Musculoskeletal Medicine and Pain Review Article

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Lower trapezius muscle function in people with and without shoulder and neck pain: a systematic review

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Abstract

Context: Shoulder and neck pain are leading causes of disability worldwide. Rotator cuff pathology has strong associations with such pain and is extensively targeted by healthcare practitioners. A dysfunctional lower trapezius muscle has also been shown to contribute to neck and shoulder pain, yet it is often overlooked.

Objectives: This systematic review analyzes those with a history of, or who are currently managing, shoulder or neck pain to indicate differences in measures of lower trapezius function when compared to subjects without that pain.

Methods: Studies with no age restrictions were included in the study. Studies could determine lower trapezius muscle function with any quantifiable measurement tool or clinical assessment. If the study included a control group (no pain) and a comparator group (pain), and if lower trapezius muscle function was assessed in both, the study was typically included. The significance of the lower trapezius muscle function change was summarized in these pain patients. From a final total of 18 studies identified, level of muscle activity, muscle activation, time to onset, muscle strength, and muscle thickness were reported.

Results: The 18 included articles involved 485 participants with shoulder and/or neck pain and 455 without. Half of the shoulder pain studies (6/12), and all of the neck pain studies (6/6), demonstrated that the lower trapezius had a noticeable impact. The lower trapezius muscle in participants with shoulder and neck pain tended to show decreased muscle strength, and decreased time to onset/latency.

Conclusions: The findings from this systematic review should be taken into consideration when assessing and treating patients with shoulder and neck pain. Future studies that define the type and duration of shoulder and neck pain, as well as prospectively assessing lower trapezius muscle function in those with and without that pain, are needed.

Keywords: EMG; muscle; neck; pain; shoulder; trapezius; ultrasound.

In today's society, with the advent and exponential increase of technology, neck pain is seen more and more often due to the improper ergonomics associated with the use of computers, cell phones, etc. [1] This static positioning of the neck and shoulder leads to many musculoskeletal complaints and pathologies [2]. It leads to weakening of the muscle tissues by decreasing biomechanical functions in the area, prolonged stiffness and hypokinetics, and postural adaptations and pain [2].

In the typical anatomy of the head and neck, both mastoid processes are located vertically with the shoulder joints and posterior cervical muscles to maintain balance during consistent contraction [3–6]. However, as mentioned previously, the prolonged use of electronics leads to the adoption of a static and flexed spinal posture, inducing a forward head posture and rounded shoulders [2, 4]. This prolonged spinal flexion is the main posture that contributes to neck pain, affecting a wide spectrum of individuals, ranging from the average person to athletes

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who use electronics. In athletes, this forward head and rounded shoulder posture is found in weightlifters who heavily target exercises that generally function as "push" exercises, such as bench and shoulder press, and do not focus much on the posterior stabilizing muscles such as the rotator cuff muscles and lower trapezius [7]. In normal movement, the lower trapezius and scapula coordinate to provide stabilization during shoulder elevation [4]. The lower trapezius, specifically, originates on the spine and inserts onto the spine of the scapula from the acromion process, which allows for significant movement of the shoulder due to its stabilizing function of the scapula [8, 9]. The lower trapezius not only stabilizes the shoulder in the sagittal plane during shoulder elevation, but also retracts and depresses the scapula during horizontal pulling movements and aids in abduction and external rotation [8]. When the lower trapezius is neglected in strength training, as previously mentioned by weightlifters, or neglected naturally by the spinal flexion caused by prolonged electronic use, it theoretically results in biomechanical dysfunction that creates instability in the cervicothoracic region [4]. Therefore, consequently, maintaining this improper, rounded posture can lead to upper crossed syndrome, in which the lower trapezius, rhomboids, and serratus anterior are weakened, and the upper trapezius, pectoralis major and minor, and levator scapulae muscles are shortened [4, 10]. These muscle imbalances results in pain.

Imbalances in these stabilizing muscles can also cause scapulothoracic dyskinesia, in which the typical position and motion of the scapula is noticeably disrupted, causing pain [11]. The majority of research relating to scapulothoracic muscle dysfunction has been noted to focus on shoulder pathologies such as shoulder instability, rotator cuff insufficiency, and shoulder impingement [11]. This research has shown that these muscle imbalances disrupt normal biomechanical positioning and cause abnormal scapular positioning and pain [11]. These imbalances can be described as impaired relationships among scapulothoracic muscles susceptible to tightness, inhibition, or weakness. Specifically, muscle imbalances in this region occur when the middle and lower trapezius are too weak and the upper trapezius is too tight [4]. To target this, many studies have shown that strengthening weak muscles and lengthening shortened muscles aid in achieving proper postural alignment [4, 12, 13]. Exercises that focus on strengthening the lower trapezius have been shown to reduce this muscle imbalance and improve posture in patients with shoulder pathologies as well as stabilize the scapula [4]. These include exercises such as the wall slide, modified prone cobra, and trapezius muscle exercise progression [4]. Additionally, it has been shown that neck-specific exercises targeting all muscle layers, including the lower trapezius, can also improve outcomes in individuals with whiplash-associated disorders and neck pain [14, 15].

As illustrated, these pathologies and imbalances are found not only in patients with shoulder issues, but also in people with neck pain and headaches [16]. Further, some research studies and textbook authors have found that individuals with neck pain typically show limited endurance and strength of the lower trapezius muscle [14, 17–20]. Under the overarching patient description of neck and shoulder pain, marked by underlying pathologies of upper crossed syndrome, scapulothoracic dyskinesia, and so on, the lower trapezius muscle undergoes potential changes as a result of these conditions. Despite this, there is still a limited amount of evidence on the clinical results from specific lower trapezius strength changes [10, 14, 17–20]. This should be measured and utilized to activate the lower trapezius exercise in neck pain patients.

There have been numerous studies on the effect of neck-focused exercises on neck pain patients, but only in the past few years was the importance of lower trapezius contraction rate and thickness identified [4, 21, 22]. This systematic review aims to determine, by review of case-control studies, if people with a history of, or current, shoulder and/or neck pain, demonstrate differences in measures of lower trapezius function when compared to people without shoulder and/or neck pain. A secondary focus is to determine if there is a difference in lower trapezius muscle function between the types and durations of shoulder and/or neck pain.

Methods

Search strategy

This systematic review was conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement. Ovid (MEDLINE), PubMed, and ScienceDirect were searched from inception until July 20, 2021. No language restrictions were applied to conference abstracts or published articles. In order to perform an all-encompassing and broad search, these keywords were utilized: (Lower Trapezius) AND (Pain OR Posture OR Dysfunction).

