ORIGINAL ARTICLE

Eastern Journal of Medicine

East J Med 27(1): 164-172, 2022
DOI: 10.5505/ejm.2022.24381

Is There any Relationship between Painful Shoulder Disorders and Balance?

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ABSTRACT

In spite of the increasing number of balance assessment studies, the relationship between painful upper extremity and balance disorders is not yet fully understood. The objective of this paper was to determine if balance was affected by painful shoulder syndromes.

A total of 40 adults aged between 20-60, 20 with painful shoulder syndrome (study group) and 20 with healthy shoulders (control group). Stability tests and the risk of fall were evaluated with the help of a Biodex Balance device, the range of motion was evaluated with the help of a universal goniometer, and the intensity of pain was measured with the help of visual analog scale (VAS) in both groups.

While the overall stability index, one of the subgroups of the stability test, differed between the groups ($p< 0.05$), no difference was observed in the fall risk scores ($p\geq0.05$). Stability test scores showed a positive significant correlation with the pain intensity, according to the VAS: pain during night ($r2=0.452$, $p=0.045$) and pain while doing any activity ($r2=0.764$, $p=0.000$).

Individuals with painful shoulders may have a stability disorder. In addition to classical measurement methods in individuals with shoulder pain, emphasis should be placed on balance assessment and shoulder evaluations may be required in adults with atypical balance disorders.

Keywords: Balance, Biodex, Pain, Postural Stability, Shoulder

Introduction

Balance is defined as a process through which muscle activity and joint proprioception maintain the center of gravity in the support area of the body. (1,2) Based on an internal body schema, information from the vestibular, visual, auditory, and motor sensory systems are move in the central nervous system (CNS) and an appropriate response is formulated by the complex coordination and integration of multiple systems. Then, muscle synergies are activated to perform the appropriate eye, limb and core movements to maintain the postural balance. (3–6)

An intact neuromuscular system and sufficient muscle strength are required by the proper motor response to keep the center of mass at the support center when the balance is disrupted.1 Most nerve and musculoskeletal system disorders can cause changes or disruptions in balance control. The lumbopelvic region forms a base of stability for the kinetic chain that enables movement of the upper limb. Decreased proprioceptive activity have been observed in patients who are complaining with rotator cuff disorder and subacromial impingement syndrome. (7,8) In the event of an upper extremity injury, proprioception of the whole kinetic chain may be affected. (9) As a result, patients will begin to exhibit signs of sensorimotor alterations, thereby indicating a non-structural comorbidity. (10) Shoulder stabilization is activated by the appropriate response and coordination of static and dynamic stabilizers that are activated by the sensorimotor system. Any kind of injury to stabilizers may disrupt proprioceptive and sensory information, neuromuscular response, integration of information, leading to a lack of sensorimotor control. (11)

After a joint or muscle damage, signals from peripheral receptors in our body cause gamma motor neuron activation and consequently changes in muscle length and function. Sensory input from the shoulder's peripheral receptors is transported from the shoulder joint to the central nervous system by afferent ways and integrated with other afferent information, revealing the muscular response required for coordination and

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Received: 08.09.2020, **Accepted:** 03.08.2021

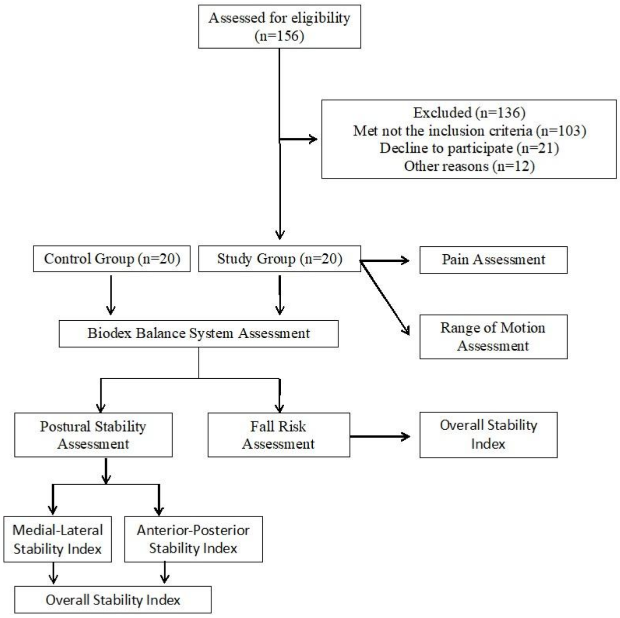

Fig 1. Design and flow of participants through the trial

joint stabilization. (11) This information is defined as the afferent information gathering from the peripheric levels of the body to provide the proper stability, arrange postural and motor control and called as proprioception. (11–13) Since pathways that process pain and provide muscle inhibition due to pain share the same pathways that control balance, it can cause imbalance. (14,15) The reason why shoulder pathologies disrupt balance is explained by two mechanisms: the change of the rate of central integration and the inhibition of muscles or proprioception. (16)

