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Exploring Muscle Strength, Proprioception, and Pain Duration in Shoulder Impingement Syndrome

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ABSTRACT

This study aimed to explore how proprioception and muscle strength relate to pain duration in individuals with shoulder impingement syndrome. The study involved 45 participants (15 males and 30 females), aged between 22 and 74 years, all diagnosed with shoulder impingement syndrome and experiencing pain lasting from 1 to 36 months. After assessment of pain duration, muscle strength was measured using a hand-held dynamometer (K-Force Kinvent, 34000 Montpellier, France), and shoulder joint proprioception was assessed with an inclinometer (Goniometer Pro, 5fuf5 Co., New Jersey, USA). All measurements were taken on the affected side with impingement. Pearson's correlation analysis was used to examine the relationship between muscle strength and proprioception with the duration of pain in parametric data, while Spearman's rank correlation coefficient was employed for non-parametric data. The results were evaluated at a significance level of 0.05. At the end of the study, there was no significant correlation found between pain duration and both muscle strength and proprioception ($p > 0.05$). The study concluded that there is no relationship between muscle strength, proprioception, and the duration of pain in shoulder impingement syndrome. Our findings suggest that when investigating upper extremity disorders with primary outcomes of muscle strength and proprioception, pain duration need not be included in study eligibility criteria. The absence of significant correlations suggests these parameters function independently of how long symptoms have persisted. Further studies are needed to explore the relationship between pain chronicity, strength deficits, and proprioceptive alterations across different painful conditions.

Omuz Sıkışma Sendromunda Kas Kuvveti, Propriyosepsiyon ve Ağrı Süresinin İncelenmesi

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ÖZET

Bu çalışmanın amacı omuz sıkışma sendromu olan bireylerde propriosepsiyon ve kas kuvvetinin ağrı süresi ile nasıl ilişkili olduğunu araştırmaktır. Çalışmaya impingement tanısı almış ve en az 1 aydır en fazla 36 aydır ağrısı olan 45 birey (22-74 yaş aralığında 15 erkek, 30 kadın) dahil edildi. Bireylerin ağrı süreleri sorgulandıktan sonra, kas kuvvet ölçümleri el dinamometresi (K-Force Kinvent, 34000 Montpellier, Fransa) ile, omuz eklemi propriosepsiyon duyusu inklinometre (Goniometer Pro, 5fuf5 Co. New Jersey, ABD) ile gerçekleştirildi. Ölçümler impingement olan tarafta yapıldı. Çalışma verilerinin istatistiksel analizinde, parametrik verilerde kas küvveti ve propriyosepsiyon duyusu ile ağrı süresi arasındaki ilişkiyi araştırmak için Pearson korelasyon analizi kullanıldı. Non-parametrik veriler için ise Spearman'ın sıra korelasyon katsayısı kullanıldı. Sonuçlar 0,05 anlamlılık düzeyinde değerlendirildi. Çalışmanın sonunda ağrı süresi ile kas kuvveti ve propriosepsiyon arasında anlamlı bir korelasyon bulunmamıştır ($p>0,05$). Çalışma sonucunda omuz impingement sendromunda ağrı süresi ile kas kuvveti ve propriosepsiyon duyusu arasında ilişki olmadığı belirlendi. Bu sonuç; kas kuvveti ve proprioseptif duyu ölçümlerinin primer sonuç ölçütleri olduğu üst ekstremite problemlerinde, ağrı süresinin çalışmaya dahil edilme ve çıkarılma kriterlerinde dikkate alınması gereken bir durum olmadığını desteklemektedir. Farklı ağrılı durumlarda ağrı süresi ile kas kuvveti ve propriosepsiyon duyusunu araştıracak çalışmalar ihtiyaç vardır.

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INTRODUCTION

Shoulder pain is one of the most common musculoskeletal complaints encountered in clinical practice, with impingement syndrome frequently identified as a primary diagnosis (Garving et al., 2017). Shoulder impingement syndrome is usually marked by the compression of soft tissues-such as the rotator cuff tendons, the long head of the biceps tendon, and the subacromial bursa-beneath the coracoacromial arch during arm elevation (Du et al., 2020). Individuals with impingement syndrome often complain of pain and related functional impairments (Tozzo et al., 2021). This pain has been shown to impair muscle function and cause abnormal EMG activation patterns (Stackhouse et al., 2021). Furthermore, muscle strength deficits tend to occur in shoulder impingement syndrome (Du et al., 2020; Kim et al., 2021).