Eligibility criteria

Case-control studies including participants of any age with upper body pain of any type (specific or nonspecific) and of any duration

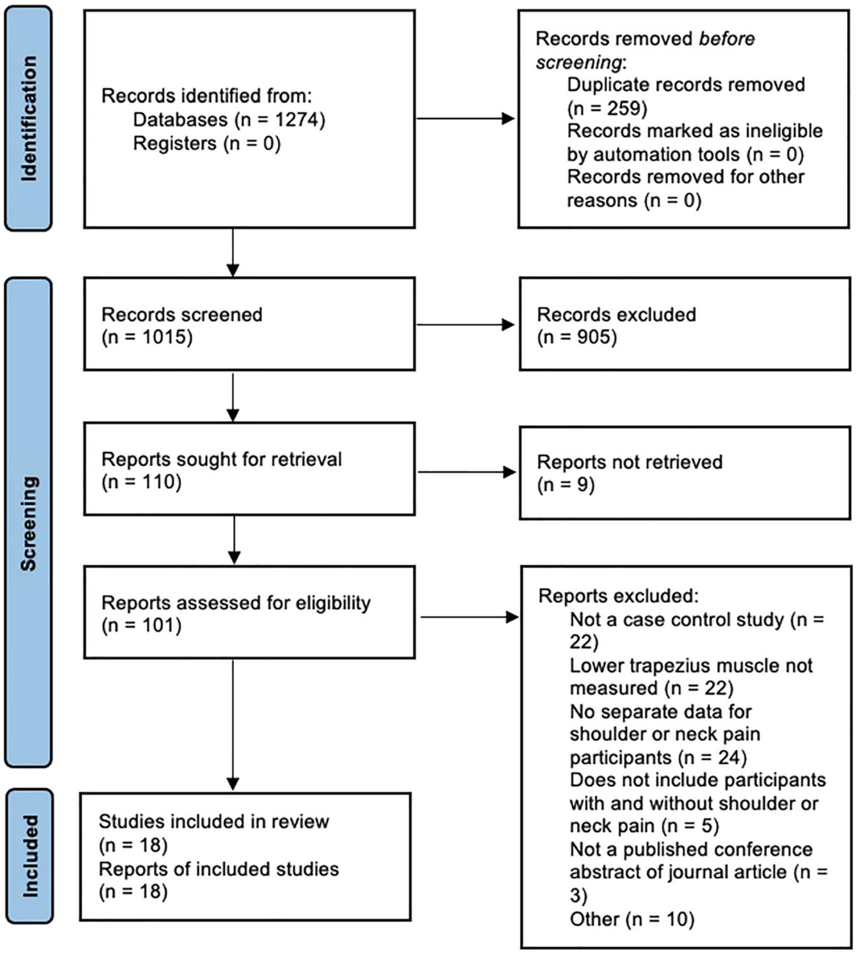

Figure 1: PRISMA flow diagram.

(acute, subacute, or chronic) were eligible for inclusion. Studies measuring lower trapezius function in any way were included. For example, strength, fatigability, percentage of maximum voluntary contraction, timing or extent of contraction, cross-sectional area, or other unidentified measurement were eligible for inclusion. Studies could assess the lower trapezius with any clinical measurement tool or quantifiable assessment, with the participant in dynamic or static activity. Studies were excluded if the subjects were solely determining the effect of an intervention on the lower trapezius muscle.

Study selection

One reviewer conducted the electronic searches (DW). Two other reviewers (NH/CL) independently screened citations at the title and abstract levels. Of the total studies identified, each citation was reviewed to identify lower trapezius effects by two independent reviewers. Data were independently extracted by two reviewers (NH/CL). Seven of the studies led to confusion whether to be included, so a third reviewer (DW) cross-checked, and a conclusion was made to include four and exclude three studies. Due to the heterogeneity among studies, a meta-analysis was not carried out.

Patient and public involvement

There was no patient and public involvement in the production of this research.

Results

Study identification

Searches retrieved 1,274 citations, of which 110 were eligible for full-text review. After review, 18 full-text articles of mixed methodological quality were included, whereas 92 were excluded based on the exclusion criteria and not being able to retrieve reports (Figure 1). Among the 92 excluded articles, nine of them could not be retrieved because they were not provided by authors. Thus, they were subsequently excluded. This can be seen in Figure 1.

Table 1: The totals and percentage of total included studies comparing the impact of the lower trapezius on shoulder and neck pain.

Lower trapezius muscle change significance level	Shoulder pain raw and percentage of total	Neck pain raw and percentage of total
Significant change	6/18 (33.3%)	6/18 (33.3%)
Nonsignificant change	6/18 (33.3%)	0/18 (0.0%)

The percentage of the total was calculated by dividing the studies that had a significant or nonsignificant lower trapezius muscle change and whether it impacted shoulder or neck pain by the total number of included studies.

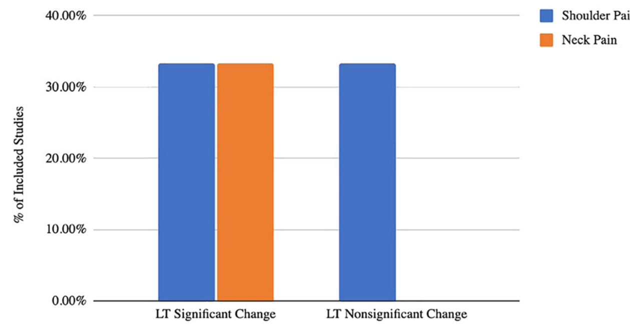

Figure 2: The impact of the lower trapezius on shoulder and neck pain in the included studies.

Of the 18 studies that were included, two-thirds of the studies (66.7%) indicated that the lower trapezius muscle had a significant impact on neck and shoulder pain [23–40]. Within the studies, there was an even split between the lower trapezius muscle having an impact on shoulder pain (6/12) [25, 26, 28, 29, 31, 34] vs neck pain (6/12) [23–27, 30, 32, 33]. Within the shoulder pain group, half the studies involved the lower trapezius having a significant impact (6/12) [25, 26, 28, 29, 31, 34] vs a nonsignificant impact (6/12) [35–40]. Interestingly, in the neck pain group, the lower trapezius muscle had a 100% impact [24, 27, 30, 32, 33]. These descriptions can be visualized in Table 1 and Figure 2.