It has been shown in the literature that changes occur in the central nervous system after an orthopedic injury, but it is unclear whether this is due to impaired joint receptors, loss of mechanical stability, or the combination of both. (17,18)

Many studies (15,17–20) have evaluated balance and fall risk in lower extremity injuries or painful syndromes, However, studies on the upper extremity are limited. In this study, experiments focused on the question of whether painful shoulder syndrome has any effect on balance.

Materials and Methods

Study Design: This randomized, single-blind, clinical trial was conducted in accordance with the principles in the Declaration of Helsinki. The study was approved by the University Institutional Non-Interventional Ethics Committee (Date: 15.08.2020, Reference Number: 10840098-604.01.01-E.34199).

Patients who had painful shoulders admitted to the orthopedics and trauma clinic in Istanbul, in 2020, were included in the study. The study was initiated with 156 patients. Out of which, 53 met the inclusion criteria, total of 32 people agreed to participate. Patients who were diagnosed by the orthopedic surgeon as painful shoulder disorders, who had shoulder induced pain, and whose pain intensity was 5 or more, with activity tested and recorded on the VAS, for three months or more were included in the study. The exclusion criteria of our study were as follows: patients with one or more of these surgical operations, existence of skeletal system fractures or dislocations, other recognized orthopedic, neurological, or rheumatic diseases, diabetes, neuropathy, pregnancy, chronic headache, depression, other acute or chronic neurological or musculoskeletal diseases that may cause impaired balance, who avoid going over the balance device, kinesiophobia, drug use that can affect the CNS, and who had participated in any physiotherapy program in the last six months. On further evaluation, 20 patients mean age of 39,85 (10F,10M) with painful shoulder problems (study group) successfully completed the measurements. 20 healthy controls mean age of 42,20 (8F,12M) asymptomatic, healthy shoulders considered as the control group.

Randomization was performed according to the sequence of patients' presentation to the hospital by an orthopedic surgeon. The demographic data of the participants was obtained before randomization and the baseline medical assessments were made by a blind physiotherapist. Evaluations were explained to all participants by the same physiotherapist. After being informed about the content and context of the study, patients granted their formal approval and filled out the participant diagnostic form that consisted of the information regarding the individual's name, surname, age, gender, height, weight, communication number, presence of diagnosed disease, past disability, or any surgeries. The postural stability and fall risk test were performed in both groups by using the Biodex Balance System (BBS) device (Fig 1).

Outcome Measures: Visual analog scale (VAS) was used to measure the intensity of shoulder pain.[21] According to VAS, 0 refers to "no pain" and 10 refers to "not tolerable".[22] The orthopedic surgeon asked the individuals with painful shoulder syndrome to mark the degree of their pain during night, pain while resting, pain while doing any activity, and pain while carrying heavy objects on a paper of 10-cm length.

