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Theraband applications for improved wall slide exercise

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Theraband applications for improved upper extremity wall slide exercise

Context: The wall slide exercise is commonly used in clinic and research settings. Theraband positioning variations for hip exercises are investigated and used, but theraband positioning variations for upper extremity wall slide exercise, though not commonly used, are not investigated.

Objective: To investigate the effect of different theraband positions (elbow and wrist) on scapular and shoulder muscles’ activation in wall slide exercises and compare them to the regular wall slide exercise for the upper limbs.

Study Design: Descriptive Laboratory Study.

Setting: University Laboratory

Patients or Other Participants: 20 participants with healthy shoulders

Interventions: Participants performed regular and two different variations of wall slide exercises (theraband at wrist and theraband at elbow) in randomized order.

Main Outcome Measures: Surface EMG activity of the trapezius muscles (upper [UT], middle [MT], and lower trapezius [LT]), infraspinatus (IS), middle deltoid (MD), and serratus anterior (SA).

Results: Regular wall slide exercise elicited low activity in MD and moderate activity in SA muscles (32% MVIC), while theraband at wrist and elbow variations elicited low activity in MT, LT, IS, and MD muscles and moderate activity in SA muscles (46% and 34% MVICs, respectively). UT activation was absent to minimal (0-15% MVIC) in all wall slide exercise variations. Theraband at wrist produced lower UT/MT, UT/LT, and UT/SA levels.

Conclusion: In shoulder rehabilitation, clinicians desiring to activate scapular stabilization muscles should consider using theraband at wrist variation; clinicians desiring to achieve more shoulder abduction activation and less scapular stabilization should consider theraband at elbow variation of upper extremity wall slide exercise.

Keywords: Shoulder, exercise therapy, electromyography, superficial back muscles, rehabilitation.

Abstract word count: 253
Key Points:

Clinicians focusing on scapular stabilization should consider theraband at wrist variation of upper extremity wall slide exercise.

Clinicians focusing more on shoulder abduction should consider Theraband at elbow variation of upper extremity wall slide exercise.

Theraband variations of upper extremity wall slide exercise can be used in clinical settings for a more goal-oriented approach.
The scapulothoracic joint is a physiological joint, which is stabilized by dynamic muscular forces working in harmony\(^1\). This harmony is crucial for the smooth and healthy movements of the scapula and arm as they provide a stable basis for glenohumeral joint\(^2,3\). Scapulothoracic and glenohumeral muscles provide this stability and mobility, mainly trapezius, serratus anterior, levator scapulae, rhomboid major, and pectoralis minor\(^4\). These muscles are mostly challenged during humeral elevation, and changes in strength and/or activation could cause scapulothoracic dysfunction. This could make the shoulder complex vulnerable to injuries, with reduced glenohumeral and acromiohumeral distance, as repetitive use may result in pathologic conditions such as shoulder pain, shoulder subacromial and internal impingement, and rotator cuff tendinopathy\(^5,8\).

Scapulothoracic dysfunction is related to lower activation levels (EMG) in middle and lower trapezius, and serratus anterior muscles\(^9\). Another important factor to consider in shoulder rehabilitation is UT activity, as excess activation of the UT was proposed as contributing factor to abnormal scapular motion\(^10\). In overhead motions, the infraspinatus muscle produces an approximation force to resist distraction of glenohumeral joint, which plays a critical role in providing dynamic stability\(^11\). Clinicians prescribe exercises, specifically aiming for these muscles, to restore harmony and quality in scapular movements in shoulder rehabilitation\(^12\). For this purpose, the wall slide exercise is recommended in shoulder elevation of 90° and above \(^9,13\). There are different variations of wall slide exercise, and in one of which, Castelein et al. used theraband at hand level to elicit more external rotation force\(^12,14-17\). The use of elastic resistance bands stimulate specific muscle activations and change in resistance band’s position alters the activation of targeted muscles\(^18,19\). As suggested by the literature, using theraband at different positions could change the activation levels of the muscles and, thus, the aim of the exercise itself.