Characteristics of included studies

The 18 articles investigating lateral trapezius function included 431 participants with pain and 405 healthy controls without pain [23–40]. The studies included one or more of the following lower trapezius measurement outcomes: electromyographic (EMG) activity level [25, 28, 32, 33, 35, 36, 39], EMG time to onset [24, 26, 31, 33, 34, 36, 39], EMG time of peak activation [24, 38], lower trapezius strength [23, 27, 29, 40], or muscle thickness [30, 37]. These details are further elaborated in Table 2.

Included studies by measurement outcome

The included studies per measurement outcome are summarized in the following sections and in Table 3.

Level of muscle activity (EMG)

Seven studies analyzed lower trapezius muscle activity with EMG [25, 28, 32, 33, 35, 36, 39]. All seven studies measured lower trapezius muscle activity dynamically, with mixed results. Three studies observed subjects with shoulder pain during functional tasks [25, 35, 36]. Specifically, Sabzehparvar et al. [35] studied 24 elite male swimmers, ages 15–21, with and without mechanical pain, and found maximal voluntary contraction (%MVC) values of 10.9% (±8.12%) and 9.3% (±4.95%), respectively (p=6.09). Meghdadi et al. [36] studied 60 elite male table tennis athletes, ages 23–27, with and without shoulder impingement syndrome (SIS), and reported muscle activity values of 37 (±5.0) and 39.2 (±6.3), respectively (p=0.301). Shih et al. [25] studied shoulder kinematics in 20 patients with frozen shoulder against 20 healthy controls, in the age range of 45–60, and found a 55.9% (p=0.001) decrease in lower trapezius muscle activity during the scaption task compared to controls.

Two studies analyzed the effects of neck pain on lower trapezius muscle activity [32, 33]. Zakharova-Luneva et al. [32] studied 18 neck pain patients against 20 healthy controls, ages 18–34, and reported significant increases in lower trapezius muscle activity during shoulder abduction and external rotation compared to controls (p<0.025, p<0.034, respectively). Helgadottir et al. [33] analyzed upper limb elevation in 22 patients with insidious onset neck pain (IONP) against 23 asymptomatic controls, ages 22–43. They found right lower trapezius muscle activity in IONP to be insignificantly greater than that of controls (0.84 [0.05]) and 0.82 [0.04], respectively, p values not reported) and left lower trapezius muscle activity in IONP to be insignificantly lower than that of controls (0.78 [0.05] and 0.80 [0.04], respectively, p values not reported) [33].

The remaining two analyzed muscle activity under load-bearing conditions [28, 39]. Michener et al. [28] observed a statistically significant decrease in lower trapezius muscle activity during active arm elevation with weights adjusted to participant BMI in 28 subjects

Table 2: Overview of included studies.

Study	Participants pain group	Participants control group	Type of pain	Duration of pain/ pain at baseline	Pain at baseline	Lower trapezius outcome
Park et al. [23]	n=26 Mean age, years (SD): 21.2 (0.9) Population: violinists (undergrads recruited from Jeongju-si, South Korea) gender: 100.0% F BMI: 18.2 (gave avg height and weight + SD)	n=26 Mean age, years (SD): 21.2 (0.9) Population: violinists (undergrads recruited from Jeongju-si, South Korea) gender: 100.0% F BMI: 18.2 (gave avg height and weight + SD)	Unilateral neck pain	7.4 (2.9) years	Yes	Muscle strength
Sabzehparvar et al. [35]	n=12 Mean age, years (SD): 18.55 (3.16) Population: professional elite male swimmers and members of the Iranian national team who trained at least 3 days/week covering 40 km Gender: 100.0% M BMI: 23.22 (0.98)	n=12 Mean age, years (SD): 18.11 (1.61) Population: professional elite male swimmers and members of the Iranian national team who trained at least 3 days/week covering 40 km Gender: 100.0% M BMI: 23.02(0.95)	Mechanical shoulder pain in dominant side	At least 3 months	Yes	Muscle activity
Meghdadi et al. [36]	n=30 Mean age, years (SD): 25 (2.29) Population: professionally active in Iran Premier League for table tennis and with right dominant hand Gender: 100.0% M BMI: n/a	n=30 Mean age, years (SD): 24 (2.59) Population: professionally active in Iran Premier League for table tennis and with right dominant hand Gender: 100.0% M BMI: n/a	Impingement on the dominant side of the upper extremity	12 (5.54) months	Yes	Muscle activity
Ghaderi et al. [24]	n=20 Mean age, years (SD): 30.93 (8.92) Population: patients referred to the physiotherapy clinic of the University of Social Welfare and Rehabilitation Sciences Gender: 100.0% M BMI: n/a	n=20 Mean age, years (SD): 31.21 (8.75) Population: patients referred to the physiotherapy clinic of the University of Social Welfare and Rehabilitation Sciences Gender: 100.0% M BMI: n/a	Chronic nonspecific neck pain	At least 12 months	Yes	Peak amplitude
Shih et al. [25]	n=20 Mean age, years (SD): 52.85 (5.95) Population: recruited from Taipei Gender: 40.0% M, 60.0% F BMI: 22.21 (3.43)	n=20 Mean age, years (SD): 53.15 (7.14) Population: recruited from Taipei Gender: 40.0% M, 60.0% F BMI: 23.32 (3.20)	Unilateral frozen shoulder	At least 3 months	Yes	Muscle activity
McKenna et al. [37]	n=26 Mean age, years (SD): 48.1 (13.9) Population: swimmers recruited through email lists of adult competitive swimming clubs in Perth Gender: 42.3% M, 57.7% F BMI: 24.8 (3.4)	n=26 Mean age, years (SD): 48.5 (13.9) Population: swimmers recruited through email lists of adult competitive swimming clubs in Perth Gender: 42.3% M, 57.7% F BMI: 23.3 (3.0)	Shoulder pain	n/a	Yes	Muscle thickness

Table 2: (continued)

