Effect of Diaphragmatic Breathing on Shoulder Rotational Mobility-Single-Blind Randomized Controlled Study

Emre Serdar ATALAY[*], Çağlar SOYLU[**], Güler ATALAY[***], Necmiye ÜN YILDIRIM[****]

Abstract

Aim: Shoulder mobility has an important place in both sports and daily life activities. The low rotational mobility of the shoulder in sports injuries is considered to be in the first place in the aetiology. The innervational and myofascial connection between the diaphragm muscle and the shoulder is known. This study aims to examine the instantaneous effect of the breathing exercise focused on the diaphragm muscle on shoulder mobility.

Method: 136 young, healthy, recreationally active adults aged 18-25 years were included in the study. Participants were randomly divided into two groups the intervention group (n=86) and the control group (n=50). The control group did nothing for 90 seconds while the intervention group engaged in the diaphragmatic breathing technique that had previously been taught. Shoulder mobility was assessed using the Functional Movement Screen (FMS™) test both before and after the intervention.

Results: Although substantial gains in shoulder mobility were observed in both shoulders of the intervention group, only the left shoulder in the control group exhibited a significant increase in mobility. In the comparison between the groups, there is a significant difference in both arms before and after the intervention ($p<0,05$).

Conclusion: The present study demonstrates the impact of diaphragmatic exercise on shoulder mobility. Nevertheless, for cases involving shoulder pain or considerable mobility limitations, further studies are necessary to evaluate not only the acute effects but also the outcomes of longer-term training.

Keywords: Glenohumeral joint, myofascia, postural control, range of motion, respiration

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[*] PhD, Assist. Prof., University of Health Sciences, Gulhane Faculty of Physical Therapy and Rehabilitation, Department of Orthopedic Physical Therapy and Rehabilitation, Ankara, Türkiye. E-mail: emreserdar.atalay@sbu.edu.tr
ORCID https://orcid.org/0000-0002-8249-8628
[**] PhD, Assist., Prof. University of Health Sciences, Gulhane Faculty of Physical Therapy and Rehabilitation, Department of Orthopedic Physical Therapy and Rehabilitation, Ankara, Türkiye. E-mail: caglar.soylu@sbu.edu.tr
ORCID https://orcid.org/0000-0002-1524-6295
[***] PhD, Lect., University of Health Sciences, Gulhane Vocational School of Health, Ankara, Türkiye.
E-mail: guler.atalay@sbu.edu.tr ORCID https://orcid.org/0000-0003-1376-4379
[****] PhD, Prof., University of Health Sciences, Gulhane Faculty of Physical Therapy and Rehabilitation, Department of Orthopedic Physical Therapy and Rehabilitation, Ankara, Türkiye. E-mail: necmiyeun.yildirim@sbu.edu.tr
ORCID https://orcid.org/0000-0002-5527-4290

ETHICAL STATEMENT: Ethics committee permission for the study was received from the University of Health Sciences, Gulhane Scientific Research Ethics Committee (Date: 12/09/2022, Number: 2022/240) and the study was conducted in accordance with the principles of the Declaration of Helsinki.

Diyafragmatik Solunumun Omuz Rotasyonel Mobilitesine Etkisi- Tek Kör Randomize Kontrollü Çalışma

Öz

Amaç: Omuz mobilitesi hem spor hem de günlük yaşam aktivitelerinde önemli bir yere sahiptir. Spor yaralanmalarında omuzun kısıtlı rotasyonel hareketliliği etiyolojide ilk sıralarda yer almaktadır. Diyafram kası ile omuz arasındaki innervasyonel ve miyofasyal bağlantı bilinmektedir. Bu çalışmanın amacı diyafram kasına odaklanan nefes egzersizinin omuz hareketliliği üzerindeki anlık etkisini incelemektir.