Therefore, we aimed to investigate the effect of different theraband positions (elbow and wrist) on scapular and shoulder muscles’ activation levels in wall slide exercises and compare these variations to each other and regular wall slide exercise. Our primary hypothesis was the location of the resistance band would produce different muscle activations in different exercise phases (ascending, stationary, and descending) of wall slide exercise. Our secondary hypothesis was this difference in muscle activations would produce different muscle activation ratios.

### Methods
Participants

We included 20 healthy male participants in our study, who were physically active but did not exercise regularly. Our inclusion criteria were: being 18 to 40 years old, no restrictions in the glenohumeral joint (range of motion limitation in shoulder goniometric measurement), no shoulder pain or instability (within last 6 months), no injury to the shoulder joint in the last 6 months, no surgical history of the shoulder or cervical regions, having symmetrical scapular movement (visually classified as Kibler type 4, by a physiotherapist with 22 years of experience), no systemic or neurological diseases. Ethics review board approved our study with the approval date and number of 09/17/2019 and 2019/22-33. All participants provided written informed consent.

Outcome Measurements

At the beginning of the study, participants’ demographic information (age, weight, height, BMI) and dominant sides were recorded (handedness was determined by asking participants which hand they use for writing).

Electromyography (EMG)

A surface EMG system with 8 channels (Noraxon Telemyo DTS System, Scottsdale, USA) was used to measure muscle activation levels. The dominant side electrode attachment places were shaved, scrubbed, and cleansed with 70% isopropyl alcohol. The sample rate for data collection was 1500 Hz. The device had a common-mode rejection ratio of 80 dB. The gain was set at 1000. A synchronized video record (Logitech C920, ABD) was taken at 50 frames per second to identify three phases of exercises (ascending phase: from start to finish position, stationary phase: the hold at the finish position, descending phase: from finish to start position).

Bipolar Ag–Cl surface electrodes (Plasmed, Trimpeks, Istanbul, Turkey) were placed over upper (UT), middle (MT) and lower trapezius (LT), infraspinatus (IS), middle deltoid (MD), and serratus anterior (SA) by the same examiner in all subjects. SENIAM (Surface ElectroMyoGraphy for the Non-Invasive Assessment of Muscles) recommendations were followed for electrode placement and interelectrode distance.
Electrodes for UT were placed halfway between the spinous process of C7 and the posterior acromion. For registration of MT activity, electrodes were placed halfway between the medial border of scapulae and the spinous process of the 3rd thoracic spine. Electrodes for registration of LT activity were placed at 2/3 on the line from trigonum spinae to the 8th thoracic vertebra. Electrodes for registration of IS activity were placed parallel to and approximately 4 cm below the spine of the scapula, on the lateral aspect, over the infrascapular fossa of the scapula. Electrodes for registration of MD activity were placed on a line from the acromion to the lateral epicondyle of the elbow, corresponding to the greatest bulge of the muscle. Electrodes for SA registration were applied horizontally just below the axillary area, at the level of the inferior tip of the scapula, and just medial of the latissimus dorsi. Additionally, a two-sided band was used to fixate electrodes.

**Testing Procedure**

In the first part of the investigation, maximum voluntary isometric contractions (MVIC) of UT, MT, LT, IS, MD, and SA were quantified in a randomized order. Each MVIC measurement lasted at least 5 seconds and was repeated three times against a fixed belt resistance band with 30 seconds rest in between contractions, 2 min rest in between different muscle’ MVIC measurements. Participants were verbally encouraged to give their maximum effort by the same investigator.

MVICs of UT, SA, and MD were measured with resisted arm elevation. Participants seated with the arm flexed forward 125° flexion and resistance was applied with a fixed belt crossing just over the elbow. For MT, participants were lying prone with their dominant arm abducted 90° and externally rotated. Resistance was applied vertically with a fixed belt, just above the elbow joint. For LT, participants were lying prone with their dominant arm abducted 140° and externally rotated. Resistance was applied towards additional flexion and parallel to the LT fibers with a fixed belt, just above the elbow joint. For IS, patients were seated with the arm abducted 90°, externally rotated 45°, and elbow flexed 90°. Participants were asked to pull obliquely against a belt positioned on wrist level (figure 2).

