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The effect of dynamic neuromuscular stabilization on trapezius muscle activation during shoulder exercises in individuals with rounded shoulder posture: a pilot study

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ABSTRACT

Aims: The aim of this pilot study is to investigate the impact of Dynamic Neuromuscular Stabilization (DNS) technique on the activation of the upper, middle, and lower parts of the trapezius muscle during commonly used shoulder exercises in individuals with rounded shoulder posture.

Methods: The study was conducted with 15 individuals exhibiting rounded shoulder posture. The determination of rounded shoulder posture was based on measuring the distance in centimeters between the posterior corner of the lateral acromion prominence and the bed in a supine position. If this distance was 2.5 cm or more, it was considered as rounded shoulder posture. Participants were taught three different shoulder exercises and the DNS respiratory technique, a component of Dynamic Neuromuscular Stabilization. The exercises were randomly performed with and without DNS, and the activation of the upper (UT), middle (MT), and lower (LT) parts of the trapezius muscle was measured separately using an 8-channel surface electromyography (EMG) system (Noraxon Ultium, Scottsdale, USA).

Results: The activation of all parts of the trapezius muscle was found to be higher when exercises were performed with DNS compared to without DNS ($p<0.05$). Additionally, the UT/MT and UT/LT activation ratios were compared during the exercises with and without DNS. It was observed that only during the 1st exercise, the UT/LT activation ratio was higher when exercises were performed with DNS ($p<0.05$), while in all other cases, it was similar ($p>0.05$).

Conclusion: The primary findings of the study suggest that the activation of all parts of the trapezius muscle is higher when exercises are performed with DNS. This implies that DNS may contribute to more effective exercise performance in terms of the activation of the relevant muscle group, indicating potential positive effects of DNS in rehabilitation programs. However, the participant profile in our study is limited to individuals with rounded shoulder posture. Further research in different populations is needed to generalize the obtained results.

Keywords: Dynamic neuromuscular stabilization, muscle activation, rounded shoulder

INTRODUCTION

Rounded shoulder posture is one of the prevalent postural abnormalities, contributing to 60% of shoulder problems. Its occurrence is reported to be 73% on the right side and 66% on the left side.[1] Considering the contemporary sedentary work conditions and prolonged use of technological devices such as smartphones and tablets, this condition appears to be commonplace. Individuals who sit for extended periods may experience fatigue in the lumbar extensors, adopting a comfortable and slouched sitting position. This prolonged flexed posture can lead to the distortion of the normal lordotic curve, increased anterior pelvic tilt, and, as a result, the development of rounded shoulder posture.[2]

As smartphones have become an integral part of daily life, they are recognized as a significant factor in the development of postural abnormalities. Unhealthy neck and shoulder postures are commonly observed during prolonged use of smartphones. Particularly, texting has been shown to significantly increase flexion angles in the cervical and upper

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thoracic spine and activate the upper part of the trapezius muscle.[3] Therefore, prolonged use of smartphones is reported to disrupt neck and upper back posture, leading to rounded shoulder posture.[4] Other causes of rounded shoulder posture include shortening of the upper trapezius (UT) muscle and weakness in the middle (MT) and lower trapezius (LT) and serratus anterior muscles. In this posture, the scapula assumes an anterior tilt position, and the shoulder moves forward. The scapula, serving as an anchor for muscles, plays a crucial role in the smooth and coordinated movement of the shoulder girdle. Therefore, alterations in scapular position can disrupt the normal biomechanics of the shoulder joint, leading to injuries.[1]

Changes in the position and kinematics of the scapula affect the activation of muscles in the scapulothoracic region.[5] Therefore, exercises targeting the muscles around the scapula play a crucial role in rehabilitation for rounded shoulder posture. Especially, the MT and LT muscles act as stabilizers in the scapulothoracic region.[6]

The increase in activation of the UT muscle leads to anterior tilting of the scapula, increasing shoulder protraction. Therefore, rehabilitation programs for the shoulder must include exercises targeting the trapezius muscle.[7]

