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Original Article

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Effect of the Scapular Retraction Exercise on the Subacromial and Costoclavicular Space According to a Thera-Band Resistance Intensity

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Purpose: This study investigated effect of the scapular retraction exercise on the subacromial and costoclavicular space using different thera-band intensities.
Methods: Thirty-six healthy adults participated in this study, and the subjects were randomly divided into three groups (low, moderate, and high-intensity groups). The exercise was conducted twice a week for three weeks. The subacromial and costoclavicular space were measured before and after the intervention via ultrasonography. Data analysis was performed using the two-way Analysis of Variance with repeated measures and the paired t-test.
Results: The effect of the scapular retraction exercise on the subacromial and costoclavicular space using a thera-band after a 60° shoulder abduction has significant difference in all groups ($p < 0.05$). However, there was no significant difference between the groups, and the values in the groups before the exercise did not differ significantly from those after the exercise ($p > 0.05$).
Conclusion: Our results indicate that the scapular retraction exercise after a 60° shoulder abduction can be used to widen the subacromial and costoclavicular spaces.

Keywords: Scapular retraction exercise, Subacromial space, Costoclavicular space, Thera-band, Ultrasonography

INTRODUCTION

The shoulder is the human joint with the largest range of motion, which is rendered possible by the glenoid cavity, humeral head, capsule, and loosening of surrounding tissues.[1-4] This range of motion provides a high level of movement with a perfect compromise condition of movement and stability. The glenohumeral joint has the balance and mobility required to maintain joint stability. It also has three degrees of freedom (flexion/extension, abduction/adduction, and internal/external rotation), and these movements could be performed in any imaginable combination. The subacromial space is defined as the space between the upper side of the humerus head and the lower side of the acromion.[5] The width of this space usually varies from 10mm to 15mm under stable conditions and is reduced by 5mm to 6mm when the shoulder is stretched passively at 90°. If the subacromial space is less than 7mm, the supraspinatus tendon and subacromial bursa could impinge. The reduction of the subacromial space during the elevation of the upper limbs could cause risk factors. Subacromial impingement syndrome is the most common diagnosis in shoulder diseases[6] which indicates significant health problems in relation to the injuries and disabilities.[7] In patients with subacromial impingement syndrome, stretching and strengthening exercises were found to effectively reduce pain and disability.[8] In patients with subacromial impingement syndrome, exercise reduces pain and improves function during short term tracking. In addition, it improves mental health in the short term and improves the function of patients with subacromial impingement syndrome in the long term.[9] The thoracic outlet consists of the clavicle, first rib, anterior scalenus, and middle scalene muscle,[10] which contains three important structures: the subclavian artery, subclavian vein, and brachial plexus.[11] Thoracic outlet syndrome occurs due to the compression of the nerve, artery, or vein crossing the thoracic outlet,[10,12] and exercise was found to be effective in 50% to 90% of cases of

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thoracic outlet syndrome.[4,13]

When a 0° abduction is conducted on a healthy shoulder and a shoulder with subacromial impingement syndrome in a patient with subacromial impingement syndrome, there was no significant difference; however, there was a significant difference in the subacromial space when a 60° shoulder abduction was performed.[14] Therefore, interventions focused on increasing the subacromial space in the 60° shoulder abduction state can be implemented. Also, training to increase the subacromial space at 60° of shoulder abduction could be helpful for patients with subacromial impingement syndrome.[15] Scapular retraction, which has been suggested as a means of increasing the subacromial space during shoulder elevation,[5] is expected to be effective in increasing the subacromial space.[16] The resistive exercise, which can be conducted with a resistive band or dumbbells, can be aimed at achieving muscular endurance. To observe improvement, all combinations of strengthening, stretching, and postural adjustment should all be integrated[4,17,18] and scapular retraction increases the costoclavicular space.[18] Scapular retraction improves the function of rhomboids, trapezius, supraspinatus, infraspinatus, deltoid, latissimus dorsi, and teres major, and thoracic outlet syndrome's symptom is improved by enhancing these muscles and increasing the costoclavicular space.

In previous studies, to increase the subacromial space, this space was measured via ultrasonography while maintaining shoulder abduction at various angles (0°, 45°, 60°, and 90°) and scapular retraction with a moderate intensity of thera-band; however, there were no significant effects.[5] There are only a few previous studies in which the subacromial and costoclavicular spaces were measured simultaneously. Whereas many others compared the subacromial space according to the angle of shoulder abduction there are relatively few studies performed according to the resistance intensity.