Study	Participants pain group	Participants control group	Type of pain	Duration of pain/pain at baseline	Pain at baseline	Lower trapezius outcome
Leong et al. [26]	n=26 Mean age, years (SD): 23.6 (3.3) Population: volleyball players recruited from local sports clubs and universities Gender: 100.0% M BMI: 21.9 (2.1)	n=17 Mean age, years (SD): 21.7 (3.5) Population: volleyball players recruited from local sports clubs and universities Gender: 100.0% M BMI: 21.7 (1.9)	RC tendinopathy	21.9 (17.1) months	Yes	Activity onset
Petersen et al. [27]	n=22 Mean age, years (SD): 31.8 (12.9) Population: students from the same university through flyers posted in common areas Gender: 86.4% M, 13.6% F BMI: BMI	n=17 Mean age, years (SD): 32.3 (11.6) Population: students from the same university through flyers posted in common areas Gender: 58.5% M, 41.2% F BMI: n/a	Idiopathic neck pain	43.27 (62.71) months	Yes	Muscle strength
Michener et al. [28]	n=28 Mean age, years (SD): 38.4 (14.1) Population: recruited from local clinics where they were seeking treatment for shoulder pain Gender: 60.7% M, 39.3% F BMI:	n=28 Mean age, years (SD): 37.9 (14.3) Population: recruited from community Gender: 60.7% M, 39.3% F BMI: n/a	Unilateral subacromial pain syndrome	n/a	Yes	Muscle activity
Leong et al. [29]	n=33 Mean age, years (SD): 24 (4.1) Population: volleyball and baseball players recruited from local sports clubs and universities Gender: 57.6% M, 42.4% F BMI: 21.9 (2.4)	n=33 Mean age, years (SD): 20.7 (2.4) Population: volleyball and baseball players recruited from local sports clubs and universities Gender: 42.4% M, 57.6% F BMI: 21.4 (3.0)	Rotator cuff tendinopathy	28.7 (29.9) months	Yes	Muscle strength
Uthaikhup et al. [30]	n=20 Mean age, years (SD): 27.75 (5.47) Population: recruited through advertising in physiotherapy clinics, hospitals, and general community in a regional city in Thailand Gender: 100.0% F BMI: 21.23 (2.85)	n=20 Mean age, years (SD): 26.8 (5.51) Population: recruited through advertising in physiotherapy clinics, hospitals, and general community in a regional city in Thailand Gender: 100.0% F BMI: 20.62 (2.19)	Right side unilateral mechanical neck pain	At least 3 months	Yes	Muscle thickness
Larsen et al. [38]	n=15 Mean age, years (SD): 40 (13) Population: recruited from physiotherapy clinics and among acquaintances Gender: 46.7% M, 53.3% F BMI: 26 (3)	n=15 Mean age, years (SD): 39 (12) Population: recruited from physiotherapy clinics and among acquaintances Gender: 46.7% M, 53.3% F BMI: 24 (2)	Shoulder pain (SIS)	At least 30 days	Yes	Muscle activity

Table 2: (continued)

Study	Participants pain group	Participants control group	Type of pain	Duration of pain/ pain at baseline	Pain at baseline	Lower trapezius outcome
Larsen et al. [39]	n=16 Mean age, years (SD): 41 (14) Population: recruited from physiotherapy clinics and among acquaintances Gender: 50.0% M, 50.0% F BMI: 25 (3)	n=15 Mean age, years (SD): 39 (12) Population: recruited from physiotherapy clinics and among acquaintances Gender: 46.7% M, 53.3% F BMI: 24 (2)	Shoulder pain (SIS)	At least 30 days	Yes	Activity level, time to onset
Phadke et al. [31]	n=24 Mean age, years (SD): 35.09 (12.5) Population: university of Minnesota area Gender: 58.3% M, 41.7% F BMI: 23.34 (2)	n=25 Mean age, years (SD): 32.2 (9.8) Population: University of Minnesota area Gender: 48.0% M, 52.0% F BMI: 23.16 (2.6)	Shoulder pain (SIS)	Longer than 6 weeks	Yes	Time to onset
Zakharova-Luneva et al. [32]	n=18 Mean age, years (SD): 27.4 (7) Population: recruited on a voluntary basis Gender: 33.3% M, 66.7% F BMI: 22.5	n=20 Mean age, years (SD): 24.9 (6.7) Population: recruited on a voluntary basis Gender: 35% M, 65.0% F BMI: 23.4	Neck pain	Longer than 3 months	Yes	Activity level
Helgadottir et al. [33]	n=22 Mean age, years (SD): 35 (8) Population: recruited from physical therapy clinics in the Reykjavik municipal area Gender: 0.09% M, 90.9% F BMI: n/a	n=23 Mean age, years (SD): 30 (8) Population: recruited from physical therapy clinics in the Reykjavik municipal area Gender: 21.7% M, 78.3% F BMI: n/a	Neck pain	Longer than 6 months	Yes	Activity level
Trakis et al. [40]	n=12 Mean age, years (SD): 15.7 (1.4) Population: adolescent baseball pitchers Gender: 100.0% M BMI: 23.1	n=11 Mean age, years (SD): 15.7 (1.4) Population: adolescent baseball pitchers Gender: 100.0% M BMI: 23.1	Shoulder and elbow pain	Throughout the baseball season (3–4 months)	Yes	Muscle strength
Cools et al. [34]	n=39 Mean age, years (SD): 25.9 (5.9) Population: The patient group consisted of 39 athletes competing in various overhand sports Gender: 66.7% M, 33.3% F BMI: n/a	n=30 Mean age, years (SD): 22.5 (4.3) Population: Thirty healthy overhand athletes with no history of shoulder injuries Gender: 63.3% M, 36.7% F BMI: n/a	Shoulder pain (SIS)	12.4 months (11.3)	Yes	Time to onset

BMI, body mass index; SIS, shoulder impingement syndrome.

(ages 24–52) with subacromial pain syndrome when relative to upper trapezius and serratus anterior (SA) muscle activities. Specifically, they compared these subjects to 28 controls (ages 24–52) and found a higher upper trapezius/lower trapezius ratio in the pain group during ascending (mean difference=0.92, p=0.008) and descending (mean difference=0.70, p=0.03) movements and a lower trapezius/serratus anterior ratio in the pain group during ascending (mean difference=−0.25, p=0.026) and descending (mean difference=−0.51, p=0.032)

Table 3: Included studies per outcome measurement.

