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Use of Feedback Mechanisms Versus Exercise Alone for Treatment of Patients With Scapular Dyskinesis

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USE OF FEEDBACK MECHANISMS VERSUS EXERCISE ALONE FOR TREATMENT OF PATIENTS WITH SCAPULAR DYSKINESIS

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Abstract

Background: Scapular dyskinesis is more prevalent in overhead athletes and can also lead to eventual shoulder injuries or shoulder dysfunction. Therefore, a rehabilitation program to manage or treat scapular dyskinesis is important. The effectiveness of feedback modalities used in combination with exercise may be more beneficial in treating and or managing scapular dyskinesis versus just exercise alone.

Purpose: In overhead athletes with scapular dyskinesis, does the use of an exercise program with biofeedback (taping, visual, verbal, surface EMG, video, tactile cueing, and conscious control) reduce the risk of shoulder injury versus exercise alone?

Results: Seventeen peer-reviewed articles were examined utilizing the John Hopkins Appraisal Tool and a matrix format. All 17 articles found positive changes in the range of motion, scapular function, and scapular muscle strength or activation when using a feedback mechanism in conjunction with an exercise program.

Conclusion: The implementation of feedback mechanisms combined with exercise is a more effective treatment compared to just exercise alone. Feedback tools give way to improved visualization of scapular movement and targeted muscle activity. The type of feedback used depends on the patient's specific scapular dyskinesis deficiencies and individual needs.

Implications for Research and Practice: These findings suggest that feedback is a beneficial addition to a rehabilitation program for overhead athletes with scapular dyskinesis. Such a program will aid in preventing further shoulder injuries and maintaining proper shoulder function along with strength. These results were also supported in populations with shoulder impingement syndrome and forward shoulder posture.

Keywords: scapular dyskinesis, feedback, rehabilitation

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Chapter I: Introduction

Proper scapulothoracic motion is essential for athletes to perform adequately and reduce shoulder pain or injury risk. Scapular dyskinesis consists of alterations in dynamic scapular control and abnormal positioning of the scapula (Starkey & Brown, 2015). It may be influenced by several factors, including fatigue, neurological dysfunction, subacromial impingement, rotator cuff pathology, labral injury, glenohumeral instability, adhesive capsulitis, posture, tight upper body musculature, and scapular stabilizer muscle imbalances or weakness (Hickey et al., 2018; Burn et al., 2016). Specific postures associated with scapular dyskinesis include thoracic kyphosis, cervical lordosis, and scoliosis (Starkey & Brown, 2015). Tight musculature associated with scapular dyskinesis includes tightness of the pectoralis minor, the short head of the biceps, posterior rotator cuff, and capsular tightness (Giuseppe et al., 2020). Weak muscles linked with scapular dyskinesis include the lower and middle trapezius, serratus anterior, or rotator cuff musculature (Hickey et al., 2018; Giuseppe et al., 2020). The purpose of the scapula is to provide a mobile and stable base for the humerus, to position the glenoid fossa and acromial arch during the humeral motion to avoid impingement and to transfer kinetic energy between the upper extremity and trunk (Starkey & Brown, 2015). Optimal scapular movement and position depend on scapular stabilizers' normal function; these include the serratus anterior, upper/middle/lower trapezius, levator scapulae, and rhomboids. The scapula's mobility and stability depend on the muscle activation of the serratus anterior and upper/lower trapezius muscles. Research has shown that these muscles' reduced strength is common among individuals with scapular dyskinesis (Starkey & Brown, 2015).

Healthcare professionals can observe and rate the severity of scapular dyskinesis in various ways. Evaluating the strength of the scapular stabilizer muscles with the scapular retraction test would be one example to determine supraspinatus strength or the scapular assistance test to look for reduced symptoms of pain (Starkey & Brown, 2015, p. 649). The shoulder abduction active range of motion is most commonly performed where patients hold small weights in each hand according to their body weight (Physiotutors, 2018). If the patient has a higher body weight, they will hold slightly heavier weights and vice versa. During this active range of motion movement, the clinician will look for any dysfunctional movements or positioning of both scapulas while the patients slowly elevate and lower their arms repeatedly (Physiotutors, 2018).