Dynamic Neuromuscular Stabilization (DNS) aims to improve motor control, posture, and movement by building on the natural movement patterns exhibited by infants during their developmental stages. Furthermore, DNS emphasizes the importance of training the dynamic and stabilization functions of muscles within the kinetic chain. The DNS respiratory technique focuses on regulating intra-abdominal pressure by utilizing proper diaphragmatic function to enhance functional core stabilization. DNS provides stabilization of the spine and surrounding muscles during both static and dynamic movements. Deep spinal flexors and extensors, multifidus, diaphragm, pelvic floor muscles, and abdominal muscles are involved in this system. DNS uses the precise coordination of these muscles and the regulation of intra-abdominal pressure by the central nervous system for optimal performance. The co-contractions of these muscles increase intra-abdominal pressure, aiding in body stabilization.[8,9]

While numerous electromyography (EMG) studies have explored muscle activation during various exercises targeting scapulothoracic region muscles, no study has been found to investigate the use of DNS respiratory technique during commonly used shoulder exercises in individuals with rounded shoulder posture.

The aim of this study is to examine the impact of the DNS technique on the activation of the upper, middle, and lower parts of the trapezius muscle during commonly used shoulder exercises in individuals with rounded shoulder posture. The information obtained from this study is expected to provide guidance in the development of rehabilitation programs for rounded shoulder posture.

METHODS

The study was conducted with the participation of 15 volunteers at the Health Sciences University, Gülhane Faculty of Physiotherapy and Rehabilitation. Ethical approval was obtained from the Gazi University Ethics Committee (Date: 07.11.2023, Decision No: E-77082166-302.08.01-809534), and the study adhered to the 2018 updated Helsinki Declaration. Participants aged 18-30, with full shoulder range of motion, a body mass index less than 30 kg/m^2, and a rounded shoulder posture were included in the study. Individuals with orthopedic, neurological, rheumatological or systemic problems that could affect shoulder biomechanics were excluded from the study.

Demographic Characteristics

Gender, age (years), height (cm), and body weight (kg) of participants were recorded, and BMI was calculated (kg/m^2).

Determination of Rounded Shoulder Posture

In the supine position, the distance from the lateral acromion process's posterior corner to the bed was measured using a ruler. A measurement result of 2.5 cm or more was considered as rounded shoulder posture.[10]

Exercise Protocol

Three different scapular retraction exercises commonly used for rounded shoulders were selected as shoulder exercises. Exercises were performed using elastic bands with increasing resistance levels (Thera-Band®, Hygenic Corp, Ohio). In the first exercise (Exercise 1), the exercise band was looped around a fixed point at the level of the navel, and participants were instructed to pull the band backward with scapular retraction (shoulders by the sides, elbows flexed at 90 degrees, **Figure 1**).

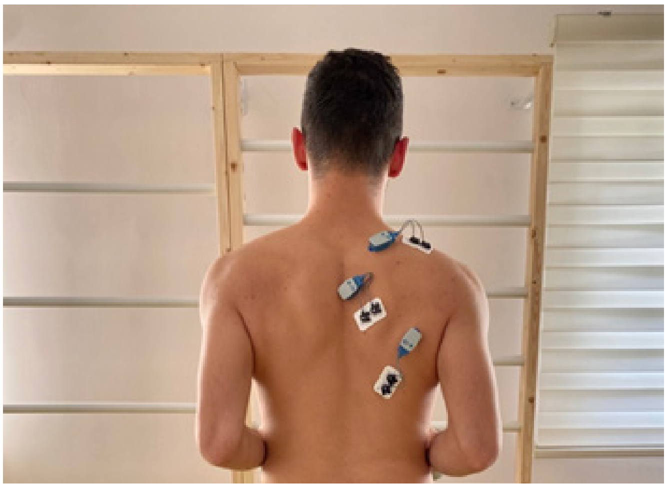

Figure 1. Exercise 1

In the second exercise (Exercise 2), the exercise band was looped around a fixed point at shoulder height, and participants were instructed to grasp the band with both hands, pulling it backward to perform scapular retraction (arms abducted at 90 degrees, elbows flexed at 90 degrees, **Figure 2**).