Therefore, this study, under shoulder abduction fixed at 60°, aims to investigate the effect of scapular retraction exercise using the low-intensity/moderate-intensity/high-intensity of a thera-band in the dominant subacromial and costoclavicular spaces and the difference depending on the resistance intensity of a thera-band in these two spaces.

METHODS

1. Subjects

This study was conducted on 36 healthy adults (18 males and 18 females) from S University in Asan, Chungnam. All participants gave their informed consent to participate before they were included in the study. We included the following categories of participants: (1) those who did not show pain and abnormal range of motion when their shoulders moved passively and actively, (2) those without subacromial impingement, (3) those with no past history of surgery, trauma, or neurological disease of the shoulder joint, (4) those who had no pain, swelling, or potential on the shoulder joint. We excluded (1) those who had undergone orthopedic surgery on the shoulder joint, (2) those with neurological diseases, (3) those with other inflammatory joint diseases of the shoulder joint, (4) those who had a deformity, deformation, instability, or neurological problems of the shoulder, (5) those who complained of severe pain and could not move the shoulder or arm. This study was approved by Sunmoon University's Institutional Review Board (SM-202103-019-2). Participants were familiarized with the exercise method in advance through pre-practice. The general characteristics of the participants are shown in Table 1, and there was no significant difference between three groups.

2. Experimental procedures

Training using a thera-band (The Hygienic Corp., USA) is applicable to people of all ages, as well as injured persons, which effectively provides safe and incremental loads.[20] The thera-band allows people to avoid the risk of excessive exercise loads and makes it easier to increase the intensity of the exercise.[21] Before the experiment, the subjects were randomly assigned to low-intensity group (LIG), moderate-intensity group (MIG), high-intensity group (HIG), and the subjects repeated scapular retraction exercises 10 times at 60° of shoulder abduction. They were also instructed to increase the resistance until the level of effort was evaluated using a 11-point scale (0 = very easy, 10 = very hard) m (Numeral Rating Scale) 2-3(low-intensity)/5 (moderate-inten-

Table 1. General characteristics of participants

	Low-intensity	Moderate-intensity	High-intensity
Age (yr)	21.1±2.8	21.2±1.9	21.2±1.2
Height (cm)	167.0±8.3	166.9±11.8	168.2±9.0
Weight (kg)	62.5±13.8	66.6±16.8	65.3±14.5

Values indicate the mean±standard deviation.

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Figure 1. A and B: Performance of scapular retraction exercise using a thera-band after 60° shoulder abduction with a goniometer, C: Measurement of the subacromial space, D and E: Measurement of the costoclavicular space.

Table 2. Comparisons between the before and after measurements of the intensity of thera-band

		Intervention (mm)		F (p)		Before and after× Intensity
		Before	After	Before and after	Intensity	
SAS	Low	5.93±2.00	6.77±1.90	31.497*	1.000	0.601
	Moderate	6.57±1.94	7.50±2.08			
	Hard	6.48±2.21	7.93±2.46			
	Total	6.33±2.01	7.40±2.15			
SA	Low	18.83±3.46	23.41±3.50	71.531*	0.230	0.499
	Moderate	19.76±2.89	23.82±3.77			
	Hard	18.46±2.15	23.88±2.83			
	Total	19.02±2.85	23.70±3.30			
SV	Low	16.06±3.68	20.18±3.20	42.118*	0.045	0.359
	Moderate	16.34±2.96	20.06±3.80			
	Hard	15.34±2.21	19.43±2.91			
	Total	15.91±2.95	19.89±3.24			

*$p<0.05$. SAS: subacromial space, SA: measurement site near the subclavian artery, SV: measurement site near the subclavian vein.

sity)/7-8 (high-intensity) starting from the yellow thera-band with the lowest resistance to the gold thera-band with the maximum resistance. The height of the thera-band attachment was adjusted to be parallel to the shoulder (Figure 1).[5,8]

3. Data acquisition

An ultrasonic imaging device (eZono, eZono 3000, Germany, 2011) with a 7-10 MHz linear probe, in B-mode, was used to measure the subacromial space and costoclavicular space for the dominant arm before and after the first exercise (Figure 1). Ultrasonography contributed significantly to the diagnosis of subacromial impingement syndrome and thoracic outlet syndrome and the measurement of the subacromial space and costoclavicular space.[19,22,23] The distance of subacromial space was measured as the minimum length of the acromion and humeral head,[5] and the distance of costoclavicular space was measured as the minimum distance from the point where the pectoralis major muscle and the subclavius muscle met and passed the subclavian artery and subclavian vein to the first rib.[24,25]