Yöntem: Çalışmaya 18-25 yaş arası toplam 136 genç, sağlıklı, rekreasyonel aktif yetişkin dahil edildi. Katılımcılar müdahale grubu (n=86) ve kontrol grubu (n=50) olmak üzere rastgele iki gruba ayrıldı. Müdahale grubu daha önce öğretilmiş olan diyafragmatik solunum tekniğini uygularken kontrol grubu 90 saniye boyunca hiçbir şey yapmadı. Hem müdahale öncesi hem de müdahale sonrası omuz mobilitesi, Fonksiyonel Hareket Taraması (FMS™) testi kullanılarak değerlendirildi.

Bulgular: Müdahale grubundaki her iki omuzda omuz rotasyon mobilitesinde önemli bir artış varken, kontrol grubunda sadece sol omuzda hareketlilikte önemli artış görüldü. Gruplar arası karşılaştırmada müdahale öncesi ve sonrası her iki kolda anlamlı farka rastlanıldı ($p<0,05$).

Sonuç: Bu çalışma, diyafram solunum egzersizinin omuz mobilitesi üzerinde etkisi olduğunu göstermiştir. Ancak omuz ağrısı veya belirgin hareket kısıtlılığı olan olgularda sadece akut etkiyi değil aynı zamanda uzun süreli antrenmanların etkilerini de değerlendiren çalışmalara ihtiyaç vardır.

Anahtar Sözcükler: Glenohumeral eklem, myofasya, postural kontrol, eklem hareket açıklığı, solunum

Introduction

Diaphragmatic breathing is deep breathing that lifts the ribs upward towards the diaphragm. This breathing is done without using the abdomen or rib cage[1]. Respiratory capacity is impacted by diaphragm activity, which also generally alters how people perceive pain. Moreover, a proper posture and body position are provided by promoting deep breathing and enhancing the diaphragm's effectiveness[2].

The diaphragm, a dome-shaped muscle that separates the chest cavity from the abdomen, is essential for human health and function. It is related to the shoulder in terms of embryological origin[3,4], myofascial and neural connection (phrenic nerve)[5-7] and muscle chain theory[8]. Different muscle groups can work together in a continuous, coordinated, and synergistic manner to efficiently transfer muscle energy and create a fully developed and well-functioning muscle chain. When one muscle group is overactive and another is weak, it creates an imbalance that puts additional stress on the rest of the body, which can quickly lead to injury. Ineffective breathing can lead to muscular imbalance, changes in motor control, and physiological changes that can alter movement[9]. Based on this information, deep abdominal muscles can become weakened and diaphragm function can be decreased by spinal instability[10]. Incorrect breathing techniques can also result from modifications in the position of the cervical and thoracic spines and decreased stability. Postural control and limb movement are both closely related to breathing movement. Thus, the diaphragm has actual therapeutic value for assessing the effectiveness of shoulder joint muscle rehabilitation[8].

It has been stated that it is also important to consider the respiratory pattern when making a functional assessment of a person regardless of whether the person is an athlete, patient, or sedentary. The reason for this is that the level of functional movement is related to the respiratory abilities of the people[9-11]. More than half of society experiences shoulder pain at least once in their life. Shoulder movement restriction, regardless of the cause, can significantly impair a person's ability to perform activities of daily living (ADLs) and limit participation in sports[12,13].

The hypothesis of the current study is that short-term diaphragmatic breathing exercises will momentarily change shoulder rotation. This study aims to determine whether diaphragmatic breathing exercise has a beneficial impact on shoulder rotation compared to a control group.

Material and Methods

Participants

A randomized, single-blind (evaluator), controlled trial was carried out. The sample size for this investigation was calculated using a power analysis. Based on the results of a pilot study involving 10 subjects, a sample size of 136 ($n_{\text{application group}}$=86 and $n_{\text{control group}}$= 50) subjects was required to provide an effect size of 0.40 an alpha level of 0.05, and a power of 0.80. A total of 136 healthy individuals aged between 18-25 were included in the study, with no gender determination to accommodate the calculated sample size. Participants were included in the study if they met the following criteria: no musculoskeletal injury or surgery to the shoulder in the past 6 months, not using any medication that could affect the respiratory system, and not having participated in any aerobic exercise training in the past 6 weeks.