Figure 2. Exercise 2

For the third exercise (Exercise 3), the band was looped around a fixed point above head level, and participants were instructed to grasp the band with both hands, pulling it downward and backward with scapular retraction (**Figure 3, Figure 4**).

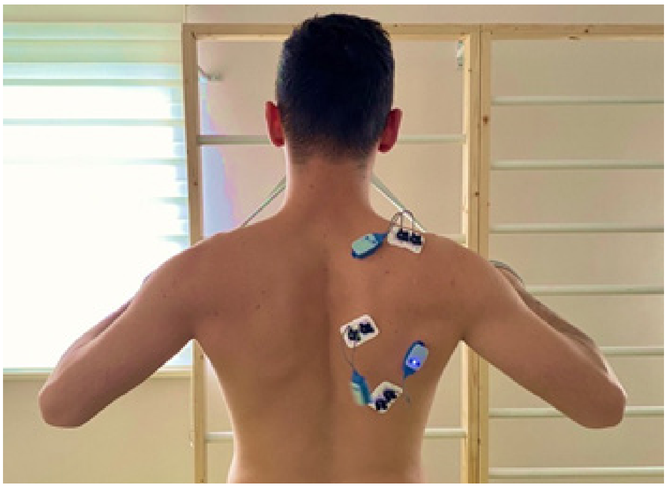

Figure 3. Exercise 3

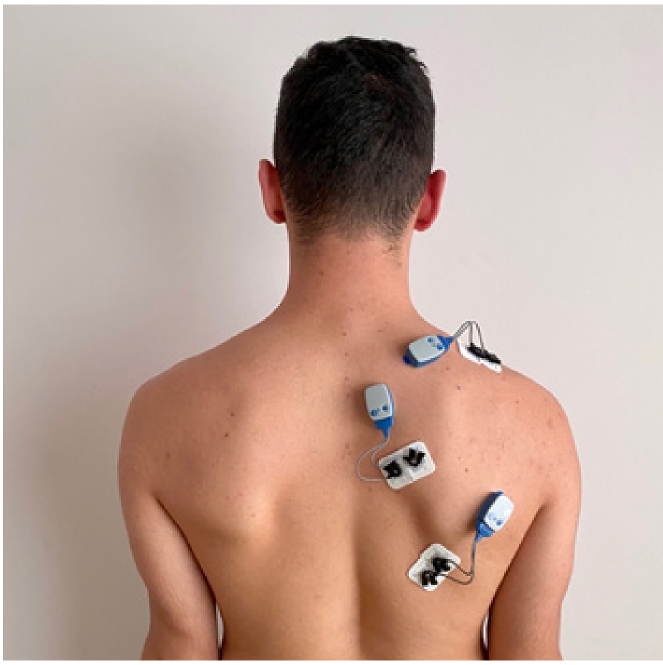

Figure 4. Electrodes placement according to SENIAM criteria

The OMNI Perceived Exertion Scale for Resistance Exercise (OMNI-RES) scale was used to determine the dosage during exercises. According to this scale, 6 points mean "somewhat hard" and 8 points mean "hard".[11] The resistance level corresponding to the 6-8 score range was selected as the dosage of elastic resistance.

Teaching of DNS Technique

The DNS respiratory technique, a component of DNS, was taught to participants by a physiotherapist with training in this technique. Participants were then asked to apply this respiratory technique along with the exercises. After ensuring that participants performed both the DNS respiratory technique and the exercises correctly, measurements were taken.