The treatment of scapular dyskinesis depends on the severity of dysfunction. Typically, scapular dyskinesis is treated with a conservative program of strengthening the scapular stabilizers, evaluating any muscle imbalances within them, stretching tight muscles, and developing a conscious awareness of proper scapular position and motion (Starkey & Brown, 2015).

Those with scapular dyskinesis often show a high level of activity of the upper trapezius (UT) and reduced activity of the middle (MT) and lower trapezius (LT) muscles; this muscle imbalance ratio is related to decreased amounts of upward scapular rotation, external rotation (ER), and posterior tilt (Mey et al., 2013). Therefore, exercises that strengthen MT, LT, and serratus anterior (SA) help promote upward rotation, ER, and posterior tilt, which will aid in normal scapular movement. An essential component in correcting scapular orientation is the scapula's conscious control by addressing neuromuscular coordination and strength deficits (Mey et al., 2013). Weakness of the SA is associated with shoulder muscle imbalances and induces scapular dysfunction and impingement (Kim et al., 2018). The SA is responsible for shoulder protraction and the pectoralis major (PM) acts as a synergist during this movement. If the PM compensates for the SA's weakness during shoulder protraction, it contributes to abnormal scapular motion, resulting in impingement. A previous study by Kim et al. (2018) has revealed that the strength of the SA during isometric protraction is lower in individuals with scapular dyskinesis versus without scapular dyskinesis.

Biofeedback is a therapy technique where individuals learn to consciously control their body functions (*Biofeedback*, 2019). There are various types of biofeedback including: surface electromyography (EMG), taping feedback techniques, and visual or verbal feedback. More specifically, Kinesiotaping (KT) feedback is the idea where the tape improves motor patterns by recruiting mechanoreceptors, improves blood flow, and decreases pain with the gate control theory. Taping is also used to mechanically restrict unwanted motion while also facilitating desired motion or muscle activation (Tooth et al., 2019). Surface EMG allows individuals to selectively activate specific muscles and correct any deficits in muscular activation or imbalance. This is done with the help of an application or a program in combination with the surface EMG where the clinician can verbally cue or the patient can visually see their muscle activating (San Juan et al., 2016; Kim et al., 2019). Visual or verbal feedback can also be considered conscious control techniques; when verbal cueing is used, the patient consciously thinks about the clinician's directions and focuses on correcting these suggestions. The clinician uses conscious control to help the individual correct abnormal movements and permit repetitive training. The clinician will observe the abnormal patterns, place them in front of a mirror or use a camera to see the movements they are performing using visual feedback. Research has shown that conscious control of scapular kinematics can improve proprioception and muscle imbalances and normalize scapular kinematics (Huang et al., 2018). A study reported that visual feedback increased the strength of the SA during a shoulder flexion exercise which reveals that visual and verbal feedback may improve the effectiveness of scapular stabilizing exercises (Kim et al., 2017). Observing scapular kinematics during exercise is difficult for the individual performing the exercises; therefore, learning to control scapular kinematics may be more effective with verbal, visual, and kinesthetic stimuli (Moslehi et al., 2020).

Statement of Purpose

The question to be presented in this critical review of literature is the following: In overhead athletes with scapular dyskinesis, does the use of an exercise program with biofeedback (taping, visual, verbal, surface EMG, video, tactile cueing, or conscious control) reduce the risk of shoulder injury versus exercise alone? The purpose of this study is to determine if the use of feedback mechanisms versus exercise alone is an effective treatment for scapular dyskinesis.