After MVIC recording, the starting position was standardized as participants would have to move away from their place between the normal and theraband wall slide variations. To provide this, the participant’s upper
arm and foot length were measured and a tape was applied to the floor marking the total distance of upper arm and foot length, for starting position. For starting position, participants were asked to stand behind this line and position their shoulders to 90° flexion in the scapular plane, their elbows to 90° flexion and forearms to mid-rotation, so that the ulnar side of the forearm would be in contact with the wall. Before exercise trials, starting and finishing positions of the arms (90° and 150° shoulder flexion in the scapular plane) were marked on the wall with a colored sticky tape. For exercise execution, participants were asked to start from the starting position and slide their forearms on the wall to the ending positions in 3 seconds, hold in this position for 3 seconds and return to starting position in 3 seconds. To accurately perform the exercise, a metronome with 60 beats per minute was used. For every exercise, researchers first described and performed the exercise and then participants performed the exercise for three trials. One-minute rest were given between trials and all exercises were executed in a randomized order and recorded with a synchronized camera. The http://randomization.com was used to randomize exercise order.

Theraband resistance bands (Thera-Band®, Performance Health. Resistance in pounds at 3.7 for 100% and 5.5 for 200% elongation) were used for two different theraband variations of wall slide exercise. For the regular wall slide exercise, the participants put their forearms on the wall with their arms placed in the scapular plane and slide their arms to their maximum shoulder flexion, hold for 5 seconds and slide back down. For theraband variations, the theraband was tied circumferentially without any slack or tension to the designated area while participants’ arms were positioned next to their body with their elbows flexed at 90° and hands were at shoulder width. At the beginning of the exercises, participants’ arms were placed in the scapular plane, which created tension on the theraband, and were asked to keep the tension on the theraband throughout the exercise. In the first variation, theraband at elbow variation, we gave theraband resistance at the elbow level, just distal to the elbow joint, to exert horizontal abduction force to achieve more middle trapezius activation. In the second variation, theraband at wrist variation, we gave theraband resistance at the wrist level to exert external rotation force to achieve more infraspinatus activation (figure 3).

(figure 3 inserts here)

Signal processing and data analysis
“Noraxon MyoResearch XP Master Edition” software (Noraxon USA, Inc) was used for signal processing. EMG signals were filtered with a 20 Hz high-pass Butterworth filter and cardiac artifact reduction (50 Hz) was performed. Full-wave rectification and smoothing (root-mean-square, window 100 ms) of the signals were performed. Synchronized video recordings were used to track the ascending, stationary and descending phases of all exercise repetitions. EMG data of the three trials were averaged for normalization in each phase and expressed as a percentage of the MVIC (%MVIC). The muscle activation levels classified as 0-15% as absent to minimal, 16-30% as low, 31-60% as moderate, and greater than 60% as high. Muscle activation ratios were calculated by dividing %MVIC of the UT by %MVICs of MT, LT, and SA muscles. A ratio that is greater than 1.00 indicates that the UT is more active than other scapular stabilizers. In rehabilitation, a lower ratio of scapular stabilization muscles to UT is desired. Statistical Analysis SPSS 26 for Windows (IBM Corporation, Armonk, NY) was used for statistical analysis. All outcome variables were normally distributed (assessed using visual (histograms and probability plots) and analytical methods (Shapiro-Wilk tests)). Demographic information and descriptive information for EMG were given as mean (x) and standard deviation (SD). Muscle activity ratios were compared with the Friedmann test. Post-hoc comparisons were made with the Wilcoxon test between exercise variations, using Bonferroni correction. To compare muscle activity between the variety of exercises, a two-way repeated measures design was used to compare exercise*muscle interaction (3 by 6) and exercise*phase interaction (3 by 3). When Mauchly’s test of sphericity was significant, Greenhouse-Geisser correction was applied. Post hoc pairwise comparisons with Bonferroni correction were performed. Statistically significance was set as <0.05. Results Twenty healthy right-hand dominant participants with a mean age of 23.8±3 years (BMI: 24.23±4.03 kg/m²) participated in our study. Mean EMG values for muscles in different exercise variations are given in Table 1.
Thereband variations produced different UT/MT, UT/LT, and UT/SA muscle activation ratios in all three phases (p<0.01). Muscle activation ratios of UT/MT, UT/LT, and UT/SA for different exercise variations are given in Table 2.

