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Flexibility deficit in chronic ankle instability

Afaf Tahoon[1*], Salwa Shendy[2*], Hamed El-khozamy[3*], Waleed Abdel Baky[4]
1 demonstrator, 2 department head, 3 lecturer * Department of physical therapy for musculoskeletal disorders and its surgery, Faculty of physical therapy, Cairo University, Cairo, Egypt.[2] Consultant of Orthopedic Surgery 6 October Health Insurance Hospital.

Abstract

Background: influence of a localized injury in a distal joint on the function of proximal muscles is an important consideration in assessment and treatment of musculoskeletal injuries. Many studies approved significant proximal deficits in chronic ankle instability (CAI) subjects regarding EMG activity, motoneurn pool excitability, strength, kinematics and kinetics. Up to our knowledge, there is no study assess flexibility changes in CAI. **Objectives:** The objective of this study is to investigate Hamstring flexibility in CAI. **Material and methods:** The study conducted on 42 subjects with unilateral CAI and controls had measure of hamstring flexibility using digital inclinometer during passive knee extension test **Results:** Revealed statistical and clinical significant difference between non-injured control group and CAI groupwith decreased hamstring flexibility in the later. **Conclusion:** CAI subjects have proximal muscular affection include hamstring tightness which may alter sacroiliac joint stability and subsequently back pain.
Key words: chronic ankle instability, Hamstring, flexibility.

Introduction

Lateral ankle sprain is the most common musculoskeletal injury among the physically active population **(1),** as well as the most prevalent ankle sprain type (85% of all ankle sprains) **(2)**. Lateral ankle sprain is often erroneously thought to be aninnocuous injury, when in truth, it represents a significant public health problem because of the joint's susceptibility to recurrent injury **(3)**.Development of residual symptoms and recurrent ankle sprains post injury refer to chronic ankle instability **(CAI).** CAI is a significant global healthcare burden that has variable incidence ranging from 3 % -34 %**(4)** and in other study on basketball players increased up to 74% (**5)**. The great variety related to the target population examined and time frame between initial injury and follow up period.

A diagnosis of CAI is considered when patients have both types of instability (mechanical and functional) with residual symptoms persistent at least one year after the initial sprain **(6).** This definition is based on the commonly accepted paradigm proposed by **Hertel, 2002** in this paradigm CAI has been associated with two predominant areas of impairments; mechanical (ligamentous laxity, range of motion deficits, arthrokinematic alterations, and degenerative changes) and functional instability (sensorimotor deficits) **(7).** In this sense, the main manifestation is "giving away" subjective feeling of the ankle joint that often ends up in the recurrence of the ankle sprain.In addition to repetitive ankle trauma, those with CAI experience have been associated with an increased risk of the development of ankle osteoarthritis, diminished physical activity across the lifespan and reduced self-reported quality of life **(8 - 11)**.Inaddition,the possibility that localized injury in one part of the body influences muscle activity in another and may ultimately lead to pain and alter the motor control programs **(12, 13)**.Many studies evaluated the proximal deficits in CAI. Some assessed strength **(14-16),** other assessed muscular activity **(12, 13)** and excitability **(17, 18)** also kinematics changes have been ssessed**(19, 20).**

Despite extensive clinical and basic science research, up to our knowledge,no previous prospective or case control studies assessed hamstring flexibility in ankle sprain or CAI and despite the benefits of manual therapy,neurodynamics and exercise approaches both as separated therapies and combined programs **(21-24)**, residual symptoms and recurrence persisted after several weeks of treatment.

In this regards, based on the multi-factorial nature of CAI, further investigations are needed to detect other deficits associated with CAI in order to orient the therapist to evaluate the proximal affection that far from the injured site that influencing both preventative and therapeutic approaches to patient care,subsequently completing the evaluation procedures, reduce recurrence rate, restore functional loss and prevent degenerative sequels. Therefore, the purpose of this study is to assess and compare hamstring flexibility in both CAI patientsand normal control group. We hypothesized no significant difference in hamstring flexibility between both groups.

Materials and Methods

Patients

A total of 42 CAI and non-injured control were students from faculty of physical therapy. Recruited through announcements for volunteering to participate in noninvasive study include participants complaining of ankle instability and others not injured their ankle before. The subjects were allocated into 2 groups based on their ankle health status (CAI or the uninjured control). Twenty one young adults acted as study group (CAI), their age ranged from 18-26 (22.09±2.04) years and 21 adults represents uninjured controls, their age ranged from 21-23 **(**21.9±0.62**)** years. Briefly, the control group was self-reported to be healthy and have no ankle injury history, matched with CAI patients in gender, dominance side and injured side. The dominance side defined as the leg that the subject used to kick a ball**(25)**.