Some of the frequent signs and symptoms associated with shoulder injuries include pain, decreased strength, and impaired proprioception (Ager et al. 2020a). Research indicates that proprioception is affected in individuals with shoulder conditions such as post-arthroplasty, rotator cuff injuries, and shoulder impingement syndrome (Echalier et al., 2019; Gumina et al., 2019; Walecka et al., 2020). Proprioception is a specialized sensory system facilitated by joint, muscle, and cutaneous peripheral receptors, providing input about limb position and movement. The shoulder's neural structures and mechanoreceptors, located in the joint capsule and ligaments, provide feedback that regulates muscle activity, thereby controlling joint position and movement, and ensuring reflex and joint stability (Sahin et al., 2017). Any impairment in the shoulder that affects proprioception can give rise to altered motor control, joint instability, and limitations in functional ability (Alfaya et al., 2023). Several studies in the literature suggest that impaired proprioception may be associated with factors such as nerve or tissue damage, nervous system desensitization, altered cortical representation, the presence of pain, swelling, fatigue, or, in some cases, a combination of these factors (Ager et al., 2020b). Furthermore, previous studies have highlighted that joint position sense plays a critical role in maintaining joint stability during both static and dynamic activities, and that impaired proprioception may increase the risk of developing clinical pain (Reddy et al., 2019).

The impact of pain on shoulder proprioception and muscle strength, when categorized as chronic or acute, lacks sufficient evidence. The extent to which pain duration affects muscle strength and proprioception remains unclear. Nonetheless, pain duration serves as a criterion for inclusion and/or exclusion in all related studies. Reviews of the literature have established that proprioception and muscle strength are altered in shoulder impingement syndrome (Alfaya et al., 2023; Sahin et al., 2017; Singh et al., 2022). Studies also suggest a correlation between pain intensity and both proprioception and muscle strength (Ager et al., 2024; Soysal Tomruk et al., 2024; Wu et al., 2022). However, current research has primarily focused on pain intensity, leaving a gap in understanding the relationship between pain duration and physical attributes like muscle strength and proprioception. Therefore, this study aims to investigate the association between pain duration and both muscle strength and proprioception in individuals with shoulder impingement syndrome.

METHOD

Research Design

This pilot study included 45 volunteers (15 males and 30 females), aged 22 to 74 years, who were clinically diagnosed with shoulder impingement syndrome by a physician at the Erzurum City Hospital's Physiotherapy and Rehabilitation Clinic.

Research Sample/Study Group/Participants

A priori power analysis was done with G*Power 3.1.9.4 to ascertain the necessary sample size needed. With an effect size of 0.4 (medium), a power of 0.80, and a significance level of 0.05, the study required at least 44 individuals (Walecka et al., 2020).

Inclusion criteria for the study included a physician's diagnosis of shoulder impingement, absence of additional shoulder discomfort, no labrum tears, no systemic diseases or health problems, no limitations in both active and passive joint ranges of motion, and participants also needed to be cooperative and capable of performing the study's tests. Exclusion criteria included not meeting the inclusion requirements, having acute or chronic neurological or orthopedic issues affecting the upper extremity, previous surgeries on the upper extremity, and any joint motion limitations. Physicians' imaging assessments and the individuals' responses to the assessment questionnaire also provided crucial information for inclusion.

Research Instruments and Processes

All evaluations were conducted on a single day. Prior to the assessments, passive range of motion (ROM) was measured for all participants. Those without limitations in passive ROM were then asked to complete a form detailing their demographic information, study inclusion criteria, and medical history. Subsequently, proprioception assessments were conducted to ensure that the muscle strength tests did not affect proprioception. Lastly, muscle strength testing were performed.

Evaluation of Shoulder Proprioceptive Sensation

An inclinometer smartphone application (Goniometer Pro, 5fuf5 Co., New Jersey, USA) was used to measure shoulder proprioception. The app has been established as valid and reliable (Ünal et al., 2017; Yarin Achachagua et al., 2021). Shoulder proprioception was assessed using an active repositioning sensation test involving flexion, abduction, and external and internal rotation movements. For shoulder flexion and abduction, measurements were taken at 30°, 60°, 90°, and 120° while the participant sat in an armless chair. For external and internal rotation, measurements were taken at 15°, 30°, and 45° while the participant lay on a stretcher. Each measurement was repeated three times, and the mean score was calculated for statistical analysis (Walecka et al., 2020). First, an angle was measured passively by the researcher with the participant's eyes closed. The participant was then instructed to actively replicate the movement to match the angle and verbally indicate completion by saying "here" once the perceived position was reached. Participants were briefed before each measurement, with a 10-second rest provided between measurements. All measurements were taken on the affected side and recorded in terms of angles.