Comparisons Between Exercise Phases

Statistical analysis showed a significant interaction effect of phase x muscle for all variations of wall slide exercise (p < 0.01, power = 0.99 for regular; p < 0.01, power = 0.98 for TBW; p<0.01, power = 0.94 for TBE). All muscles’ activation levels differed between all phases (p<0.05) with some exceptions. In regular wall slide exercise, differences were insignificant between stationary and descending phases for MT, LT, and IS muscles, and ascending and stationary phases for SA muscle. In theraband at wrist variation, differences were insignificant between stationary and descending phases for UT, IS, and SA muscles, and ascending and stationary phases for MD muscle. In theraband at elbow variation, differences were insignificant between stationary and descending phases for UT, MD, and SA muscles in wall slide exercise with theraband at elbow (figure 4).

Comparisons Between Exercise Variations

Statistical analysis showed a significant interaction effect of muscle x exercise for all three phases (ps< 0.01, powers = 0.99). In all phases, both variations produced better MT, LT, and IS activation than regular wall slide exercise (ps<0.01). In ascending phase, TBW produced higher IS and SA activations and TBE produced higher MD activation than regular wall slide exercise (both ps<0.01). In the stationary phase, TBW produces higher LT, IS, and SA activation (ps<0.01) and TBE produces higher MD activation than regular wall slide exercise (p=0.02). In descending phase, TBW produces the higher IS activation (p<0.01) and TBE produces higher MD activation (p<0.05). Results of the post hoc tests are displayed in Table 3.

Discussion
In shoulder exercises, MT, LT, and SA muscles are targeted due to their role in scapular stabilization and energy transfer. While increasing these muscles' activation, an increase in UT activation is not desired as it causes a decrease in other scapular muscles. Theraband at wrist variation produced the lowest UT/MT, UT/LT, UT/SA ratios and produced the highest IS activation. These findings confirmed our initial hypotheses; different theraband positions produced different muscular activities in scapular and shoulder muscles and different muscle activations resulted in different muscle activation ratios.

As a result of our study, we have shown that wall slide exercise with theraband at either elbow or wrist require moderate (31–60% MVIC) SA muscle activation and low (16-30% MVIC) MT, LT, IS activation in ascending phase; low (16-30% MVIC) SA and IS activation in stationary phase; low (16-30% MVIC) SA, MT, IS activation in descending phase. All variations of wall slide exercise require absent to minimal (0-15% MVIC) UT activation. Both variations activated scapular stabilization muscles higher than regular exercise and, while theraband at wrist produced better UT/MT, UT/LT, and UT/SA levels, and IS activation, theraband at elbow focused more on middle deltoid muscle.

In this study, regular wall slide exercise produced similar trapezius and slightly higher serratus anterior muscle activation (mean difference ±3%) values to Castelein et al.'s and produced slightly higher infraspinatus muscle activation (mean difference %4.07) values to Wise et al.'s. Theraband variations elicited greater activity in MT, LT, and IS in all phases (difference ranging from 3.92% to 15.61%) and greater SA activity in descending phase compared to Castelein et al., Wise et al.'s and, to our regular theraband exercise. This higher activation in scapular dynamic stabilization muscles (i.e., MT, LT, and SA) could be explained with theraband producing additional forces that challenge scapular stabilization. The higher activation in IS could be explained by theraband producing internal rotatory moment. In all three phases, theraband at elbow variation and normal wall slide exercise elicited more UT activation (difference ranging from 1.01% to 4.11%) than theraband at wrist. Theraband at wrist level elicits scapular internal rotation moment in addition to shoulder downward rotation moment, which might explain lower UT activation.