<u>Inclusion criteria</u>Based on functional ankle instability questionnaire that was modified from one developed by **Hubbard and Kaminski, 2002** as follows:CAI group had a self-report of a past history of unilateral ankle inversion injury since at least more than 1 year before the study onset which required a period of protected weight bearing and/or immobilization at least one day, the

patient reported a tendency for the ankle to give way or repeatedly turn over during functional activity and/or recurrent ankle sprainand perceives that the ankle was chronically weaker, more painful and/or less functional than the other ankle or than before first injury **(26).**

The subjects were excluded if they had a history of lower extremity injury, surgery or fracture, history of low back dysfunction that required medical or surgical intervention within the last year**,** Current participation in formal or informal rehabilitation, historyof hamstring strain, bilateral ankle sprain injury, ankle injury within 3 months of participation, history of ankle fracture and any neuromuscluskeletal disease could affect the condition. All subjects read and signed informed consent form before initiation of testing which approved by research ethical committee of faculty of Physical Therapy Cairo University under number P.T.REC/012/001312.

Design

The design of this study was a matched group case control design. When the patient met the inclusion and exclusion criteria, the purposes of the research were explained to the participants then some documents were taken include demographic data of the patient, history of initial ankle sprain event (date, time of limited weight bearing, using external support or cast or crutches), date of last ankle sprain and other clinical tests done include anterior drawer test, talar tilt test, single leg stance test, wobble board test and ankle performance tests. the procedure of the test was described Data collected at one shot ,started on February ended on July 2016 and conducted at outpatient clinic of the faculty of physical therapy, Cairo University. The examiner was the same.

Instrumentation

Digital inclinometer

Digital inclinometer was used to measure the angular displacement of the hip or knee. Digital inclinometer showed to be reliable and valid method. In addition, the inclinometer reported more reliability than goniometer **(27-30)** in both inter and intra examiner reliability.Good values reported for the validity of the inclinometer concurrently with universal goniometer that ICC ≥ 0.85, but using these devices can't been used interchangeably**(28, 30, 31)**.According to its manual,the standard reference mode level (true horizontal) is displayed as 0.0° corresponds to 90° of knee flexion in our procedure and The total knee extension was set as 90°.

The inclinometer was checked for its accuracy before using it as described in its manual; first, the inclinometer with its display faced to the examiner, was positioned on clean flat horizontal surface, 10 seconds left and the angle on the display was noted. Secondly, the unit end-for-end was rotated so the display faced away from the examiner on the same spot and 10 seconds left before reading the angle. Third and fourth steps were the same previous 2 but the inclinometer rotated upside down.

Metal bar

Made of 2 metal bars connected at right angle used as feedback to the participant in order to maintain his hip at 90 angle.

Procedure

Hamstring flexibility was evaluated by passive knee extension test **(**PKE).One of indirect clinical tests that used to assess the maximal length of hamstring flexibility**(32).** The intra-rater reliability of the test was excellent with ICC ranged from 0.945 -0.98 **(33-35)**. The average standard error of measurement based on the data of **O'Sullivan** and colleagues was 1.84 degrees **(34).**

Normative data for PKE test were reported, with the mean knee flexion angle being 38.6 (SD 8.1) for males, and 28 (SD 10.6) for females, with no significant differences between any age group**(36).**

The subjects tested in supine lying position with untested limb in extended hip and knee joints and stabilized by strap secured to the table .Then 2 reference lines were determined on the tested leg; one at the middle of the thigh (for measuring hip flexion angle) and the other at the middle of the tibia (for measuring knee extension angle) by a marker (Figure 1A) after using a tape measurement as follows: The first line at half of the distance between anterior superior iliac spine to medial femoral condyle and the second line at the half of the distance from tibial tuberosity to medial malleolus. Then, the inclinometer was positioned on the 1st reference line and the inclination angle was read and considered it as reference angle, for example if the inclination is 5^0, now this 5^0 angle is considered as 0 reference angle (Figure 1B). The subject was asked to flex his hip to reach a 95^0 (Figure 1C).