Measurement of Trapezius Muscle Activation

During the three different shoulder exercises, the activation of the upper, middle, and lower parts of the trapezius muscle on the dominant side was measured separately using an 8-channel surface electromyography (EMG) system (Noraxon Ultium, Scottsdale, USA). Silver/silver-chloride surface electrodes (3M™ Red Dot™) were used, and before electrode placement, the skin was cleaned. Electrodes were placed on the upper, middle, and lower parts of the trapezius muscle on the dominant side according to SENIAM criteria.[12] Maximum Voluntary Isometric Contraction (MVIC) values were measured separately for the three parts of the trapezius muscle and muscle activations during the exercises were normalized as %MVIC.[13,14]

Statistical Analysis

Statistical analyses were performed using the Statistical Package for Social Sciences (SPSS) version 21.0. Categorical variables were presented as frequencies and percentages. Variables were examined analytically using the Shapiro-Wilk test and visually using methods such as histograms and probability plots to determine normal distribution. Descriptive data were presented as median and interquartile range (25-75). As the data did not show normal distribution, the Friedman test was applied for multiple comparisons (comparison of upper, middle, and lower trapezius activations). Results were evaluated using Bonferroni correction for multiple comparisons. A total type-1 error level of 5% was used for statistical significance.

RESULTS

A total of 15 individuals with rounded shoulder posture participated in this pilot study (7 females, 8 males). All participants had their dominant upper extremity on the right side. The demographic characteristics of the participants are presented in **Table 1**.

Table 1. Demographic characteristics

	Median (IQR 25/75)
Age (years)	19 (18/19)
Height length (cm)	175 (163/180)
Body weight (kg)	69 (60/75)
BMI (kg/m²)	22,3 (20,6/24,4)

IQR: Interquartile range, BMI: Body Mass Index

Acromion-bed distance, an indicator of rounded shoulders, and MVIC values for the upper, middle, and lower parts of the trapezius muscle are shown in Table 2.

Table 2. Other features

	Median (IQR 25/75)
Acromion-examining table distance	6 (4.5/7)
UT MVIC	507 (333/747)
MT MVIC	401 (277/681)
LT MVIC	185 (125/277)

IQR: Interquartile range, UT MVIC: Upper trapezius maximum voluntary isometric contraction, MT MVIC: Middle trapezius maximum voluntary isometric contraction, LT MVIC: Lower trapezius maximum voluntary isometric contraction

The UT muscle activation measured during exercises without and with DNS, normalized as %MVIC, is presented in Table 3. Similarly, MT muscle activation is shown in Table 4, and LT muscle activation is presented in Table 5. The activation of all parts of the trapezius muscle was found to be higher when exercises were performed with DNS compared to without DNS ($p<0.05$). P values are given one by one in the tables, and significant values are written in bold.

Table 3. Comparison of upper trapezius muscle activations during exercises

	Without DNS (n=32) Median (IQR 25/75)	With DNS (n=32) Median (IQR 25/75)	p
Exercise 1	13.8 (10.1/23.4)	28.6 (18.1/45.5)	**0.001**
Exercise 2	57.6 (41.7/80.4)	69.7 (61/92.9)	**0.001**
Exercise 3	27.5 (18.8/40.2)	42.4 (28.8/57.1)	**0.001**

IQR: Interquartile range

Table 4. Comparison of middle trapezius muscle activations during exercises

	Without DNS (n=32) Median (IQR 25/75)	With DNS (n=32) Median (IQR 25/75)	p
Exercise 1	27.6 (25/48.9)	43. 4 (29.6/59.3)	**0.001**
Exercise 2	62.7 (36/84.2)	73.8 (47.1/97.3)	**0.001**
Exercise 3	34 (26.9/44.9)	52.8 (47.7/68.7)	**0.008**

IQR: Interquartile range

Table 5. Comparison of lower trapezius muscle activations during exercises

	Without DNS (n=32) Median (IQR 25/75)	With DNS (n=32) Median (IQR 25/75)	p
Exercise 1	59 (37/78)	83 (57.8/101)	**0.001**
Exercise 2	50.2 (38/84.4)	62.2 (57.4/101.1)	**0.005**
Exercise 3	54.7 (30.7/71.5)	72.5 (41/87.5)	**0.008**

IQR: Interquartile range

The comparison of the UT/MT and UT/LT activation ratios of the trapezius muscle during three different exercises without and with DNS is given in Table 6. The analysis revealed that only during the 1st exercise, the UT/LT activation ratio was higher when exercises were performed with DNS ($p<0.05$), while in all other cases, it was similar ($p>0.05$). P values are given one by one in the table, and the significant p value is written in bold.