Study	Measurement equipment	Method	Activity level	Fatigability	Time to onset	Time of peak	Major conclusions
Park et al. [23]	Handheld dynamometer (HHD)	Subjects performed diagonal, overhead shoulder external rotation and abduction.	Strength: pain/Ipsilateral=26.9 n (±13.10 n) nPain/contralateral=29.8 n (±15.8 n), p=0.02	n/a	n/a	n/a	LT strength significantly decreased on the painful side compared to the contralateral side.
Sabzehparvar et al. [35]	Surface EMG – ME6000 Biomonitor EMG System	Subjects marked points with pen within each of the three 70 mm circles (which formed corners of an equilateral triangle of 23 cm) counterclockwise and in coordination with metronome set at 88 beats/min	RMS: pain=10.92% (±8.12%) nPain=9.26% (±4.95%), p>0.05 normalization: 5 s MVC while subjects in side-lying position with the arm kept on the head and in the direction of LT fibers	n/a	n/a	n/a	No difference in activation of LT in shoulder pain group vs. control
Meghdadi et al. [36]	EMG – Muscle Tester ME6000	LT muscle activity was measured while performing the table tennis forehand topspin loop diagonally on the table utilizing an EMG-synchronized table tennis racket.	Muscular activity: pain=37 (±5.0) nPain=39.2 (±6.3), p>0.05 normalization: root mean square analysis in the subsequent 25 ms segments of the movement cycle	n/a	Pain=−386.93 ms (±31.02 ms) nPain=−384.12 ms (±31.09 ms), p>0.05 normalization: respect to the time of ball contact.	n/a	No significant differences in activity of LT in subjects with SIS
Ghaderi et al. [24]	EMG – MT8 telemetric system CAS dynamometer	Participants elevated shoulders in the scapular plane in an “empty can position” with 90° shoulder elevation, while elbows were in full extension and forearms in pronation and pulled fixed dynamometer handle upward isometrically for 10s.x	%MVE: pain=0.67 (±0.15) nPain=0.71 (±0.17), p>0.05	n/a	Pain=0.21 ms (±0.21 ms) nPain=0.14 ms (±0.15 ms), p=0.18	Pain=1.91 ms (±0.55 ms) nPain=1.89 ms (±0.64 ms), p=0.97	All changes were statistically insignificant
Shih et al. [25]	8-channel FM/FM Telemetric EMG System: TeleMyo 2400, Noraxane USA	Three functional tasks in the sitting position with the trunk well stabilized. Each task was performed at subjects’ comfortable speed three times with 30 s rest	Muscle activity: scaption task: pain=100.22% (±29.06%) nPain=156.11% (±63.61%), p<0.05 hand to neck task: pain=102.09% (±32.93%) nPain=129.5% (±48.75%), p>0.05 thumb to waist task: pain=20.75% (±18.49%) nPain=25.62% (±22.07%), p>0.05	n/a	n/a	n/a	Pain group revealed significantly less LT activity during scaption task, and insignificantly less activity during the hand-to-neck and thumb-to-waist tasks

Table 3: (continued)

Study	Measurement equipment	Method	Activity level	Fatigability	Time to onset	Time of peak	Major conclusions
McKenna et al. [37]	Toshiba Xario XG US Machine	Ultrasound imaging	Muscle thickness: pain=8.8 mm (±2.0 mm) nPain=9.3 mm (±2.3 mm), p>0.05	n/a	n/a	n/a	No significant changes in muscle thickness
Leong et al. [26]	Vicon v-370 3-D motion analysis system. EMG with circular Ag/AGcl bipolar electrodes	Participants performed shoulder abductions, in time with metronome, from resting position to maximum achievable range and then back to rest, with elbow flexed at 90° and forearm in pronation.	n/a	n/a	Pain=−18.5 ms (±43.9 ms) nPain=−72.4–ms (±39 ms), p=0.001 normalization: onset of muscle activity minus the arm movement onset	n/a	RC group had a significant delayed activity onset to LT relative to UT when compared to healthy
Peterson et al. [27]	microFET2 digital handheld dynamometer	Participants maintained arm position while the examiner provided pressure with HHD in downward direction until participants' maximal effort was overcome.	Muscle Strength: within group strength: pain side=18.9 n (±6.5 n) nPain side=21.5 n (±9.4 n), p<0.01 right side (control)=24.4 n (±8.5 n) left side (control)=23.9 n (±8.8 n), p>0.05 between-group strength: pain=18.9 n (±6.5 n) nPain=24.4 n (±8.5 n), p=0.02	n/a	n/a	n/a	Muscle weakness in the LT is present in individuals with neck pain. LT is weaker on the side of neck pain compared to the contralateral side
Michener et al. [28]	EMG	5 repetitions of a weighted arm elevation task	Relative activity ratio: UT/LT: ascending phase: 30°–60° pain=2.54 (±1.98) nPain=1.37 (±0.58) 60°–90° pain=2.29 (±1.30) nPain=1.45 (±0.60) 90°–120° pain=2.25 (±1.37) nPain=1.49 (±0.71) mean difference=0.92, p=.008	n/a	n/a	n/a	There is disruption in coordination by the LT and SA, LT and UT during arm elevation in patients in pain.

Table 3: (continued)

Study	Measurement equipment	Method	Activity level	Fatigability	Time to onset	Time of peak	Major conclusions
			descending phase: 120°–90° pain=1.77 (±1.02) nPain=1.18 (±0.71) 90°–60° pain=1.94 (±1.07) nPain=1.14 (±0.69) 60°–30° pain=1.83 (±1.20) nPain=1.14 (±0.93) mean difference=0.70, p=0.03 LT/SA: ascending phase: 30°–60° pain=0.69 (±0.51) nPain=0.93 (±0.73) 60°–90° pain=0.53 (±0.29) pain=0.79 (±0.35) 90°–120° pain=0.59 (±0.33) nPain=0.80 (±0.36) mean difference=−0.25, p=0.026 descending phase: 120°–90° pain=0.95 (±0.72) nPain=1.60 (±0.74) 90°–60° pain=1.01 (±0.78) nPain=1.46 (±1.31) 60°–30° pain=1.45 (±1.44) nPain=1.90 (±2.18) mean difference=−0.51, p=0.032				
Leong et al. [29]	microFET2 Digital handheld dynamometer, Aixplorer US scanning system	Participants underwent manual muscle testing, SAS measured with the arm at 0°, and after static holding at 30° and 60° of abduction	Normalized muscle strength (N/kg): athletes with RC tendinopathy had weaker LT by 24.3% compared to controls, p<0.05	n/a	n/a	n/a	Athletes with RC tendinopathy have weaker LT muscles
Uthaikhup et al. [30]	Toshiba Famio 8 with 12 MHz linear transducer	Imaging obtained at rest with the arms relaxed at the sides, at rest with the arm positioned 120° abduction, and during static contraction with the arm positioned in 120° of abduction	Muscle Thickness: at rest 0° abduction: pain=2.39 mm (±0.68 mm) nPain=3.04 mm (±0.66 mm), p<0.01 at rest 120° abduction: pain=2.83 mm (±0.96 mm) nPain=3.47 mm (±0.78 mm), p<0.05	n/a	n/a	n/a	Neck pain group had smaller LT thickness than controls at rest and contraction but insignificant thickness difference during 120° shoulder abduction