In order to stabilize the pelvis and maintain lower back flat, the participant was asked to clasp both hands behind the back of the thigh. Then instructed the subject to maintain the hip at 90^0 through maintaining the contact of distal anterior surface of the thigh with the metal bar. The digital inclinometer was positioned on the 2nd reference line on the middle tibia and set a reference zero angle as described above (Figure 1 D) thenthe participant's leg was passively extended until firm resistance (not painful) to further motion was felt and the subject said that maximum knee extension had been reached. Finally, the knee extension angle was recorded on the same 2nd reference line (Figure 1 E). The test was repeated 3 times and the average was taken.

Statistical analysis

Data were checked for normality using Shapiro-Wilk test and homogeneity. Independent t-test was used to analyze the difference in hamstring flexibility between the tested groups. Statistical analysis was conducted using the statistical package for social studies (SPSS) for windows, version 18 (SPSS, Inc., Chicago, IL). The data are presented as Mean ±SD.Significance was determined at p< 0.05.

Results

There were no significant differences p>0.05) in the mean values of age, body mass and height between both tested groups (Table1). As shown in table (2),Chi square revealed there was no significant differences between both groups in sex distribution (p>0.05). As presented in table (3), unpaired t test revealed that therewas a significant reduction in hamstring flexibility in study group in compared with control group (t=5.167, p= 0.0001*).

Discussion

The results didn't support the initial hypothesis, as there was statistically and clinically significant hamstring flexibility deficits in CAI compared to control non-injured subjects with large effect size (1.685) according to **Cohen, 1988** guidelines **(37).** No previous studies assessed hamstring flexibility, up to our knowledge, in order to directly compare with but there were other studies examined hamstring motoneurn pool excitability and activation. **Sedory et al., (18)** reported that the hamstrings central activation ratio was significantly lower for the CAI group as compared with the control group. **Deun et al. (17)** assessed hamstring onset of activity during transition from double to single leg stance at eyes opened and closed conditions reported significant delay in CAI group than control group.

Bullock-Saxton et al.(12,13) examined gluteus maximus muscle activity during hip extension from prone lying between the injured group compared to control group, reported significant delay in the onset time in CAI group and uninjured side in injured group versus each side of control group in addition the time span between the recruited onset of activity was 72% longer than the control group and the whole the patterns showed little consistency within the subject nor between sides. Not only gluteus maximum affected during active isolated movement but also during functional activity like the rotational squat exercise, the CAI group had significantly lower gluteus maximus activation than the healthy group that associated with a moderate to strong effect size **(18)**. Delay in the activation of the gluteus maximus could have important implications such as the development of altered joint stability and possibly the development of low back pain**(39)**, in contrast the early activation of this muscle provides appropriate stability to the pelvis in such functional activities as gait**(40).**

A study conductedby **Arab et al. (41)** In subjects with SI joint dysfunction, those with gluteal muscle weakness had slightly shorter but statistically significant, hamstring muscle length (mean=158±11) compared to individuals without gluteal weakness (mean=165±10). **Hungerford et al. (42)** found that patients with SI joint pain exhibit early activation of the biceps femoris and delayed activation of the gluteus maximus during single-leg stance. Other study showed resolution of hamstring muscle injuries following lumbosacral joint manipulations **(43).**

The relation between hamstrings and gluteus maximus related to functionally and anatomically connections. These muscles are in the same posterior sling according to Janda classifications for extension during reciprocal gait. Therefore, hamstring muscles function synergistically with the gluteus maximus to produce hip extension. When there is gluteus maximus inhibition, the hamstrings substitute with hip extension during gait propulsion; therefore, gluteal atrophy often is associated with hypertrophy of the hamstrings on the ipsilateral side **(44).** While the anatomical connectionbetween both through the sacrotuberous ligament. **van Wingerden et al.(45,46)** suggested that hamstring tightness could be a compensatory mechanism for providing SI stability in patients with SI joint dysfunction and gluteal muscle weakness. Other cadaveric studies by **Vleeming et al. (47, 48)** support the speculation that compensatory shortening of the hamstring muscles could compensate for ligamentous laxity induced by gluteus maximus weakness

Clinical implication

As long as hamstring muscles are 2 joint muscles (except short head of biceps femoris), therefore the muscle has proximally and distally clinical implication. Proximally, tight hamstring could cause posterior pelvic tilting, associated with kyphosis and forward head in sitting **(49).** Any changes in the length-tension relationships of any lower extremity muscle with pelvic attachments can have tremendous effects on lumbosacral alignment. These changes often result in accumulated microtrauma at the pars **(50).** At the level of the knee, hamstring tightness could increase flexion angle, during 200 ms pre- to 200 ms post heel strike the LAS group displayed increased knee flexion compared to control **(51)**. Other study by from 200 ms pre- to 200 ms post-toe off increased knee flexion bilaterally in CAI group compared to coper (LAS) group **(52).**