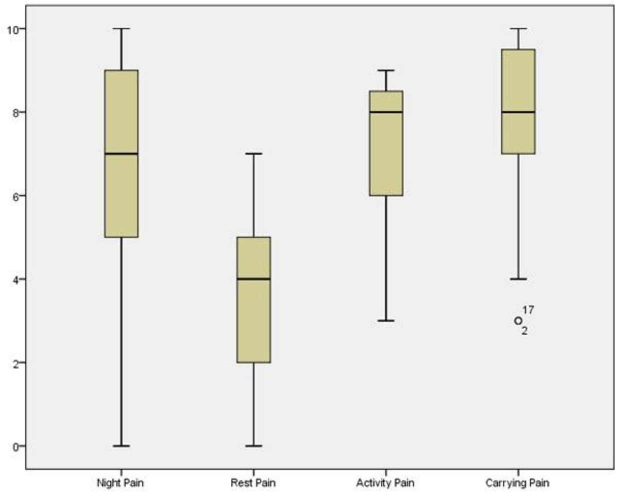

Fig 2. Mean values of shoulder pain of patients with painful shoulders

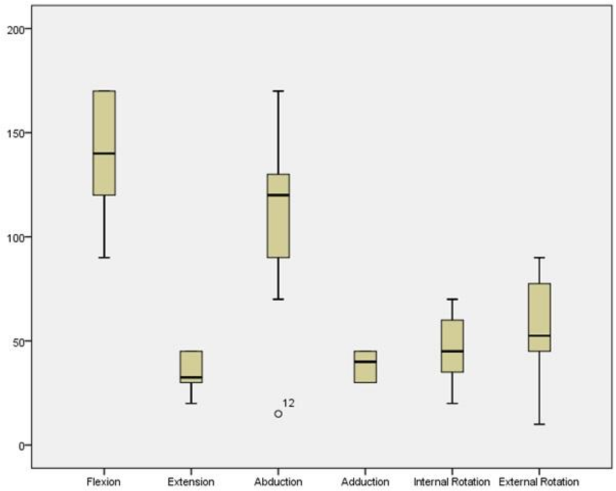

Fig 3. Mean values of Range of Motion of patients with painful shoulders

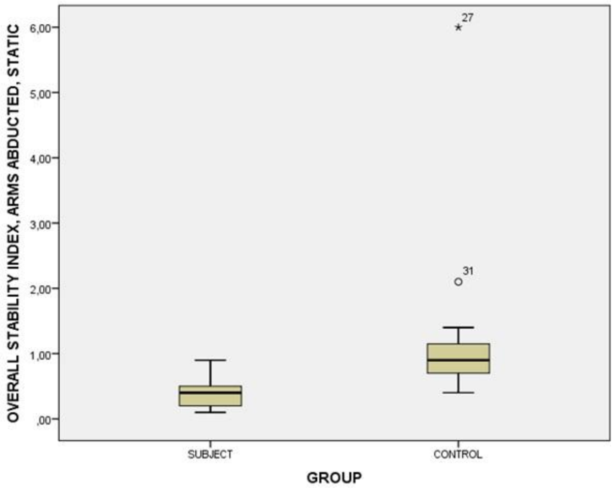

Fig 4. Overall Stability Index Static results of study and control group with arms abducted

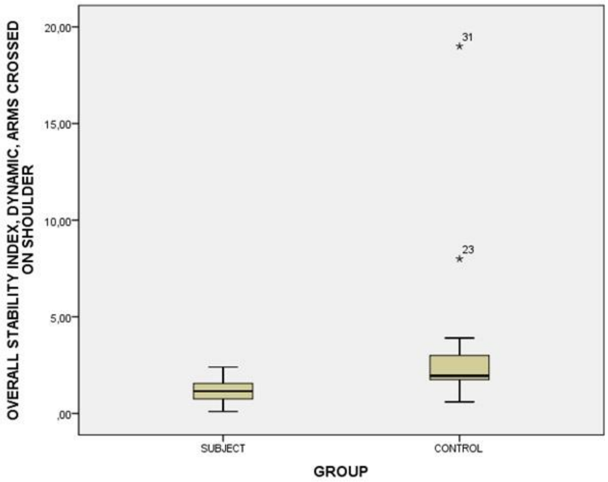

Fig 5. Overall Stability Index Dynamic results of study and control group with arms abducted

The range of motion (ROM) in the axis of transverse, sagittal, and vertical were actively requested from the participants and recorded with a universal goniometer for the shoulder. The shoulder ROM values published by the American Association of Orthopaedic Surgeons were accepted as normal values. (23)

Biodex Balance System **(**BBS)(*Balance System™ SD, 115 VAC, New York*) uses a circular platform in both mediolateral and anteroposterior directions with a free motion that allows to objectively and simultaneously measure an individual's ability to stabilize the involved joint under the action of dynamic forces. BBS allows a foot tilt, up to 20°, thereby allowing a maximal stimulation of the ankle joint mechanoreceptors. It measures the degree of inclination relative to the three axes under dynamic forces and calculates the medial-lateral stability index (MLSI), anterior-posterior stability index (APSI), and overall stability index (OSI). These indices show alterations relative to the zero point in stabilization created before testing. For example, an OSI of 10 ° would mean that on average the distance from the center is 10 °.