Regular wall slide exercise and theraband at elbow variation produced similar UT/SA activation ratios to each other and literature. Theraband at wrist variation produced the lowest UT/SA ratios, which could be a result of higher SA activation with lower UT activation. Similar UT, MT, and LT activation levels (mean
difference ±5% MVIC) can be seen in Castelein et al.’s study, in which they investigated bilateral shoulder elevation with resisted external rotation\textsuperscript{17}. But, our study had higher serratus anterior activation (mean difference 23.79%) levels that are probably caused by exercise execution difference (their exercise was open kinetic chain vs. our exercise was closed kinetic chain and participants put small enough weight to slide the arms on the wall comfortably). As exercises with higher MT, LT, and SA activations are beneficial to shoulder stabilization, theraband at wrist variation of the wall slide exercise seems to be a better choice\textsuperscript{12, 15, 17, 24, 30}.

Different positioning of the theraband may change the lever arm of the force, which alters the activation of the targeted muscles\textsuperscript{3, 19}. Cambridge et al. used different resistance band positionings and produced progressive resistance for hip muscles\textsuperscript{18}. In our study, theraband at wrist not only increased the resistance, but also may have produced rotatory forces in the shoulder which caused higher LT and SA activations than other exercises. Also, due to being synergists, higher activation of LT muscle might have caused UT muscle to activate lesser. On the other hand, theraband at elbow produced resistance to shoulder muscles and to abductors, which caused highest MD activity in most phases. Generally, in descending phase, gravitational forces lessen the load on the shoulder and scapular muscles and being an eccentric phase could also lower the EMG activations\textsuperscript{32, 33}. This might have resulted in two things: first, lesser load on scapular muscles diminished the LT activation difference between theraband variations. Second, decreased SA activation levels. Even though SA activation levels were decreased, they were higher than regular as theraband put more load on SA muscles. Considering activation levels and ratios, clinicians can prefer theraband at wrist variation to focus mostly on scapular stabilization muscles (MT, LT, SA) and IS; prefer theraband at elbow variation to focus on MD, while still activating scapular stabilization muscles (MT, LT, SA) and IS.

Muscle activation patterns by phases slightly differed between exercise variations. In all variations of wall slide exercise (including regular), ascending phase was the most demanding phase and the descending phase was the least demanding phase\textsuperscript{32, 33}. Theraband variations produced additional loads that altered this phase order, i.e. theraband at wrist variation altered LT activation to higher levels and theraband at elbow variation altered MD activation to higher levels in descending phase. UT activation was similar in all exercises.

Additional loading with theraband causes different activation levels in muscles depending on the theraband position\textsuperscript{18, 19}. Positioning of the theraband on the wrist might have produced rotatory forces causing higher LT
activation and positioning of the theraband on the elbow might have caused adduction forces in the shoulder, causing higher MD activation. Considering activation levels and ratios, theraband at wrist variation is beneficial to achieve higher activation in scapular stabilization muscles (MT, LT, SA) and IS, whereas theraband at elbow variation is beneficial to achieve higher activation in MD and still challenging scapular stabilization muscles (MT, LT, SA) and IS.

**Limitations**

Our sample pool consisted of healthy male participants, with no shoulder pain in daily living activities. Although, individuals with mild shoulder dysfunction also have similar activation patterns to the healthy individuals in other exercises, patients with shoulder pain should be investigated for wall slide exercise\(^{13}\). There is a possibility that theraband variations may have altered shoulder and scapular kinematics. Analyzing scapular and shoulder kinematics simultaneously with the theraband variations could be useful for this purpose. Another limitation was the use of surface EMG. We followed the SENIAM guideline and recommendations, but crosstalk could have occurred during measurements.