Table 3: (continued)

Study	Measurement equipment	Method	Activity level	Fatigability	Time to onset	Time of peak	Major conclusions
			contraction 120° abduction: pain=3.81 mm (±1.96 mm) nPain=5.27 mm (1.63 mm), $p<0.05$				
Larsen et al. [38]	EMG	Participants performed isometric arm elevation and arm abduction in which peak RMS value was recorded during MVE.	Activation ratio with biofeedback mean (SEM) SIS group: 95.6 (1.5), control: 96.4 (.7)	n/a	n/a	n/a	There were no significant differences
Larsen et al. [39]	EMG	Participants performed three attempts of isometric LT MVIC bilaterally with resistance (no-load, 1 kg, 3 kg).	Mean muscle activity: lower trap $p=0.11$	n/a	Onset difference UT-LWT: $p=0.98$ LWT-SA: $p=.53$	n/a	No significant difference between the groups of muscles were found, in both loadbearing and non-loadbearing conditions
Phadke et al. [31]	EMG	Participants raised and lowered their arms in which data was collected during unloaded, loaded, and after repetitive arm raising motion conditions. Kinematic data and myoelectric activities were collected.	n/a	n/a	Lower trapezius latency: unloaded = latency higher in healthy patients compared to impingement; loaded = latency higher in impingement patients compared to controls; after repetitive motions = latency higher in impingement patients compared to controls	n/a	Higher absolute latency in lower trap
Zakharova-Luneva et al. [32]	EMG	Participants performed isometric shoulder abduction, external rotation, and flexion at 3 intensities of effort (maximum voluntary contraction [MVC], 50% MVC, and 20% MVC).	RMS MVC significantly greater levels of lower trapezius electromyographic: abduction ($p < 0.027$) and external rotation ($p < 0.036$) flexion condition ($p > 0.0392$)	n/a	n/a	n/a	RMS MVC had significantly greater levels of lower trapezius and should be considered in patients with neck pain.
Helgadottir et al. [33]	EMG four sensors from Kine, Hafnardfjordur, Iceland	Surface EMG was utilized to measure onset of muscle activation and duration of muscle activity during unilateral arm elevation. Both arms were tested.	Right LT control: 0.82 (0.04) IONP: 0.84 (0.05) Left LT control: 0.80 (0.04) IONP: 0.78 (0.05)	n/a	Right LT Control: 0.34 s (0.07) IONP: 0.43 s (0.10) Left LT Control: 0.36 s (0.05) IONP: 0.48 s (0.08)	n/a	Pain in the upper trapezius changes the motor control in the upper and lower trapezius not only on the painful side but also on the contralateral side.

Table 3: (continued)

Study	Measurement equipment	Method	Activity level	Fatigability	Time to onset	Time of peak	Major conclusions
Trakis et al. [40]	handheld dynamometer	Strength testing was performed utilizing a handheld dynamometer in the order of: lower trapezius, middle trapezius, rhomboids, latissimus dorsi, supraspinatus, internal rotators, and external rotators	Strength imbalance in lower trapezius: pain: 9% ± 17%, nPain: 11% ± 16%, p=0.74	n/a	n/a	n/a	No significant difference between athletes with and without prior shoulder pain for the other strength tests.
Cools et al. [34]	Noraxon Myosystem 2000 EMG receiver	Overhead athletes with and without shoulder impingement muscle latency times in all three parts of the trapezius and middle deltoid were evaluated during sudden downward falling movement of the arm.	Threshold for muscle activity was set at 10% of the EMG activity of maximal voluntary contraction	n/a	SIS: injured side=177.3 ms (30.5); non-injured side=174.3 (38.9); control: nondominant side=160.2 (27.6); dominant side=142.8 (33.1)	n/a	There were significant differences in the relative muscle latency times between the impingement and the control group subjects. Those with impingement showed a delay in muscle activation of the middle and lower trapezius muscle. Significantly longer muscle latency times in the patient group for the middle and lower trapezius muscle on the injured side compared with the dominant side of the control group

EMG, electromyographic; HHD, handheld dynamometer; LT, lower trapezius; MVC, maximum voluntary contraction; RC, rotator cuff; RMS, root mean square; SA, serratus anterior; SIS, shoulder impingement syndrome; UT, upper trapezius.

movements [28]. Larsen et al. [39] observed a nonsignificant higher level of lower trapezius muscle activity (p=0.11, raw data not reported) during weighted shoulder elevation in 16 subjects (ages 27–55) with subacromial impingement syndrome against 15 healthy controls (ages 27–51).

Muscle activation (EMG)

Two studies analyzed lower trapezius muscle activation [24, 38]. Ghaderi et al. [24] studied 40 individuals with and without shoulder pain (ages 22–39) to observe differences in time to reach peak activation between the two groups, but their conclusions were statistically insignificant (1.91 ms [0.55] and 1.89 ms [0.64], respectively, p=0.97]. Larsen et al. [38] analyzed the ability to selectively activate the lower trapezius muscle through EMG and observed that fewer subjects with SIS were able to successfully selectively activate the lower compartments of the trapezius as defined by activation ratios equal to or greater than 95.0% when compared to their healthy controls. Specifically, out of 15 patients with SIS (ages 27–53), three were able to reach selective activation (p=0.03) compared to the 9 out of 15 controls (ages 27–51) who attained selective activation [38].

Time to onset (EMG)

Seven studies reviewed the amount of time it took for the lower trapezius to activate [24, 26, 31, 33, 34, 36, 39]. Cools et al. [34] and Phadke and Ludewig [31] both studied subjects with SIS, evaluating trapezius muscle latency. Cools et al. [34] compared 39 subjects with SIS (ages 20–32) against 30 healthy controls (ages 18–26) and found that the lower trapezius on the injured side of individuals with SIS had a longer mean muscle latency time of 174.3 ms (38.9), which is 31.5 ms longer (p<0.01) than the mean muscle latency time of the dominant side of the controls, which was reported to be 142.8 ms (33.1). On the contrary, Phadke and Ludewig [31] studied 24 patients with SIS (ages 23–47) against 25 healthy controls (ages 22–42) to determine the lower trapezius latency relative to the serratus anterior and upper trapezius during unloaded, loaded, and after repetitive motion conditions. They found that, relative to the serratus anterior, the lower trapezius in healthy controls had a higher latency than that in patients with impingement under unloaded conditions, but they found the opposite result under loaded and after repetitive motion conditions (results were graphically reported, raw data unavailable) [31].