Need for the Critical Review

The increased stress on the glenohumeral and scapula-thoracic joints puts overhead athletes at a greater risk for shoulder injuries. Burn et al. (2016) completed a systematic review and reported overhead athletes have a higher prevalence of developing scapular dyskinesis than non-overhead athletes; this was present in 61% of overhead athletes. As athletic trainers, it is common knowledge that overhead athletes need effective shoulder mobility and stability to meet their specific muscular demands during repetitive overhead activities. According to research, scapular dyskinesis can be associated with chronic shoulder pain in overhead athletes (Struyf et al., 2013; Hickey et al., 2018; Giuseppe et al., 2020). In addition, scapular orientation and movement can influence the function of the glenohumeral joint and the rotator cuff muscles; therefore, it is important to focus on these structures for overhead athletes (Burn et al., 2016).

Significance to Athletic Training

The scope of practice of athletic trainers includes “prevention, examination and diagnosis, treatment, and rehabilitation of emergent, acute, subacute, and chronic neuromusculoskeletal conditions” (Hortz, n.d. p. 2). If an athlete has scapular dyskinesis, the athletic trainer should have the knowledge and tools to implement a treatment program to improve scapular control. Overhead sports like tennis, handball, volleyball, baseball, softball, golf, and throwing athletes are at an increased risk for shoulder injuries due to the excessive loads and forces placed on the upper extremities. These forces and loads could lead to glenohumeral modifications and scapulothoracic alterations such as scapular dyskinesis (Tooth et al., 2019). Scapular dyskinesis is thought to be more common in overhead or throwing athletes because of their consistent unilateral upper extremity function. Since overuse injuries are common in overhead athletes, athletic trainers should understand the predictive risk factors and preventative measures. Biofeedback can be a beneficial tool when treating scapular dyskinesis by adding motivation and improving adherence to a rehabilitation program. This literature review will explore the benefits of various feedback mechanisms that can be used during scapular dyskinesis rehabilitation to aid in normal scapular position and possibly prevent future shoulder injuries.

Chapter II: Methods

This chapter will address the search strategies used to obtain studies on the topic of scapular dyskinesis in overhead athletes and the influence of treatment using biofeedback with exercise or just exercise alone. It will also describe the inclusion and exclusion criteria, the number and type of studies, and the criteria used to evaluate the quality of the studies.

Search Strategies

The databases used for this Critical Review of Literature consisted of Scopus, Sports Medicine and Education Index, and CINHAL. A few additional studies were found by looking at the reference page of other high-quality articles included in this Critical Review of Literature (Tooth et al., 2020; Du, W. et al., 2020). Keywords used during the search were *scapular dyskinesis*, *scapular dyskinesia, winged scapula, biofeedback, EMG, electromyography, and video feedback*. Using the Scopus database, a search of *scapular dyskinesis* or *scapular dyskinesia* and *biofeedback* yielded three results. A search of *dyskinesis* AND *video feedback* OR *electromyography* OR biofeedback yielded 36 results, and another search using the terms *winged scapula** AND *biofeedback* yielded 14 results. Using the Sports Medicine and Education Index, searches were conducted using the following terms, *dyskinesis* OR *wing* scap** AND *biofeedback* which yielded 139 results. Searches with the CINHAL database included *scapular dyskinesis* OR *scapular dyskinesia* and *biofeedback* OR *video feedback* which yielded 1 result.

Dyskinesis AND *vid* feedback* OR *electromyography,* which yielded 38 results. Additional articles were found concerning overhead athletes with scapular dyskinesis by using Scopus and CINHAL. A search using *scapula* dyskinesi** OR *wing* scap** AND overhead athletes revealed 25 articles using CINHAL and 64 results using Scopus. For further limitations articles were required to be peer-reviewed, in English text, and published within the last 20 years. After examining the abstracts and titles of the 225 articles searched for the inclusion of a type of feedback and a population with scapular dyskinesis, approximately 30 articles were read and 17 were included in the final Critical Review of Literature according to the research question.