**Conclusion**

The wall slide exercise variations elicited higher activation levels than regular wall slide, which were low (16-30% MVIC) to moderate (31-60% MVIC) activation in IS, MD, and scapular muscles. Theraband at wrist variation is a preferable method to focus on scapular stabilization (MT, LT, SA) and IS muscles as it produced the lowest UT/MT, UT/LT, and UT/SA ratios. Theraband at elbow variation is a preferable method to focus on MD while activating scapular stabilization muscles (MT, LT, SA) and IS. Theraband positioning is a useful approach to achieve the desired muscle activation ratios. These results might assist exercise selection in clinical practice.

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**Legends to figures**

Figure 1. Flowchart of the study.

Figure 2. A and B. MVIC position for UT, MD, and SA from two different perspectives to show the placement of the electrodes. C. MVIC position for MT. D. MVIC position for LT. E. MVIC position for IS.

Figure 3. Three variations of wall slide exercise; A.regular, B.theraband at elbow, C.theraband at wrist.
Figure 4. Muscle activations comparison of different phases by muscles.

Bars represent mean MVIC% values; error bars represent standard deviation; * represent statistically significant difference.
Randomization of the exercise order from the http://randomization.com

20 healthy male participants were included in the study.

MVIC measurements of UT, MT, LT, IS, MD, and SA were recorded in a randomized order.

Starting positions were marked on the floor for regular wall slide and theraband variations (distance of upper arm length + foot length)

Exercises were demonstrated by the researcher and participants were familiarized with the exercises.

Regular wall slide, theraband at wrist variation and theraband at elbow variation were executed in random order with metronome and recorded with EMG.
Table 1. Mean EMG Values (% MVIC±Standard Deviation) for Muscles in Different Exercise Variations.

|                  | Regular          | Theraband at wrist | Theraband at elbow |
|------------------|------------------|--------------------|--------------------|
|                  | Asc. phase       | Stat. phase        | Desc. phase        | Asc. phase       | Stat. phase        | Desc. phase        |
| UT               | 11.54±5.19       | 7.37±4.68          | 4.13±3.13          | 7.43±5.01        | 3.22±3.33          | 3.12±2.98          | 11.18±5.36         | 5.31±4.3          | 5.11±4.25         |
| MT               | 10.31±8.87       | 4.92±3.78          | 4.57±3.33          | 24.70±19.85      | 12.32±11.68       | 16.64±15.19        | 24.3±16.2          | 10.99±7.45        | 16.33±13.14       |
| LT               | 11.18±8.48       | 5.85±5.95          | 6.24±5.67          | 22.67±11.61      | 12.17±9.09        | 16.74±9.32         | 18.85±10.2         | 9.11±7.39         | 14.88±9.4         |
| IS               | 13.92±7.89       | 8.43±5.23          | 8.81±6.7           | 29.53±16.67      | 19.95±13.07       | 21.86±10.88        | 22.3±11.75         | 12.47±7.22        | 16.6±9.59         |
| MD               | 16.42±8.9        | 14.8±8.93          | 8.43±5.61          | 15.26±13.6       | 14.2±14.34        | 10.06±11.61        | 24.23±18.59        | 17.47±9.54        | 16.01±13.22       |
| SA               | 32.12±21.03      | 20.38±15.69        | 14.44±9.08         | 46.29±37.37      | 27.87±24.62       | 20.51±10.74        | 34.03±19.61        | 19.8±13.03        | 18.35±12.04       |

Asc. stands for ascending, Stat. stands for stationary, Desc. stands for descending, SD stands for standard deviation; UT, upper trapezius; MT, middle trapezius; LT, lower trapezius; IS, infraspinatus; MD, middle deltoid; SA, serratus anterior.
Table 2. Muscle Activation Ratio Comparisons of UT/MT, UT/LT, and UT/SA.