Table 6. Comparison of upper trapezius/ middle trapezius and upper trapezius/ lower trapezius muscle activation rates during exercises

		Without DNS (n=32) Median (IQR 25/75)	With DNS (n=32) Median (IQR 25/75)	p
Exercise 1	UT/MT	0.54 (0.30/1.06)	0.66 (0.32/1.16)	0.691
	UT/MT	0.28 (0.21/0.45)	0.36 (0.25/0.79)	**0.027**
Exercise 2	UT/MT	0.95 (0.61/1.30)	1 (0.77/1.22)	0.910
	UT/MT	1.1 (0.74/1.86)	1.1 (0.87/1.56)	0.233
Exercise 3	UT/MT	0.90 (0.51/1.28)	0.76 (0.6/1.13)	0.865
	UT/MT	0.59 (0.37/1.03)	0.61 (0.37/1.44)	0.233

IQR: Interquartile range UT: Upper trapezius, MT: Middle trapezius, LT: Lower trapezius

DISCUSSION

This pilot study aims to investigate how the activation of the upper, middle, and lower parts of the trapezius muscle changes during three different exercises commonly used in the rehabilitation of rounded shoulder posture when performed with and without DNS. The demographic characteristics of the participants are provided, and the activation of the UT, MT, and LT muscles during exercises without and with DNS is compared. The key findings of the study indicate that the activation of all parts of the trapezius muscle is higher when exercises are performed with DNS. This suggests that DNS may enhance the effectiveness of exercises in activating the relevant muscle group and points to the potential positive effects of DNS in rehabilitation programs.

In a study examining the impact of DNS on functional movements, 34 participants were divided into two groups (DNS group and physical fitness group) and subjected to a 6-week training program. Results were assessed through five different functional movement tests, consistently showing superior outcomes in the DNS group. The study concluded that DNS could be employed to enhance functional movements.[15] Marand et al.[16] also utilized DNS in the rehabilitation of MS patients, comparing its effects on balance, trunk function, mobility, fall prevention, and spasticity with core stabilization exercises. They found that DNS improved balance, trunk function, and mobility, effectively preventing falls and demonstrating superiority over core stabilization exercises. These results were attributed to the reflexive activation of the diaphragm, transverse abdominal muscles, pelvic floor, and multifidus muscles in coordination with spinal muscles, contributing to active postural stability. Similarly, Son et al.[17] reported that DNS increased postural stability in children with cerebral palsy, aligning with the findings of the aforementioned study. Furthermore, DNS is reported to be utilized and effective in stroke rehabilitation, athlete rehabilitation, and correcting poor posture.[18] Based on the results of our study, we believe that DNS can be employed in rounded shoulder posture rehabilitation. It is suggested that respiratory muscles play a significant role in both static and dynamic postural stability. DNS is known to increase intra-abdominal pressure (IAP) by utilizing the diaphragm, pelvic floor muscles, multifidus muscle, internal oblique muscles (IO), and transversus abdominis (TrA). There is a consensus that an increase in IAP stabilizes the spine. In the DNS technique, as the diaphragm descends during inhalation, it reflexively activates deep core muscles (TrA, IO, pelvic floor muscles, multifidus) eccentrically. Eccentrically activated muscles contract concentrically, creating IAP, thereby providing the necessary core stabilization and postural stability during dynamic movements.[9,19] Additionally, it has been demonstrated that DNS can be used to strengthen core muscles and is more effective than many other core stabilization methods.18 In a study by Lee et al.[20], where they compared core stabilization techniques (abdominal drawing-in maneuver, abdominal bracing, and DNS) through assessment with ultrasound and EMG, they concluded that DNS is the most effective technique for core stabilization. This determination was based on its ability to achieve balanced and coordinated activation of the diaphragm and TrA muscles. In their study, Yoon et al.[21] investigated the effects of DNS and NDT (Neurodevelopmental Treatment) in healthy adults and individuals with hemiparetic stroke. They evaluated outcome parameters using EMG and ultrasound. The study reported that in both the healthy and patient groups, DNS demonstrated better activation of TrA and IO muscles compared to NDT. They emphasized that DNS, through the coordination of the diaphragm with the superficial core muscles, facilitates the co-activation of TrA, IO, pelvic floor muscles, and multifidus muscles, dynamically stabilizing the spine. The stabilization of the core region is defined as a prerequisite for the manifestation of functional extremity movements, as it facilitates power generation, transfer, and control.[22] Ensuring the stabilization of proximal body segments is crucial for revealing good functional movement in distal body segments.[23] DNS may enhance trapezius muscle activation by increasing spine stabilization. However, it is important to consider that DNS may also increase UT activation, which could be a potential drawback for shoulder rehabilitation. While some authors suggest a potential connection between shoulder pathologies and overall weakness of the scapulothoracic muscles, the current perspective leans towards attributing shoulder issues to scapular muscle imbalance rather than generalized weakness. Particularly, excessive activation of the UT may lead to abnormal scapular movement, accompanied by decreased control of the anterior deltoid and serratus anterior muscles.[24,25] Therefore, instead of general strengthening of the scapular muscles, selective activation of weak muscles and minimal UT activation are recommended in shoulder rehabilitation programs.[26]