It measures the slope degree around each axis during dynamic conditions and calculates the medial–lateral stability index (MLSI), the anterior–posterior stability index (APSI), and the overall stability index (OSI). These indices show fluctuations around the zero point that was created before the test, when the platform was stable. For example, an OSI of 5° will mean that on an average, the distance from the center is 5°. The postural control score refers to the person's balance ability in general and high values indicate that the balance is bad. Studies have demonstrated the reliability of the BBC in terms of dynamic posture assessment in healthy individuals. BBS provides an opportunity to measure balance and

Table 1. Demographic Characteristics of Individuals

	Control Group M±SD	Study Group M±SD	p-value
Age (N=20)	42.20±10.82	39.85±7.33	0.240
Height (N=20)	170.75±7.11	151.43±51.63	0.125
Weight (N=20)	76.45±14.9	74.85±12.47	0.946
BMI (N=20)	26.14±4.55	25.33±7.79	0.433
Sex	% (N)	% (N)	
Female	40 (8)	50 (10)	0.267
Male	60 (12)	50 (10)	

BMI= Body Mass Index, M= Mean Value, SD= Standard Deviation

fall risk. (2,3) Postural stability test was performed in four different combinations: at the stable platform level 12 (static) and at moderately unstable platform level 6 (dynamic), with arms abducted at 90º (open) and arms crossed on the shoulder as standing on the balance platform. Participants' feet were positioned over the center of the platform to always maintain the balance in the same coordinates and not lose foot placement for subsequent trials.

The evaluation of the fall risk test was conducted when the dynamic platforms were increasingly moved from 12th grade to 6th grade, with participants' eyes open and eyes closed, their arms crossed on the shoulder and arms abducted at 90º positions. During the test, participants were asked to look at a fixed spot in the level of eyeline. After three trials of tests, same protocols on a one-minute gap were tested for three times. The average of these three tests was taken as the primary value for the individuals. Higher scores indicated a better performance. (2)

Data Analysis: All statistical analyses were conducted by using "Statistical Package for Social Sciences" (SPSS) Version 22.0 (*SPSS Inc. Chicago, IL, ABD*). Descriptive statistics in the form of means, standard deviations, and counts were used to describe the baseline characteristics across study groups. Normality was assessed by using the Shapiro–Wilks test. Comparison analysis of independent and parametric data was conducted with the help of "Independent Sample T Test." As all data sets showed a normal distribution, the correlation analysis was performed by using "Pearson Correlation Analysis". G*Power 3.1 statistical power analysis was used to calculate the sample size. (24,25) Effect sizes were derived from a prior research, which used BBS. Sample size calculations were performed by using an independent sample t test to examine the significant differences in the means of study and control groups (power=0.95, a= 0.05). The effect size of 1.68 was required for a total sample size of 22, of which the allocation ratio is 1. Significance was set a priori at an alpha value of % 5 ($p<0.05$).

Results

The demographic characteristics of the individuals such as sex, age, height, weight, and BMI are illustrated in Table 1. The sample size was estimated to be of 40 participants in two groups. There are no statistic differences between the two groups in terms of age, height, weight, BMI, and sex ($p>0.05$) (Table 1).

Pain levels performed in different situations, assessed by VAS, are given in Figure 2. Mean intensities of pain during night, pain during rest and pain while doing an activity were 6.65 ± 2.9, 3.55 ± 1.95, and 7.2 ± 1.73, respectively (Fig 2). ROM measurements of the study group participations are shown in Figure 3. The ROM values of the extension, flexion, abduction, adduction, external and internal rotation movements were not different than normal values ($p>0,05$).

The study group showed a significant difference in the Postural stability assessment Overall Stability Index scores in static and dynamic positions while their arms were open as compared with the control group ($p<0.05$) (Fig 4, Fig 5). No statistical differences were found in APSI and MLSI between groups ($p\geq0.05$) (Table 2).

