001*
Extension	5.49±1.95	1.26±0.52	4.23	65.75	0.0001*
Right side bending	4.02±1.62	1.22±0.42	2.80	89.79	0.0001*
Left side bending	4.08±1.62	1.22±0.42	2.86	43.77	0.0001*
Right rotation	4.62±1.66	1.50±0.40	3.12	46.98	0.0001*
Left rotation	4.76±1.42	1.43±0.35	3.33	77.51	0.006*

$\bar{X}$: Mean, SD: Standard deviation, MD: Mean difference, p-value: Probability value, *Significant

DISCUSSION

This study was conducted to investigate the association between the effect of CAI and cervical proprioception. The CAI of participants was assessed using the CAIT for FAI assessment and manual tests as talar tilt and ant. drawer test for MAI assessment. The CROM device was used for assessment of repositioning error of the cervical spine for all participants in both groups.

The study findings revealed that there was a significant increase in cervical repositioning error in the CAI group compared with the control group. This finding might be due to damage of the articular mechanoreceptors in the lateral ankle ligaments, which resulted in proprioceptive deficits[25].

Damaged joint mechanoreceptors during an ankle sprain provoke a complex chain of adaptation reactions[25]. Interruption of the flow of afferent fibers impulses from the mechanoreceptors in an ankle joint capsule into the central nervous system would lead to clinically evident disturbances of perception of joint proprioception and of the reflexes concerned with posture and gait[26].

Moreover, this finding might be caused by impairment in neuromuscular control, which occurs after lateral ankle sprain[27]. In addition, Hubbard *et al.*[12] and McKeon *et al.*[28] had suggested that participants with FAI have sensory-motor system impairments, which results in poor sensory integration of afferent and efferent signals.

Furthermore, the increase in cervical repositioning error in the chronic ankle instability group may be attributed to the finding of Terada *et al.*[13], who reported that, after lateral ankle sprain, changes in afferent inputs from the somatosensory system around the ankle and central changes in sensorimotor control may result in proximal joint adjustments to compensate for residual symptoms and functional impairments.

Another explanation for alteration of cervical proprioception may be attributed to the effect of CAI on proximal muscles as stated by Martin *et al.*[25], Friel *et al.*[29] and Van Deun *et al.*[30] who concluded that a lateral ankle sprain not only affects local musculature but may also lead to proximal muscle weakness of the biceps femoris, lumbar erector spinae, bilateral gluteus maximus and hip abductors. This decrease in muscle strength may be accompanied by poor proprioception[31].

Another reason for increasing cervical repositioning error could be related to malalignment of the pelvis, as ankle sprain induces subtalar joint supination leading to compensatory tibial, femoral and pelvis external rotation[32].

Also, it may be as a result of lumbar proprioception affection in patients with FAI as revealed by Ali and Alasar[15]. As the spine is one unit, any change in lumbar proprioception could affect cervical part as well.

Moreover, the finding of this study is supported by Marshall *et al.*[33] who investigated the association between FAI and trunk instability by assessing the time to stabilization (TTS) response to sudden balance disturbance. The TTS is an assessment measure of lower limb function and FAI. Trunk instability has also been associated with spinal pain. Investigators screened 24 individuals, 12 with FAI and 12 without FAI. Individuals with FAI had a more delayed TTS and are more likely to develop spinal pain compared with the healthy ones.

However, the current work is in disagreement with that of De Noronha *et al.*[34] who concluded that ankle proprioception was not impaired after an ankle sprain but their research was on people with FAI only not CAI.

The main limitation of this study was that the nature of previous treatment during ankle sprain was not documented.

CONCLUSION

The CAI may be associated with cervical proprioception deficit. According to the current study finding, neck proprioception should be considered in rehabilitation program of ankle instability. Further studies should be conducted in different age groups and take sex as a factor and also more studies to assess hip joint proprioception in CAI participants.

SIGNIFICANCE STATEMENT

This study investigated the relation between chronic ankle instability and cervical proprioception. As, after ankle sprains central and proximal impairments may occur, local rehabilitation strategies that focus only on restoring normal range of motion and strength of the muscles surrounding the injured ankle may not be enough to reduce the risk of injury recurrence. Although ankle instability has an effect on ankle proprioception and on lumbar proprioception, the effect of chronic ankle instability on cervical proprioception was not clearly established.

This study confirmed that chronic ankle instability can negatively affect cervical proprioception, So, cervical proprioception training ought to be considered in the rehabilitation protocols of ankle instability.

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