The protocol and CONSORT checklist for this trial are available as supporting information. Participants were randomly (the participants was done through the website (www.randomizer.org) allocated to Group A (Application) of Group B (Control) groups. The remaining participants continued as the exercise group once the required number for the control group had been attained. The study was randomized at the level of the individual participant, and it was a single-blind test in which only assessors were blinded to the details.

Written informed consent was obtained from the patients. This study was conducted in accordance with the Helsinki Declaration and was approved by the University of Health Sciences Gülhane Scientific Research Ethics Committee (Committee No: 2022-240) on 12/09/22.

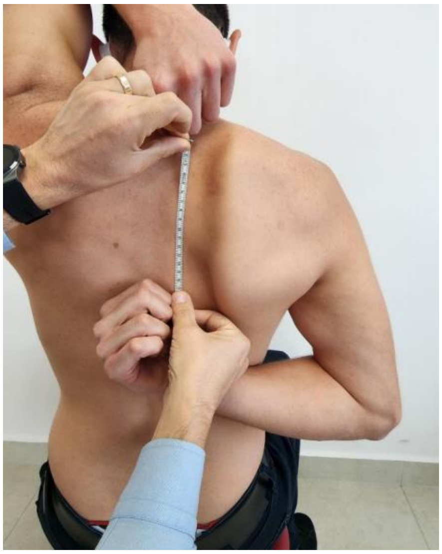
Evaluations

Functional Movement Screen (FMS™) Shoulder Mobility Test: This test is one of the seven functional movements assessed in the FMS[14] protocol. It measures the participant's ability to achieve internal and external rotation of the glenohumeral joint (GH joint) in a combined movement.

To perform the test, the participant stands with their arms at their sides. They then place one hand behind their back, palm facing out (internal rotation), and the other hand behind their head, palm facing in (external rotation). The participant then brings their hands together behind their backs as close as possible. The distance between the two fists is measured in centimeters with a tape measure.

This type of reaching test is a reliable and valid measure of GH joint mobility. It is used by clinicians and researchers to assess shoulder function and identify individuals who may be at risk for shoulder injuries[15].

Figure 1. Shoulder rotational mobility measurement



Interventions

The physiotherapist who showed the exercises described the exercise/control application to the participant according to the group they were assigned. The participant was placed in a comfortable supine position with their knees flexed. Participants in the application group were first taught diaphragmatic breathing and then asked to perform diaphragmatic breathing for 90 seconds. After this period, the participant was referred back to the evaluating physiotherapist, who reassessed shoulder mobility without knowing which group the participant was in.

In the control group, the participant's shoulder mobility was evaluated, and they were then asked to lie in a supine position for 90 seconds without performing any specific intervention. At the end of this period, the evaluating physiotherapist reassessed the participant's shoulder mobility.

Statistical Analysis

All statistical analysis was performed using SPSS 25 Statistics Software (SPSS Inc. Chicago, IL). The normality of variables was evaluated by the Shapiro-Wilk test. The mean ± standard deviation (minimum; maximum) was used to summarize the continuous variables. The Paired Samples T Test was used to evaluate the effectiveness of the training in each group and the Independent Samples T Test was used for comparison between groups. The level of significance for all analyses was set at $p \leq 0.05$. The effect size (f) was interpreted as follows: ≥0.40: large, 0.25-0.39: medium, 0.10- 0.24: small effect size[16].

Results

The descriptive information of the participants and their intergroup comparisons are presented in Table 1. Those with statistically significant differences are marked in bold.

Table 1. Descriptive statistics and group comparisons

	Exercise Group (n=86)	**Control Group (n=50)**	**p***
	Mean ± SD	Mean ± SD	
Age (year)	21.12± 0.91	20.28± 1.30	**<0.01**
Height (m)	1.70± 0.08	1.67± 0.08	0.06
Weight (kg)	64.26± 10.53	59.56± 11.15	**0.01**
BMI (kg/m^2)	22.19± 3.05	21.17± 2.35	**0.04**

*Independent Samples t-test, SD: Standard Deviation, BMI: Body Mass Index, m: meter, kg: kilogram

The analysis of the differences between the groups and the analysis of the within-group measurements are given in Table 2. Except for the difference between before and after in the control group, a difference was found in all other comparisons ($p<0.05$). In terms of effect sizes, a moderate effect size in the right arm (0.5-0.8) and a large effect size (>0.8) in the left arm were observed in the comparison between the two groups after exercise. Other effect sizes are small (<0.5).