The mean scores of fall risk assessment show higher values in the group with shoulder disorders; no statistical differences were found

Table 2. Stability Index and Fall Risk Scores of Control and Study Group

Assessment Steps			Control Group	Study Group	p
			Mean±SD	Mean±SD	
Overall Stability Index	Arms open	S	0.41±0.23	0.93±0.37	0.000*
		D6	1.16±0.6	3.23±4.03	0.000*
	Arms on shoulder	S	0.65±0.37	0.89±0.5	0.059
		D6	1.54±0.67	1.99±1.11	0.119
Anterior-Posterior Stability Index	Arms open	S	0.37±0.4	0.39±0.74	0.677
		D6	0.81±0.53	1.03±0.48	0.106
	Arms on shoulder	S	0.44±0.36	0.47±0.68	0.827
		D6	0.85±0.51	0.89±0.39	0.462
Medial-Lateral Stability Index	Arms open	S	0.25±0.17	0.57±0.84	0.301
		D6	0.64±0.33	0.89±0.8	0.334
	Arms on shoulder	S	0.39±0.2	0.57±0.98	0.967
		D6	0.6±0.31	0.65±0.47	0.967
Fall Risk	Arms open	EO	1.01±0.43	0.93±0.37	0.454
		EC	3.46±2.5	3.22±4.03	0.498
	Arms on shoulder	EO	1.09±0.55	0.89±0.5	0.077
		EC	3.79±2.12	3.37±3.4	0.167

*p<0,05
SD: Standard Deviation, S: Static, D6: 6th level of dynamic, EO: Eyes Open, EC: Eyes Closed

Table 3. Correlation Table of Postural Stability and Pain

		Arms on shoulder-Static	Arms on shoulder-Dynamic 6	Arms open- Static	Arms open-Dynamic 6
Rest pain	r2	0.418	0.325	0.326	0.382
	p	0.670	0.163	0.160	0.017
Pain with activity	r2	0.300	-0.253	0.339	0.607
	p	0.901	0.282	0.144	0.005*
Night pain	r2	-0.223	-0,296	-0.160	0.355
	p	0.345	0.206	0.499	0.124
Pain while carrying heavy objects	r2	0.412	0.384	0.111	-0.009
	p	0.071	0.095	0.642	0.969

*p<0,05

between the groups in fall risk scores (p≥0.05) (Table 2).

The correlation analysis of static and dynamic OSI values while arms open showed statistically significant and positive correlations between pain with activity (r^2=0.607, p=0.005) (Table 3). There was no significant correlation between other parameters and pain.

Discussion

This randomized, single-blind study in which 40 adults (20-60 years) with painful shoulder disorders were diagnosed, their balance was examined. With this study, it was determined that the stability was significantly different between the control and study groups and that stability was positively correlated with pain intensity.

Balance or postural stability is a complex task that involves maintaining balance and integrating the appropriate neuromuscular activity required with multiple sensory, motor and cognitive inputs. (6) Current evidence suggests that patients with shoulder pain suffer from lack of proprioceptive input in their shoulders, as well as a lack of coordination in the body and lower extremities. (10,11,28,34) Machner et al. (7) evaluated in 15 patients with Neer Stage II impingement syndrome shoulder motion sensation treated with arthroscopic subacromial decompression. After adjusting the motion perception thresholds for the patient, they measured shoulder movements in a specially designed chair. Before the decompression surgery, the perception of motion was found to be lower in the affected shoulder compared to the healthy shoulder. While an increase was observed in the affected shoulder proprioception after the operation, no change was found on the healthy side. (7) Cuomo et al. (34) analyzed passive position sensation and movement using the shoulder proprioception test in 20 patients with unilateral glenohumeral arthritis undergoing Total Shoulder Arthroplasty (TSA). The test was performed 1 week before the TSA operation and 6 months after Total Shoulder Arthroplasty (TSA). The presence of glenohumeral arthritis had a significant effect on flexion, abduction, external rotation, and sense of position. They found significant differences when compared to age- and sex-matched healthy control group. After TSA results showed that the sense of position improved significantly and was not significantly different from that of the opposite shoulder or comparison group. Motion detection was also significantly worse on the arthritic side compared to the opposite side. Six months after TSA, sensitivity to detect motion increased and was not significantly different compared to the unaffected contralateral shoulder and the control group. With this study, proprioceptive function significantly decreased in patients with glenohumeral arthritis has been shown. (34)

Myers et al. (11) announced that proprioception deficits lead to abnormal proprioception in the whole muscle chain and, affect the central control system which has same paths on central nervous system ultimately. (11,14) Thus, disorders seen in the shoulder can affect proprioception, disrupt the whole chain and may be a cause of loss in balance or stability. Treede et al.[14] believed that pain can be the one of the reasons of balance disorders. A explanation for this may be in the processing of pain, the balance control circuit, and the inhibition of pain-induced muscles that share same common paths of the CNS.[14] Baierle et al.[29] included 40 painful shoulders (more than 7 on 15cm long VAS) aged between 35-80, they demonstrated that painful shoulder disorders can disturb body stability while comparing with healthy control groups but no correlation between pain intensity. They reported that it might be related to pain processing which has partly the same pathway. (35)