Scapular retraction exercise using a thera-band was performed twice a week for 3 weeks: it was performed at 60° of shoulder abduction. To maintain a 60° shoulder abduction, the researchers continuously measured the angle of shoulder abduction during exercise using a goniometer (Fabrication Enterprises Inc., digital Absolutte+ Axistm goniometer, USA, 2008), and to avoid the activation of the upper trapezius, the scapular depression was instructed and the exercise was performed. The exercise was performed in three sets of 10 reps (contraction for three seconds, maintenance for three seconds, and relaxation for three seconds), and a one-minute break was taken between each set of reps.

4. Statistical analysis

SPSS/PC version 18.0 for windows (SPSS INC., Chicago, IL) was used for all statistical analyses. The repeated measures two-way Analysis of Variance was used to examine the difference before and after intervention, to compare the difference in the effect between the three groups (LIG/MIG/HIG) and to examine interaction between before and after exercise and intensity. Then, post-analysis was conducted using a paired t-test to find out the differences between the pre-intervention and post-intervention periods within each group. All statistical significance levels were set to $p<0.05$.

RESULTS

In the subacromial space and the space passing the subclavian artery and subclavian vein in the costoclavicular space, there was a significant difference between the periods before and after scapular retraction exercise in the 60° shoulder abduction position using a thera-band ($p<0.05$), and there was no significant difference between the groups

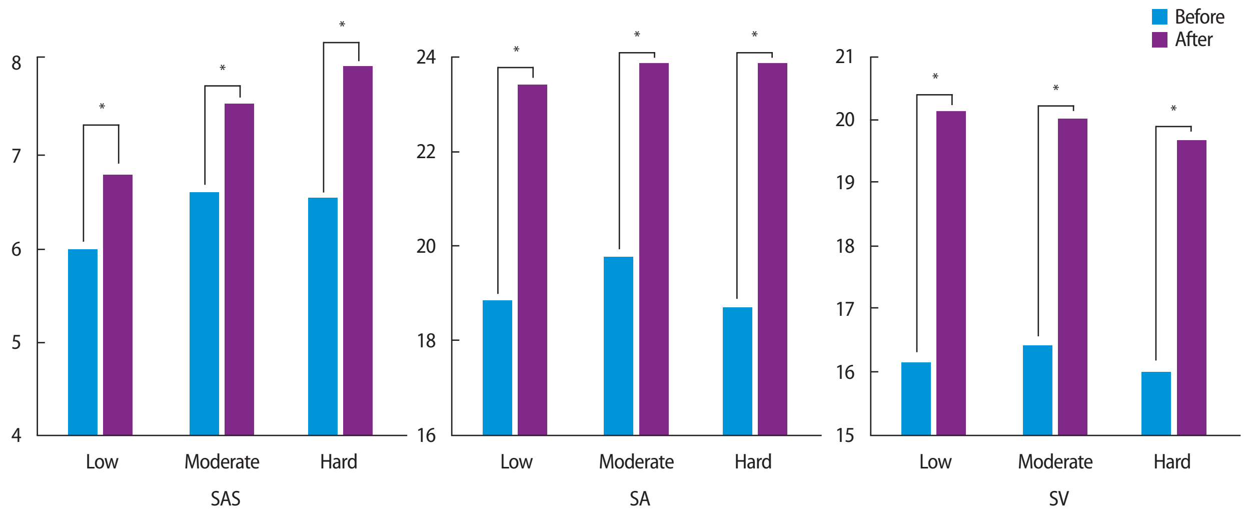

Figure 2. Before and after measurements depending on the intensity of the thera-band. *$p<0.05$, Unit: mm, SAS: subacromial space, SA: measurement site near the subclavian artery, SV: measurement site near the subclavian vein.

of low-intensity/moderate-intensity/high-intensity exercise ($p>0.05$). There was also no interaction in the groups between the periods before and after exercise ($p>0.05$)(Table 2). As a result of post-verification before and after exercise, there was a significant difference in the subacromial space and the space passing the subclavian artery and subclavian vein in the costoclavicular space of all groups of low-intensity/moderate-intensity/high-intensity ($p<0.05$)(Figure 2).