| Friedmann | Phase   | Regular | TBW  | TBE  | $X^2$ | p    |
|-----------|---------|---------|------|------|-------|------|
| UT/MT     | Ascending | 2.32    | 0.75 | 0.87 | 0.31  | <0.01|
|           | Stationary | 2.47    | 0.62 | 0.82 | 0.35  | <0.01|
|           | Descending | 1.44    | 0.39 | 0.57 | 0.24  | <0.01|
| UT/LT     | Ascending | 2.86    | 0.61 | 0.92 | 0.31  | <0.01|
|           | Stationary | 3.65    | 0.42 | 0.95 | 0.4   | <0.01|
|           | Descending | 1.36    | 0.33 | 0.52 | 0.31  | <0.01|
| UT/SA     | Ascending | 0.51    | 0.24 | 0.45 | 0.2   | <0.01|
|           | Stationary | 0.56    | 0.18 | 0.44 | 0.27  | <0.01|
|           | Descending | 0.35    | 0.18 | 0.55 | 0.18  | <0.01|

Statistically significance was accepted as $p=0.05$, Bonferroni correction was made for post-hoc comparisons. $^a$, statistically different from regular; $^b$, statistically different from regular and TBE. TBW, theraband at wrist; TBE, theraband at elbow; UT, upper trapezius; MT, middle trapezius; LT, lower trapezius; SA, serratus anterior.
Table 3. Post Hoc Pairwise Comparisons of Total Mean Normalized EMG Activity of Upper Trapezius (UT), Middle Trapezius (MT), Lower Trapezius (LT), Infraspinatus (IS), Middle Deltoid (MD) and Serratus Anterior (SA) Between Exercises.

| Comparison (A VS. B) | UT (MVC%) | SE | MT (MVC%) | SE | LT (MVC%) | SE | IS (MVC%) | SE | MD (MVC%) | SE | SA (MVC%) | SE |
|----------------------|-----------|----|-----------|----|-----------|----|-----------|----|-----------|----|-----------|----|
| Regular vs. TBW      | 4.1 (p<0.01) | 1.03 | -14.39 (p<0.01) | 2.78 | -11.49 (p<0.01) | 1.44 | -15.61 (p<0.01) | 2.27 | No sign. / | -14.17 (p<0.01) | 4.61 |
| Regular vs. TBE      | No sign. diff. | / | -13.99 (p<0.01) | 2.11 | -7.77 (p<0.01) | 1.14 | -8.38 (p<0.01) | 1.22 | No sign. / | No sign. / | diff. |
| TBW vs. TBE          | -3.75 (p<0.01) | 1.03 | No sign. diff. | / | 3.82 (p<0.01) | 1.09 | 7.23 (p<0.01) | 1.96 | -8.98 (p<0.01) | 2.65 | No sign. / | diff. |
| Regular vs. TBW      | 4.08 (p<0.01) | 1.03 | -14.39 (p<0.01) | 2.78 | -11.49 (p<0.01) | 1.44 | -15.61 (p<0.01) | 2.27 | No sign. / | -14.17 (p<0.01) | 4.61 |
| Regular vs. TBE      | No sign. diff. | / | -13.99 (p<0.01) | 2.11 | -7.67 (p<0.01) | 1.14 | -8.38 (p<0.01) | 1.22 | No sign. / | No sign. / | diff. |
| TBW vs. TBE          | -3.75 (p<0.01) | 1.03 | No sign. diff. | / | 3.82 (p<0.01) | 1.09 | 7.23 (p<0.01) | 1.96 | -8.98 (p<0.01) | 2.65 | 12.26 (p=0.02) | 4.99 |

**CLINICAL CONCLUSION**

In ascending phase, TBW produces the best IS and SA activations and TBE produces the best MD activation. They both produce better MT, LT, and IS activation than regular wall slide exercise.

In stationary phase, TBW produces the best LT, IS, and SA activation and TBE produces the best MD activation. They both produce better MT, LT, and IS activation than regular wall slide exercise.

In descending phase, TBW produces the best IS activation and TBE produces the best MD activation. They both produce better MT, LT, IS, and SA activation than regular wall slide exercise.

Values are given as mean difference A-B. TBW, theraband at wrist variation; TBE, theraband at elbow variation exercises; UT, upper trapezius; MT, middle trapezius; LT, lower trapezius; IS, infraspinatus; MD, middle deltoid; SA, serratus anterior muscles.