General rule, ROM and soft tissue extensibility are important factors in motor function. Limitations in these factors could restrict the normal coordinated pattern of the muscles and alter the biomechanical alignment of the body segment and posture **(49).**Based on this rule, as medial hamstring inserted onto the fibular head may the tightness has distal affection and restrict anterior glide of proximal tibiofibular joint. As proximal and distal tibiofibular joints are mechanically linked to each other **(53, 54)**,therefore the distal fibular would be displaced in the anterior direction that suggested by **Mulligan (55)**, individuals with CAI may have an anteriorly and inferiorly displaced distal fibula. Other studies using radiography have noted anterior fibular translation in CAI ankles **(56-59)**.If the lateral malleolus is stuck in this anteriorly displaced position, the ATFL may be more slack in this resting position **(60, 61**). In addition, **Mulligan (55)** claimed that anterior subluxation of the fibula on the tibia at the distal tibiofibular joint may be the cause of painfully limited inversion after ankle sprain, plus the increased in neutral zone of accessory movement of the joint could lead to abnormal movement pattern of the instantaneous axis of rotation of the joint with physiologic movement **(62)** and consequently alter the proprioception input and the motor control programs to compensate **(63)**.

Wikstrom and Hubbard (59) confirmed the anterior positional fault of talus which may affect its posterior glide, subsequently the dorsiflexion range might be limited which supported by some studies **(64, 65)**.Dorsiflexion ROM restriction results in more vulnerable ankle to injury as it is the closed back position of the talocrural joint. In addition restriction in posterior glide of the lateral malleolus or anterior glide of the fibular head associated directly with dorsiflexion ROM restriction **(66)** as during the dorsiflexion, talus glides in posteriorly and external rotate in relation to mortise and produce a superior-posterior -lateral glide of the distal fibula in relation to the tibia. At the same time, the proximal tibiofibular joint, the fibula glides anterolaterally and superiorly **(53, 54)** that supported by**Dananberg et al (67)** who concluded that hypomobility at the proximal tibiofibular joint can also limit ankle dorsiflexion. Generally the inability of the fibula to move may compromise the stable base from which the peroneus longus and brevis muscles act to plantar flex the first ray, transfer weight across the metatarsals and dynamically stabilize the ankle**(54)**.

Limitations of the study

Because of the retrospective nature of this study, it is possible that the observed hamstring tightness may be influenced by other factors that are not directly associated with CAI, such as spinal, pelvis and lower extremity malalignment which were not quantified in this study. Also, it is not possible to determine whether alterations were present prior to injury in the CAI or not.

Conclusion: CAI subjects hamstring tightness compared to non-injured ankle subjects which may alter SI stability and subsequently back pain.

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Table (1): Physical characteristics of patients in both groups

Items	Control group	Study group	Comparison		
	Mean ± SD	Mean ± SD	t-value	P-value	S
Age (Years)	21.9±0.62	22.09±2.04	-0.408	0.686	**NS**
Body mass (Kg)	69.54±14.63	71.66±13.95	-0.48	0.634	**NS**
Height (cm)	163.97±9.25	160.61±9.16	1.181	0.244	**NS**

***SD: standard deviation, P: probability, S: significance, NS: non-significant.**

Table (2): Distribution of sex in both groups

	Study group		Control group		Chi -Square	
	Females	Males	Females	Males	X^2	P -value
No.	17 (81%)	4 (9%)	17 (81%)	4 (9%)	1.03	0.597
Total	21 (100%)		21 (100%)			

Table (3): Mean ±SD, t and p values ofhamstring flexibility of both groups

Hamstring flexibility	Control group	Study group
Mean	162.19	145.76
SD	±9.74	±10.83
M D	16.42	
t-value	5.167	
P-value	0.0001*	
S	S	

***Significant level is set at alpha level <0.05** **SD: standard deviation**

MD: Mean difference, **p-value: probability value**

Figure 1: Showing knee extension test stages: (A): Showing 2 reference lines; B: demonstrating the inclinometer position at the 1st reference line, C: measuring the 90 of hip flexion, D: showing the inclinometer position at 2nd reference line, E: measuring the PKE angle.