Restoring balanced muscle activation can be challenging for clinicians. Selective activation of weak muscle parts with minimal activation of overactive muscles is a crucial component in reducing imbalances. The ratios of UT to MT and UT to LT muscle activations are particularly important, as the deficiency in activity in MT and LT trapezius often combines with the overuse of the UT. In shoulder rehabilitation, the goal is typically to create an exercise program where UT activation is low, and MT and LT activation is high.[27] It has been reported that excessive activation of the UT causes superior translation of the humeral head and anterior tilt of the scapula, narrowing the subacromial space.[28] According to Cools et al.[25], during an exercise given for the rehabilitation of scapular muscle balance, the UT/MT and UT/LT muscle activation ratio should be less than 0.60. In our study, UT/MT and UT/LT muscle activation ratios were examined, and it was found that only in the first exercise, the UT/LT activation ratio was higher when the exercise was performed with DNS. In other cases, similar ratios were observed. While the higher UT/LT activation ratio during the first exercise with DNS may initially seem unfavorable, it is still below the critical threshold determined by Cools et al.[25] (0.36). Even though UT activation increases with the relevant exercise performed with DNS, the UT/LT ratio remaining below the critical threshold suggests that this exercise can be prescribed with DNS. In all other cases, where the UT/MT and UT/LT ratios did not change when exercises were performed with DNS, we believe that these exercises can be safely used.

CONCLUSION

Our study is the first to examine the impact of DNS on the activation of the trapezius muscle during various shoulder exercises. Our findings underscore the potential benefits of DNS in exercise routines commonly used in rehabilitation programs. In conclusion, this study demonstrates that DNS can positively influence exercise performance by increasing trapezius muscle activation in individuals with rounded shoulder posture. However, the participant profile in our study is limited to individuals with rounded shoulder posture. Further research involving diverse populations is needed to generalize the results obtained.

ETHICAL DECLARATIONS

Ethics Committee Approval

The study was carried out with the permission of Gazi University Ethics Committee (Date: 07.11.2023, Decision No: E-77082166-302.08.01-809534).

Informed Consent

All patients signed and free and informed consent form.

Referee Evaluation Process

Externally peer-reviewed.

Conflict of Interest Statement

The authors have no conflicts of interest to declare.

Financial Disclosure

The authors declared that this study has received no financial support.

Author Contributions

All of the authors declared that they have all participated in the design, execution, and analysis of the paper, and that they have approved the final version.

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