Evaluation of Shoulder Muscle Strength

Shoulder muscle strength was measured using a K-Force handheld dynamometer (Kinvent, 34000 Montpellier, France) in accordance with manual muscle strength guidelines (Cildan Uysal et al., 2022). During the assessment, the researcher first demonstrated the target position to establish the correct participant replication. Measurements were taken after a single trial attempt and recorded in Newtons, with a standardized 10-second rest interval between each testing repetition.

Shoulder flexion: the participant was instructed to perform a 90° shoulder flexion while seated in an upright position, with the palm facing down. The measurement was then taken by applying resistance in the direction of shoulder extension over the humerus.

Shoulder hyperextension: the participant was instructed to perform hyperextension of the arm while lying in a prone position. The measurement was taken by applying resistance downward from the distal part of the elbow joint.

Shoulder abduction: the participant was instructed to perform 90° shoulder abduction in an upright sitting position, and the measurement was made by applying resistance in the direction of adduction from the distal part of the elbow joint.

Shoulder horizontal abduction: the participant was instructed to keep their forearm hanging from the edge of the bed in a 90° shoulder abduction position while lying prone with the elbow perpendicular to the floor. The participant's scapula was fixed by the researcher, then they were asked to open their arm to the side, and the measurement was made by applying downward resistance from the distal part of the elbow joint.

Shoulder horizontal adduction: the participant was instructed to pull their hand towards their opposite shoulder with the arm in 90° abduction while lying supine. The measurement was taken by applying outward resistance from the inner surface of the humerus.

Shoulder external rotation: the participant was instructed to put their shoulder into 90° abduction, elbow in 90° flexion, and hand positioned neutrally while lying in the supine position. The measurement was taken by applying opposing resistance from the distal part of the wrist.

Shoulder internal rotation: The participant was instructed to put their shoulder into 90° abduction, elbow in 90° flexion, and the hand in a neutral position while lying prone. The measurement was taken by applying resistance in the opposing direction from the distal part of the wrist (Otman and Köse, 2016).

Data Analysis

Data analysis of the study was performed with SPSS version 20 (Statistical Package for the Social Sciences). Descriptive statistics, i.e., mean, standard deviation, and range (minimum and maximum), were calculated for the variables. The Shapiro-Wilk test was employed to evaluate whether there was normality in the distribution of the study data. To explore the relationships between pain duration, muscle strength, and proprioceptive sensation, Pearson’s correlation analysis was applied to the parametric data, while Spearman’s rank correlation was selected for analysis of non-parametric data. Statistical significance was set at a p-value of < 0.05.

RESULTS

This study involved a total of 45 participants, carefully selected to analyze the relationship between pain duration, proprioception, and muscle strength. Among the participants, the duration of pain varied significantly, ranging from one month to thirty-six months.

In anthropometric characteristics, the participants had an average body weight of 72.36±14,73 kg. Their average height was measured at 165.31±9.34 cm. The calculated Body Mass Index (BMI) for the participants averaged at 26.60±5,69 kg/m². The participants' mean age was 51±15 years, spanning a broad age range, which ensured representation from middle-aged and older adults. The demographic and physical characteristics of the study participants are summarized in Table 1.

Table 1

Demographic Data and Physical Characteristics (n=45)