Ali M. Alshami's study showed that 30 patients with mild to moderate chronic shoulder pain did not show statistically significant differences in standing and walking balance when compared with healthy shoulder controls. However, they found trends that balance was lower in the shoulder pain group than in the healthy controls. (36) Although it was not associated with pain severity, they proved that a painful shoulder negatively affects balance.

Study of Eker and Kaygisiz were included 60 subjects, whose shoulder pain intensity during activity and rest were evaluated by VAS, were divided into two groups as moderate and severe pain. Postural stability, balance and fall risk were evaluated with the Sportkat System, Berg Balance Scale (BBS), and Fall Efficacy scale (FES). It was concluded that there was a correlation between pain intensity and balance and stability disorder. (37)

In our study, it was shown that painful shoulder pathologies may impair the stability of the body. Although no significant difference was found between the groups in terms of the risk of falling in our study, static and dynamic OSI has shown statistically higher scores than the healthy controls. This result might be conceive that the affected shoulder leads to coordination deficits between body parts. However, the OSI scores were higher with the condition of patients keeping their arms open. Generally, individuals' open arms during activity may explain the positive correlation between pain during activity and OSI. This observation suggested that higher pain values while doing any activity as opening arms lead to an increase in the OSI scores. Our study has a similar aim with the study of Eker and Kaygisiz and shows parallel results. The strength of our study is the use of the Biodex Balance device, which gives objective results.

Lower extremity stability and core neuromuscular control were evaluated in 80 athletes (with 40 shoulder injuries) with eyes open and closed. As a result of this evaluation, no difference was found between core neuromuscular control and lower extremity stabilization in patients with or without shoulder injury. (38) The fact that this study is different from the others suggests that it may be due to the fact that it consists of athletes who do high physical activity and have developed high balance ability.

Sibley et al. (30) showed that pain leads to presynaptic inhibition of muscle afferents and that these pain-related muscle inhibition mechanisms can have a negative effect on balance ability. The fact that the range of motion values of the study group are not statistically different from the values of the control group suggests that the deterioration in balance is may not related to

ROM, but is may related to the processing of pain and proprioceptive information by muscle inhibition mechanisms. Ruhe et al. (31) announced that the patients with non-specific back pain have decreased postural sway when the pain has been stopped. Muto et al.[32] evaluated the postural control and balance in women with and without fibromyalgia and found that postural control and balance were adversely affected in patients with fibromyalgia due to pain, muscle weakness, and the prevalence of symptoms. Jones et al. (33) showed that people with fibromyalgia have consistent objective sensory deficits that were measured by dynamic posturography despite normal clinical neurological examination. It has been proven that pain has an effect on stability or balance in different diseases. The positive correlation between pain and stabilization in our study is similar to these results and shows that the effect of painful shoulder disorders on balance may be like the others.

When the literature is examined, there are not many studies were found to evaluate the stability and the risk of falling by objective measurement methods, in upper extremity painful disorders. In our study, individuals with only painful shoulders and no obstacles to disrupt balance were evaluated in terms of stability and fall risk and compared with healthy controls. In summary, in our study objective balance assessment was performed in patients with painful shoulder disorders and compared with healthy controls. As a result of the evaluation, it was concluded that impaired balance and positive correlation between pain and stability in painful shoulder disorders has been seen. However, shoulder pain disorders are discussed in general, not divided into subtitles, and can be considered as a limitation of the study. To obtain more reliable results, a more specific shoulder syndrome and with more participants should be investigated in future studies.

In conclusion, the results clearly showed that painful shoulder pathologies may cause stability disorders and do not affect the risk of fall. These findings suggest that shoulder pathologies can lead to an impairment in body stability and balance problems. In addition to classical measurement methods in individuals with shoulder pain, emphasis should be placed on balance assessment and shoulder evaluations may be required in adults with atypical balance disorders. Further longitudinal studies are required to define whether shoulder pain affects balance or not.

Acknowledgments: Declarations of interest: None

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

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