Table 2. Before and after comparisons of participants between groups and within groups

	Exercise Group (cm)		**Control Group (cm)**		**Between Groups Comparison***	
	Right	**Left**	**Right**	**Left**	**Right**	**Left**
FMS SM Measurement Before Exercise	6.05±4.64	8.46±5.91	8.47±6.63	10.73±6.77	0.02 (Cohen's d: 0.442)	0.04 (Cohen's d: 0.357)
FMS SM Measurement After Exercise	4.43±4.57	7.08±5.50	7.30±6.39	10.39±6.94	<0.01 (Cohen's d: 0.516)	<0.01 (Cohen's d: 0.851)
In-group before and after comparison**	<0.01 (Cohen's d: 0.351)	<0.01 (Cohen's d: 0.241)	<0.01 (Cohen's d: 0.179)	0.22 (Cohen's d: 0.049)		

* Independent Samples t Test, ** Paired Samples t Test, FMS: Functional Movement Screen, SM: Shoulder Mobility

Discussion

In this study, we tried to determine by virtue of the connections of the shoulder and diaphragm muscles the effect of diaphragmatic breathing on shoulder rotational mobility. According to our results, the treatment group is significantly different from the control group. To our knowledge, there are no studies on the effect of respiration on the rotational mobility of the shoulder. Fernandez-Lopez et al. (2021) published as a data set examines the effect of diaphragmatic muscle training on shoulder pain and mobility in shoulder pain[7]. This study planned to investigate the effectiveness of manual approaches and breathing exercises based on the diaphragm. Lee (2015) used deep breathing exercises in addition to proprioceptive neuromuscular exercises in a case study (frozen shoulder)[17], Tyree & May (2018) used breathing techique combined with total motion release in a case study[18]. Both studies showed an improvement in shoulder range of motion. Similarly, in the current study, we found that short-term diaphragmatic breathing performed in the supine position influenced shoulder mobility and increased rotational range of motion. This indicates the huge impact diaphragmatic breathing can have on the physio-mechanical function of the shoulder joint.

When all in-group and inter-group comparisons were examined, it was seen that the highest effect size was between intergroup measurements in the left extremities. Considering that the high proportion of the participants is right dominant, it is remarkable that diaphragmatic breathing exercise is used in the extremity that is less used in daily life. It is possible to say that the mobility of the dominant extremity is already more dependent on use. The findings also support this.

According to the literature and based on our clinical experience, we can say that the dominant extremity is injured more[19]. From this point of view, although mobility is important in injury factors, it can be thought that frequent use of the arm, excessive movements, or overuse traumas should also be considered injury factors.

Generally, breathing exercises are used in combination with other treatments. And as far as we can see, no randomized controlled studies are showing the effects of breathing exercises in studies on the shoulder. Our study is an important study on this subject, both by evaluating the instantaneous effect of breathing alone and using a control group.

As a clinical implication, this study directs researchers and clinicians that shoulder mobility may be affected in patients with respiratory problems and that diaphragmatic breathing should be included in the exercise programs of shoulder patients in rehabilitation programs.

Limitations

Diaphragm efficiency was not evaluated. Although our study had a large sample size compared to other studies in the literature, it was conducted at a single center. It would be more appropriate to conduct a similar study with cases with and without shoulder problems in terms of observing the effectiveness.

Conclusion

Diaphragmatic breathing can be a short-term and effective approach that can be used not only in treatments but also in supporting shoulder health and in the preparation period before the activity. Randomized controlled studies are needed to evaluate the effectiveness of long-term diaphragmatic breathing. Studies in different disease groups or athletes will also enrich the literature on the subject.

Conflict of Interest

The authors declare no conflict of interest.

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