Variables			**Mean ± SD**	**Min-Max**
Body weight (kg)			72.36±14.73	42.00-100.00
Body height (cm)			165.31±9.34	150.00-188.00
BMI (kg/m²)			26.60±5.69	14.69-36.73
Ages			51±15	22-74
Muscle strength	*Flexion*		5.5±1.4	3.0-8.0
	Hyper-Extension		4.8±1.3	2.4-7.6
	Abduction		5.3±1.4	2.9-8.9
	Hyper-Abduction		5.5±1.5	2.3-8.9
	Hyper-Adduction		4.2±1.2	2.5-7.8
	Internal Rotation		4.8±1.1	3.0-6.8
	External Rotation		4.8±1.1	3.0-7.1
Proprioception sense	*Flexion*	*120°*	103.70±41.32	0.00-133.33
	Abduction	*30°*	39.07±5.31	25.33-49.67
		60°	64.30±5.21	45.33-74.00
		90°	89.37±14.28	0.00-103.33
		120°	93.55±50.67	0.00-129.67
	Internal Rotation	*15°*	21.64±3.36	10.33-30.00
		30°	36.39±2.99	28.33-42.67
		45°	48.61±2.95	41.33-56.33
	External Rotation	*15°*	21.31±2.54	15.67-27.33
		30°	35.97±3.12	24.00-44.33
		45°	47.86±2.93	38.33-53.33

Mean ± SD: Mean ± Standard deviation, Min-Max: Minimum – Maximum, °: degree, BMI: Body mass index, m: metre, kg: kilogram, cm: centimetre

Table 2 presents a comparative analysis of the duration of pain in relation to proprioception and muscle strength. The results demonstrated that no statistically significant correlation was observed between the duration of pain and either proprioception and muscle strength ($p > 0.05$). This lack of significant association suggests that, within this sample, the length of time participants experienced pain did not directly impact their proprioception or muscular strength.

Table 2
Comparison of the Relationship Between Proprioception and Muscle Strength with Pain Duration

Variables			**Pain duration**	
			r	**p**
Shoulder muscle strength (Nm)	*Flexion*		0.213	0.159
	Hyper-Extension		0.082	0.593
	Abduction		0.044	0.774
	Hyper-Abduction		-0.079	0.607
	Hyper-Adduction		0.289	0.054
	Internal Rotation		0.178	0.241
	External Rotation		0.165	0.279
Shoulder proprioception (°)	*Flexion*	*30°*	-0.019	0.900
		60°	-0.042	0.785
		90°	-0.093	0.542
		120°	0.094	0.537
	Abduction	*30°*	0.073	0.634
		60°	-0.140	0.359
		90°	-0.146	0.337
		120°	0.000	0.998
	Internal Rotation	*15°*	-0.045	0.769
		30°	-0.061	0.689
		45°	-0.275	0.067
	External Rotation	*15°*	-0.135	0.378
		30°	-0.006	0.967
		45°	-0.275	0.067

Nm: Newton metre, p: p-value, r: correlation coefficient, °: degree

DISCUSSION

Our study examined potential associations between pain chronicity, muscular strength deficits, and proprioceptive alterations in patients diagnosed with shoulder impingement syndrome. Analysis of the data revealed no statistically significant correlations between symptom duration and shoulder muscle strength parameters or proprioceptive acuity in the affected population.

In a study similar to ours, Youssef et al. (2024) observed that although functional performance in patients with subacromial impingement syndrome correlates with the degree of pain and disability, shoulder joint proprioception does not appear to correlate with the measured outcome variables. on the other hand, contrary to our findings, multiple studies in the literature have documented impaired shoulder proprioception in impingement syndrome patients, corroborating previous research that reported proprioceptive deficits in individuals with various shoulder pathologies (Ager et al., 2017; Alfaya et al., 2023; Saadatian et al., 2022). The proprioceptive impairments observed in these studies may be attributed to altered sensory input resulting from anatomical changes and inflammatory processes associated with subacromial impingement syndrome. Smith et al. (2013) supported the concept that proprioceptive deficits are associated with greater pain severity and functional limitations. Additionally, these strong positive correlations between impaired shoulder proprioception and elevated pain intensity and disability scores suggest that individuals with more pronounced proprioceptive deficits tend to experience more severe pain and functional limitations (Alfaya et al., 2023).

A study examining the relationship between pain duration and muscle strength in the knee joint found that as the duration of pain increased, quadriceps muscle strength decreased (Saral et al., 2022). This finding is supported by research on individuals with anterior knee pain, which similarly reported a negative association between pain duration and muscle strength (Kim and Park, 2022). However, few studies have explored the relationship between pain duration and muscle strength in the shoulder joint. One such study found no correlation between shoulder function and pain duration in patients with

rheumatoid arthritis (Slungaard and Mengshoel, 2013). This result is consistent with our own study, which also found no significant correlation between shoulder muscle strength and pain duration.