DISCUSSION

This study aimed to investigate the difference between the subacromial space and costoclavicular space according to differences such as low-intensity/moderate-intensity/high-intensity when performing the scapular retraction exercise at 60° of shoulder abduction using a thera-band. As a result of the study, it was confirmed that both the subacromial space and costoclavicular space increased, and there was no significant difference between low-intensity, moderate-intensity, and high-intensity exercises.

When performing the scapular retraction exercise after maintaining the 60° shoulder abduction position, the increase in the subacromial space and costoclavicular space may be related to the muscle contraction of the shoulder abduction and scapular retraction. Since scapular retraction is mainly composed of a scapular posterior tilt and a scapular external rotation, scapular retraction increases the subacromial space[5] and contracts the trapezius and rhomboids.[4,26] Ryan et al.[27] stated that strengthening exercises for scapular external rotators are routinely used in shoulder disease prevention and as rehabilitation exercises. Escamilla et al.[28] reported that scapular retraction can increase the subacromial space and also increase the production of the muscle strength of the Supraspinatus. Also, Bdaiwi et al.[29] evaluated the effect of scapular activation on the subacromial space, and the stimulation of serratus anterior, which causes the upward rotation of the scapula, and the lower trapezius, which causes the scapula to tilt posteriorly, increased the subacromial space at 60° of shoulder abduction, Guney-Deniz et al.[30] found that scapular retraction exercises at various scapular retraction positions are widely used in clinical practice to balance the activities of scapular and rotator cuff muscles. In addition, Lindgren et al.[31] evaluated that in patients with thoracic outlet syndrome, muscle-strengthening exercises for the shoulder complex could improve symptoms by widening the thoracic outlet, and Watson et al.[18] reported that scapular retraction exercises increase the costoclavicular space. Levin et al.[4] also reported that scapular retraction exercises target rhomboids, trapezius, supraspinatus, deltoid, latissimus dorsi, teres major, and by contracting these muscles, they improve the symptoms of thoracic outlet syndrome. In addition, posture correction exercises by Porter et al.[32] and osteopathic manipulative treatments and motion exercises of the first rib by Dobrusin et al.[33] have been suggested to improve symptoms by widening the thoracic outlet.

The reason why there was no significant difference between the three groups (low-intensity LIG, MIG, and HIG) in this study may be due to the characteristic of the thera-band elastic resistance and

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because the intensity criteria were set to individual subjective measures. Training using a thera-band, which is applicable to people of all ages and also applicable to the injured, effectively provides a safe and gradual load,[20] and the thera-band enables people to avoid the risk of excessive exercise load while facilitating the process of increasing the exercise intensity.[21] However, training using a thera-band may not complete the desired exercise because the more the elastic resistance increases, the more the required force gradually increases.[34] In addition, high-intensity exercise such as resistance training is difficult to measure objectively because it cannot be objectively evaluated using physiological and comprehensive measures such as the heart rate.[35] Therefore, this study set the difference in intensity as an individual's subjective measure; however, it is thought that it did not show an effective difference between the intensities. Fatouros et al.[36] reported that as a result of 48 weeks of training by assigning low-intensity training (55% of 1RM) and high-intensity training (82% of 1RM) to healthy but inactive elderly people, both groups improved muscle strength, anaerobic power, and mobility but showed greater effectiveness in high-intensity training and was maintained for longer after training. As a result of examining the effect of resistance training (according to the difference in intensity) on muscle hypertrophy and muscle strength in healthy young adults by Lopez Petal[37], it has been reported that high-intensity resistance training programs (80% of ≥1RM or ≤8RM) can target shorter training periods for both goals, leading to superior muscle hypertrophy and increased strength than low-intensity resistance training programs (≥15RM).

This study had some limitations: First, all participants were young, healthy adults without subacromial impingement syndrome or thoracic outlet syndrome symptoms; Second, both the subacromial space and costoclavicular space belong to the shoulder complex; however, there are relatively few previous studies on both spaces. Third, there are studies that measure the distance of the costoclavicular space using cadavers and CT but there is no study that measures the exact distance and average distance of the costoclavicular space through ultrasonography.[24,25,38] Fourth, this is not an objective measure of the classification criteria of low strength/medium strength/high strength but a subjective measure; Fifth, only the immediate effects of exercise on the subacromial space and costoclavicular space were investigated. Researchers need to evaluate the relationship between the long term effects of exercise and the muscle-strengthening pattern or muscle collection pattern (or both) in the subacromial and costoclavicular spaces. However, this study identified that the scapular retraction exercise using the thera-band positively increased the subacromial and costoclavicular spaces.