Leong et al. [26] studied 43 male volleyball players with and without rotator cuff tendinopathy (RCT) (ages 18–27) and found that the lower trapezius of the RCT group is activated slower than that of the control group (−18.5 ms [43.9] vs. −72.4 ms [39.0], respectively; p=0.001). Helgadottir et al. [33] studied the time to onset of lower trapezius muscle activation on both sides, and concluded that there is an insignificant increased delay to onset in the 22 IONP patients compared to the 23 healthy controls (right side: 0.43 s [0.10] IONP vs. 0.34 s [0.07], respectively; left side: 0.48 s [0.08] vs. 0.36 s [0.05], respectively). Similarly, in the 20 patients with neck pain in the study by Ghaderi et al. [24], they found an insignificant delay in lower trapezius muscle onset time (0.21 ms [0.21] vs. 0.14 ms [0.15]) compared to the 20 controls (p=0.18). On the contrary, Meghdadi et al. [36] observed an insignificant reduction in time to onset in the 30 subjects with pain compared to their 30 healthy controls (−386.93 ms [31.02] and −384.12 ms [31.09], respectively; p=0.807). Finally, Larsen et al. [39] studied lower trapezius muscle onset time in 16 cases of SIS against 15 control cases under nonloading and load-bearing conditions, and they observed an insignificant difference in time to onset in subjects with pain in these muscle pairs: upper trapezius/lower trapezius (p=0.98) and lower trapezius/serratus anterior (p=0.53).

Muscle strength

Four studies utilized handheld dynamometers to consider strength in the lower trapezius [23, 27, 29, 40]. Three of these studies were in agreement and observed a significant decrease in lower trapezius muscle strength in subjects with pain compared to their healthy controls. Specifically, of these three studies, Park et al. [23] and Petersen et al. [27] both measured muscle strength in subjects with unilateral neck pain and found significantly reduced muscle strength in the lower trapezius ipsilateral compared to that contralateral to the pain. Park et al. [23] observed 26 female violinists (ages 20–22) with unilateral neck pain, studying their contralateral, nonpain side as controls, and found lower trapezius strength on the side with pain to be 26.9 N (13.10), whereas strength on the contralateral side was 29.8 N (15.8), p=0.02. Similarly, Peterson et al. [27] observed 22 subjects with idiopathic neck pain (ages 19–45) with 17 healthy controls (ages 20–44), first analyzing the strength of the lower trapezius muscles ipsilateral and contralateral to the site of neck pain in the pain group and the strength of the right and left lower trapezius in the controls, and then comparing within groups and between groups. They found that in the pain group, the ipsilateral lower trapezius had a measured strength of 18.9 N (6.5), whereas the contralateral lower trapezius had a measured strength of 21.5 N (9.4) (p<0.01) [27]. Additionally, the pain side adjacent in the control group—the right side—had a measured muscle strength of 24.4 N (8.5), which is significantly greater than the ipsilateral lower trapezius in the pain group (p=0.02) [27]. Leong et al. [29] analyzed 66 athletes with and without RCT (ages 18–28) and also observed a decrease in lower trapezius strength by 24.3% in those with RCT compared to healthy controls (p<0.05). The remaining study by Trakis et al. [40] observed no significant changes in lower trapezius muscle strength in 12 male baseball pitchers, ages 15–17, with shoulder and elbow pain compared to the 11 healthy male controls, ages 15–17 (strength imbalance of 9% [17] and 11% [16], respectively; p=0.74).

Muscle thickness

Two studies analyzed lower trapezius muscle thickness through ultrasound imaging [30, 37]. McKenna et al. [37] measured lower trapezius thickness at rest and submaximal contraction between 52 swimmers (ages 34–62) with and without shoulder pain. At rest, the lower trapezius of those with pain had a thickness of 5.1 mm (4.5–6.7), while the lower trapezius of the controls had a thickness of 4.6 mm (4.4–6.2), although this difference was insignificant (p=0.59) [37]. During contraction, they found the lower trapezius of those with pain to have a thickness of 8.8 mm (2.0), while the lower trapezius of the controls had a thickness of 9.3 mm (2.3), although this difference was insignificant (p=0.36) as well [37]. Similarly, Uthaikhup et al. [30] measured lower trapezius muscle thickness at rest at 0° abduction and at rest at 120° abduction in 40 female subjects with and without right-side neck pain (ages 21–32), but instead found a significant decrease in muscle thickness in neck pain subjects compared to controls at 0° rest (2.39 mm [0.68] and 3.04 mm [0.66], respectively [p<0.01]) and 120° rest (2.83 mm [0.96], 3.47 mm [0.78], respectively [p<0.05]), as well as a significant decrease in lower trapezius thickness from rest to contraction in pain subjects compared to healthy controls (3.81 mm [1.96], 5.27 mm [1.63], respectively [p<0.05]).

Discussion

This systematic review included 18 studies investigating lower trapezius muscle function in people with and without shoulder or neck pain. The findings for lower trapezius muscle activity [25, 28, 32, 33, 35, 36, 39], time to onset [24, 26, 31, 34, 36, 39], time to peak activation [24, 38], muscle strength [23, 27, 29, 40] and thickness [30, 37] were mixed. Of the seven studies that focused on muscle activity, two observed a significant decrease in muscle activity in subjects with pain [25, 28], whereas another two observed a significant increase in muscle activity in subjects with pain [32, 33]. The remaining three studies observed nonsignificant changes in lower trapezius activity [35, 36, 39]. Two of these three studies [32, 39] observed an insignificant increase in muscle activity in subjects with pain, although the remaining study [33] observed an insignificant decrease in muscle activity in subjects with pain. Seven studies [24, 26, 31, 34, 36, 39] analyzed the changes in time to onset of the lower trapezius, of which four observed a significant increase in onset delay in subjects with pain compared to healthy controls [26, 31, 33, 34]. The remaining three [24, 36, 39] had insignificant conclusions: one observed an insignificant shorter time to onset in subjects with pain [36], whereas the other two observed an insignificant longer time to onset in subjects with pain [24, 39]. Four studies considered changes in lower trapezius strength [23, 27, 29, 40]. Three of these studies demonstrated that subjects with pain had a significant decrease in the lower trapezius muscle compared to healthy controls [23, 27, 29], while the remaining study also showed a decrease in the lower trapezius muscle, although results were insignificant [40]. Only two studies considered the effects of pain on lower trapezius muscle thickness [30, 37]. One saw a significant decrease in muscle thickness in subjects with pain [30], whereas the other study observed an insignificant increase in muscle thickness in subjects with pain [37]. Due to differences in measurement techniques, combining studies in a meta-analysis was not possible. Finally, two out of the total 18 studies considered muscle activation. Ghaderi et al. [24] found insignificant differences in time to reach peak activation, and Larsen et al. [38] analyzed an individual's ability to selectively activate the lower trapezius, in individuals with and without pain.