Studies focusing on the knee joint and the relationship between pain duration and muscle strength suggest that neural adaptation in the central nervous system, due to pain, may influence peripheral nociceptor activity over time (Kim and Park, 2022). The observed contradiction in the relationship between pain duration and muscle strength could be attributed to structural differences between joints and variations in nociceptor activity. The knee joint primarily bears weight during movement, while the shoulder joint, which is not typically load-bearing, emphasizes functionality. Numerous studies have highlighted the connection between pain and functionality (Lee and Oh, 2019; Mallick-Searle et al., 2021; Prado et al., 2023; Savaş and Şimşek, 2023; Tanrıverdi et al., 2019). Given these findings, it is plausible that the observed relationships may be more closely linked to declines in functionality and muscle strength rather than pain duration, suggesting a need for further research to better understand these dynamics.

Few studies have explored the impact of pain duration on proprioception. One study comparing neck pain patients and asymptomatic subjects found no significant relationship between pain duration and neck proprioception (Dugailly et al., 2015). Similarly, our research found no correlation between the duration of shoulder pain and proprioception. The effect of pain on proprioception can be partially explained by the final common input hypothesis, which posits that sensory inputs, such as proprioception, are integrated with efferent outputs, like pain, within the nervous system. This essentially suggests that pain and proprioception are interconnected and processed together in the brain and nervous system (Ager et al., 2020b). Based on the analysis of our study findings, it appears that pain duration does not significantly alter the inputs within these pathways.

CONCLUSION AND SUGGESTIONS

In conclusion, this study examined the relationship between pain chronicity, muscular strength deficits, and proprioceptive alterations in individuals with shoulder impingement syndrome, finding no significant correlation. Our findings demonstrate that symptom chronicity does not significantly influence upper extremity muscle strength parameters or proprioceptive acuity in the studied population. These results corroborate previous research in the literatüre and suggest that pain duration need not be incorporated into eligibility criteria for investigations where neuromuscular performance or proprioceptive function serve as primary outcome measures. The apparent independence of these physiological parameters from the temporal aspects of pain presentation may have important implications for research methodology and clinical assessment protocols.

Further research is needed to examine the role of pain duration in muscle strength and proprioception across other painful conditions. This study ultimately reiterates that pain duration does not influence muscle strength and proprioception in those with shoulder impingement syndrome.

LIMITATIONS

Our study presents several limitations that warrant consideration. Primarily, our methodology focused exclusively on pain duration without concurrent assessment of pain intensity or functionality, both of which potentially modulate neuromuscular adaptations and proprioception. The absence of standardized pain intensity measurements and validated functional outcomes represents a significant limitation in presenting the multidimensional nature of shoulder dysfunction. Furthermore, we did not account for potential compensatory mechanisms that may appear in adjacent muscles and joints. Such adaptations frequently develop in response to nociceptive input and could substantially influence shoulder biomechanics through altered movement patterns. This may partially explain the absence of observed correlations between our measured parameters.

Additionally, the study design did not incorporate comprehensive quantification of participants' physical activity levels or occupational demands. These factors constitute potential confounding variables that may influence both strength parameters and proprioceptive acuity independent of pain characteristics. Previous research has established that regular physical activity significantly impacts neuromuscular performance and sensorimotor function, potentially making it difficult to ascertain relationships between pain duration and other outcome measures. Lastly, the cross-sectional design of our study does not allow us to determine causal relationships between measured variables. Longitudinal studies with repeated measurements would provide stronger evidence of how pain duration, strength, and proprioceptive deficits are related over time in this population.

Ethics Approval

All procedures of the study comply with the principles of the Declaration of Helsinki (2008), and Ethics committee approval for the study was granted by the Ankara Yıldırım Beyazıt University Health Sciences Institute's Ethics Committee before the commencement of the study (Decision no: 14.06.2023\06-261). Permission from Erzurum City Hospital's Physiotherapy and Rehabilitation Clinic were obtained to conduct the research. Participants were both verbally and textually informed about the study's objectives and the assessments to be conducted. Subsequently, written consent was obtained from those who consented to be a part of the study.

Conflict of interest

Authors do not have any conflict of interest.

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Author Contributions

Design: B.A., S.K. Data Collection or Processing: S.K., B.A. Analysis or Interpretation: B.A. Literature Search: S.U.S., S. K., B.A. Writing: S.U.S., B.A.

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