CONCLUSION

This study was conducted on 36 healthy adults to examine the effect of scapular retraction exercises and the difference in resistance strength of the thera-band in the state of 60° shoulder abduction using a thera-band in the subacromial and costoclavicular spaces, the subacromial space and the space passing the subclavian artery and subclavian vein of the costoclavicular space was measured, and the conclusions are as follows:

First, scapular retraction exercises at 60° shoulder abduction significantly increased in subacromial and costoclavicular space in the three groups (low-intensity/moderate-intensity/high-intensity). Second, there was no significant difference in the effect of exercise between the three groups (low-intensity/moderate-intensity/high-intensity) in the subacromial and costoclavicular spaces. In conclusion, the scapular retraction exercise in the 60° shoulder abduction state using a thera-band can be effectively used as an exercise to increase the subacromial and costoclavicular spaces.

REFERENCES

1. Perry J. Normal upper extremity kinesiology. Phys Ther. 1978;58(3):265-78.
2. Fu FH, Seel MJ, Berger RA. Relevant shoulder biomechanics. Oper Tech Orthop. 1991;1(2):134-46.
3. Veeger HE, van der Helm FC. Shoulder function: the perfect compromise between mobility and stability. J Biomech. 2007;40(10):2119-29.
4. Levine NA, Rigby BR. Thoracic outlet syndrome: biomechanical and exercise considerations. Healthc. 2018;6(2):68.
5. Harput G, Guney-Deniz H, Düzgün I et al. Active scapular retraction and acromiohumeral distance at various degrees of shoulder abduction. J Athl Train. 2018;53(6):584-9.
6. Beirer M, Imhoff AB, Braun S. Impingement-Syndrome der Schulter [Impingement syndromes of the shoulder]. Der Orthopade. 2017;46(4):373-86.
7. Desmeules F, Minville L, Riederer B et al. Acromio-humeral distance variation measured by ultrasonography and its association with the outcome of rehabilitation for shoulder impingement syndrome. Clin J Sport Med. 2004;14(4):197-205.
8. Camargo PR, Alburquerque-Sendín F, Avila MA et al. Effects of stretch-