The majority of the studies (11 out of 18) utilizing EMG to assess lower trapezius muscle function did so during dynamic movement [24, 26, 28, 31–36, 38, 39]. Overall, the number of EMG variables were inconsistent across multiple studies and were limited within individual studies and variables. Examining whether dynamic function in the lower trapezius muscle has an impact on those with and without shoulder or neck pain, and whether it is predictive of this pain development, is needed to assist in understanding this muscle's role in developing shoulder or neck pain. Considering other EMG outcome variables, such as minimum to maximum amplitude, minimum level of activity, and mean amplitude, can provide more insight into this muscle's nature.

The majority of the included studies report a reduction in lower trapezius muscle strength. This is consistent with previously reported theoretical links between the upper extremities and cervicothoracic-shoulder complex, and the development of shoulder and neck pain [4]. During normal movement, the lower trapezius is responsible for scapular stabilization and specifically in the sagittal plane during shoulder elevation [4]. It is theorized that weakness of the lower trapezius muscle results in changes in biomechanical function that create instability and position changes of the cervicothoracic region and may lead to shoulder and neck pain [4]. The major function of the lower trapezius can be explained by its anatomy. The lower trapezius originates on the spine and extends from T2 to T12 and inserts onto the spine of the scapula from the acromion process [8]. The lower trapezius itself is a multipennate muscle innervated by the spinal accessory nerve and ventral rami of C3 and C4 via the cervical plexus [4, 8]. The scapula contributes to the majority of upper limb kinetic chain movements and requires mobility to achieve positions through movement of the humerus but also necessitates stability during overhead activities, such as the overhead sports some of the studies touched upon like throwing, tennis, and swimming [9]. The study on the biomechanics of the lower trapezius in the setting of shoulder disability revealed that the lower trapezius yields significant abduction and external rotation [8, 9]. These movements are made possible by the lower trapezius stabilizing the scapula. Upward rotations, posterior tilt, and external rotation of the scapula are made possible by the lower trapezius, middle trapezius, and serratus anterior [4, 8, 9]. In addition, the lower trapezius retracts and depresses the scapula during horizontal pulling movements [8]. The relationship of the lower trapezius and subsequent shoulder pain relies on the function of the lower trapezius. When the lower trapezius is unable to function properly, the scapula cannot maintain the stability necessary to achieve full rotator cuff function. This scapular dyskinesis leads to worsened shoulder pain, impingement, and dysfunction. Due to the lower trapezius insertion and function, dysfunctions within the lower trapezius can cause SIS, which is when the acromion impinges or entraps the rotator cuff [41]. The pathological mechanism is structural narrowing in the subacromial space, which can be influenced by dysfunction or weakness of the lower trapezius.

The types and duration of shoulder and neck pain were also examined. This was, however, limited by variable definitions of shoulder and neck pain. There was a general lack of detail of the type and duration of pain in the included studies. Additional differences between studies, such as the specific method for diagnosing pain, assessment methods and techniques, the tools utilized to assess the severity of pain, and whether pain patients had pain present at the time of beginning the study, are additional areas that future studies should target to create consistency and standardization so that pooled statistical analyses may be conducted. The purpose of this review was not to complete a comprehensive statistical analysis. Rather, the goal was to preliminarily observe quantifiable patterns in lower trapezius status in those with neck and shoulder pain for the organizational purpose of a meta-analysis in future works.

Limitations

This systematic review was created to be comprehensive and thorough. However, it may be possible that not all appropriate studies were included. The chances of this happening were reduced by an all-encompassing search methodology, individual abstract and title screening by two researchers (NH/CL), and strict adherence to PRISMA guidelines. Further, limitations such as only a small number of studies per measurement outcome, unclear definitions of the duration and type of shoulder and neck pain, and variation in study methodology have precluded more advanced methods of analysis. This variation may play a part in explaining some insignificance between controls and comparators within studies. They could have additionally diluted this systematic review's results, which may explain why some of these findings are unclear for some measurable outcomes. As in many studies, differences in reliability of measures may also affect outcomes of the included studies, especially if they may be based on how well versed a practitioner is at utilizing equipment that relies on it. Further, only 11 of the included studies reported measurement reliability, with an increased variability among studies for the indicated measurement outcomes [24–31, 35, 37, 40]. If reliability is poor, this can influence the findings and cause more insignificance in which the differences between the comparator and control groups are relatively small. As such, this may have an impact on the results of the included studies in this systematic review. A thorough investigation should be conducted on the existing reliability in this field. The significance and results of this finding should be taken with caution given the existing limitations of this review and the individual studies. However, it provides a comprehensive summary of the literature that can be of use to clinical practitioners and researchers.

Conclusions

To summarize, we found that among those with shoulder and/or neck pain, the lower trapezius muscle had a significant decrease in muscle strength. Findings of lower trapezius muscle activity, time to onset, time to peak activation, and fatigability were mixed and thus inconclusive. If utilizing these data as a factor in the clinical management of patients with shoulder and/or neck pain, healthcare practitioners should exercise caution because this review was not targeted toward seeing the effect of interventions. Nonetheless, focusing on strengthening the lower trapezius muscle is a vital component of the multifactorial clinical treatment plan of these pain patients; however, further investigation is required before this is universally recommended. Further, future investigation should focus on prospectively assessing lower trapezius muscle function with dynamic and static assignments within a broad set of outcomes, and in those with and without shoulder and neck pain. Therefore, future studies have the potential to monumentally change the treatment of chronic neck and shoulder pain from an exercise treatment perspective by going from primarily focusing on the rotator cuff muscles to additionally focusing on the lower trapezius muscle.

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