ing and strengthening exercises, with and without manual therapy, on scapular kinematics, function, and pain in individuals with shoulder impingement: a randomized controlled trial. J Orthop Sports Phys Ther. 2015;45(12):984-97.
9. Hanratty CE, McVeigh JG, Kerr DP et al. The effectiveness of physiotherapy exercises in subacromial impingement syndrome: a systematic review and meta-analysis. Semin Arthritis Rheum. 2012;42(3):297–316.
10. Nichols AW. Diagnosis and management of thoracic outlet syndrome. Curr Sports Med Rep. 2009;8(5):240-9.
11. Atasoy E. Thoracic outlet syndrome: anatomy. Hand Clin. 2004;20(1), 7-14.
12. Demondion X, Herbinet P, Van Sint Jan S et al. Imaaging assessment of thoracic outlet syndrome. Radiographics : a review publication of the radiological society of North America. Inc. 2006;26(6):1735-50.
13. Huang JH, Zager EL. Thoracic outlet syndrome. Neurosurg. 2004;55(4): 897-903.
14. Solem-Bertoft E, Thuomas KA, Westerberg CE. The influence of scapular retraction and protraction on the width of the subacromial space: an MRI study. Clin Orthop Relat Res. 93;(296):99-103.
15. Navarro-Ledesma S, Luque-Suarez A. Comparison of acromiohumeral distance in symptomatic and asymptomatic patient shoulders and those of healthy controls. Clin Biomech. 2018;53:101-6.
16. Seitz AL., McClure PW, Lynch SS et al. Effects of scapular dyskinesis and scapular assistance test on subacromial space during static arm elevation. J Shoulder Elbow Surg. 2012;21(5):631-40.
17. Novak CB, Mackinnon SE. Repetitive use and static postures: a source of nerve compression and pain. J Hand Ther. 1997;10(2):151-9.
18. Watson LA, Pizzari T, Balster S. Thoracic outlet syndrome part 2: conservative management of thoracic outlet. Man ther. 2010;15(4):305-14.
19. Azzoni R, Cabitza P, Parrini M. Sonographic evaluation of subacromial space. Ultrasonics. 2004;42(1-9):683-7.
20. Aloui G, Hammami M, Fathloun M. Effects of an 8-week in-season elastic band training program on explosive muscle performance, change of direction, and repeated changes of direction in the lower limbs of junior male handball players. J Strength Cond. 2019;33(7):1804-15.
21. Uchida MC, Nishida MM, Sampaio RA et al. Thera-band elastic band tension: reference values for physical activity. J Phys Ther Sci. 2016;28(4): 1266-71.
22. Gillard J, Pérez-Cousin M, Hachulla E et al. Diagnosing thoracic outlet syndrome: contribution of provocative tests, ultrasonography, electrophysiology, and helical computed tomography in 48 patients. Jt Bone Spine. 2001;68(5):416-24.
23. Demondion X, Vidal C, Herbinet P et al. Ultrasonographic assessment of arterial cross-sectional area in the thoracic outlet on postural maneuvers measured with power Doppler ultrasonography in both asymptomatic and symptomatic populations. J Ultrasound Med. 2006;25(2): 217-24.
24. Ramesh, Shubha M, Sowmya M et al. Comparison of ultrasound guided costoclavicular brachial plexus block versus supraclavicular brachial plexus block for forearm and hand surgeries for surgical anaesthesia: a prospective randomised clinical study. Indian J Clin Anaesth. 2018; 10(8): 96-101.
25. Duarte FH, Zerati AE, Gornati VC et al. Normal costoclavicular distance as a standard in the radiological evaluation of thoracic outlet syndrome in the costoclavicular space. Ann Vasc Surg. 2001;72:138-46.
26. Contemori S, Panichi R, Biscarini. Effects of scapular retraction/protraction position and scapular elevation on shoulder girdle muscle activity during glenohumeral abduction. Hum Mov Sci. 2019;64:55-66.
27. Ryan G, Johnston H, Moreside J. Infraspinatus isolation during external rotation exercise at varying degrees of abduction. J Sport Rehabil. 2018; 27(4):334-9.
28. Escamilla RF, Yamashiro K, Paulos L et al. Shoulder muscle activity and function in common shoulder rehabilitation exercises. Sports Med. 2009; 39(8):663-85.
29. Bdaiwi AH, Mackenzie TA, Herrington L et al. Acromiohumeral distance during neuromuscular electrical stimulation of the lower trapezius and serratus anterior muscles in healthy participants. J Athl Train. 2015; 50(7):713-8.
30. Guney-Deniz H, Harput G, Toprak U et al. Relationship between middle trapezius muscle activation and acromiohumeral distance change during shoulder elevation with scapular retraction. J Sport Rehab. 2019; 28(3):266-71.
31. Lindgren KA. Conservative treatment of thoracic outlet syndrome: a 2-year follow-up. Arch Phys Med Rehabil. 1997;78(4):373-8.
32. Porter JM, Rivers SP, Coull BM. Thoracic outlet syndrome: a conservative approach. Vase Diagn Ther. 1982;3:35-42.
33. Dobrusin R. An osteopathic approach to conservative management of thoracic outlet syndromes. J Am Osteopath Assoc. 1989;89(8):1046-50.
34. Patterson RM, Stegink Jansen CW, Hogan HA et al. Material properties of theraband tubing. Phys Ther. 2001;81(8):1437-45.
35. Day ML, McGuigan MR, Brice G et al. Monitoring exercise intensity during resistance training using the session RPE scale. J Strength Cond. 2004;18(2): 353-8.
36. Fatouros IG, Kambas A, Katrabasas I et al. Strength training and detraining effects on muscular strength, anaerobic power, and mobility of inactive older men are intensity dependent. Br J Sports Med. 2005;39(10): 776-80.
37. Lopez P, Radaelli R, Taaffe DR et al. Resistance training load effects on muscle hypertrophy and strength gain: systematic review and network meta-analysis. Med Sci Sports Exerc. 2021;53(6):1206.
38. Dahlstrom KA, Olinger AB. Descriptive anatomy of the interscalene triangle and the costoclavicular space and their relationship to thoracic outlet syndrome: a study of 60 cadavers. J Manipulative Physiol Ther. 2012; 35(5):396-401.

https://doi.org/10.18857/jkpt.2023.35.2.71