Inclusion and Exclusion Criteria

Inclusion criteria made sure that the articles were relevant and recent. Articles published within the years of 2000 to 2020 were included and were required to have a type of biofeedback as an intervention or a scapular stabilization rehabilitation program. The biofeedback types could be either surface electromyography (EMG) feedback, visual or video feedback, conscious or verbal feedback, or taping feedback. All populations were included in the literature review, but there were 8 studies whose specific population were overhead athletes. In addition, each study included a population with scapular dyskinesis. Articles were excluded if they were not peer-reviewed, not in English, and if they required purchasing. Articles were eliminated if they did not consist of any of the keywords or the multiple types of the feedback mentioned. There were no exclusion criteria for the type of study designs included.

Number and Type of Articles

Based on the inclusion criteria and the research question of interest, 17 articles were included in this literature review. All research studies were evaluated using the Johns Hopkins Nursing Evidence-Based Practice Research Evidence Appraisal Tool. This tool helped determine the level of evidence of the study design and the quality of studies. The level of evidence depended on the study design; level I consisted of randomized controlled trials and experimental studies, level II was quasi-experimental studies, and level III was nonexperimental studies. The quality of studies was rated as either high, good, or low quality. Different questions and procedures were used if there was a meta-analysis, a systematic review, or qualitative study but all ratings remained consistent. The more "yes" answered questions on the John Hopkins Appraisal Tool led to a higher quality score and the more "no" answers or "N/A" answers led to a lower quality score (Johns Hopkins Nursing Evidence-Based Practice, 2017).

Articles were also ranked according to the study's level of evidence and quality with the "Hierarchy of Evidence for Intervention Studies" (Fineout-Overholt, Melnyk, Stillwell, & Williamson, 2010). Within the hierarchy of evidence chart, the lower the evidence level number implies a higher quality study, and the higher the evidence level number, the lower the quality (Fineout-Overholt, Melnyk, Stillwell, & Williamson, 2010). As shown below, Figure 1 is the "Hierarchy of Evidence for Intervention Studies" chart describing the organizational ranking. Table 1 consists of the articles used in this literature review and their hierarchical ranking. Level I depicts systematic reviews; level II depicts randomized controlled trials; level III depicts controlled trials without randomization; level IV depicts case-control and cohort studies, and level V depicts qualitative or descriptive studies.

Figure 1

Hierarchy of Evidence for Intervention Studies

Type of evidence	Level of evidence	Description
Systematic review or meta-analysis	I	A synthesis of evidence from all relevant randomized controlled trials.
Randomized controlled trial	II	An experiment in which subjects are randomized to a treatment group or control group.
Controlled trial without randomization	III	An experiment in which subjects are nonrandomly assigned to a treatment group or control group.
Case-control or cohort study	IV	Case-control study: a comparison of subjects with a condition (case) with those who don't have the condition (control) to determine characteristics that might predict the condition. Cohort study: an observation of a group(s) (cohort[s]) to determine the development of an outcome(s) such as a disease.
Systematic review of qualitative or descriptive studies	V	A synthesis of evidence from qualitative or descriptive studies to answer a clinical question.
Qualitative or descriptive study	VI	Qualitative study: gathers data on human behavior to understand *why* and *how* decisions are made. Descriptive study: provides background information on the *what*, *where*, and *when* of a topic of interest.
Expert opinion or consensus	VII	Authoritative opinion of expert committee.

Adapted with permission from Melnyk BM, Fineout-Overholt E, editors. Evidence-based practice in nursing and healthcare: a guide to best practice [forthcoming]. 2nd ed. Philadelphia: Wolters Kluwer Health/Lippincott Williams and Wilkins.

Table 1: Articles According to Level of Evidence and Quality

Level of Evidence	Quality: High	Quality: Good	Quality: Low	Total # of Articles
I	0	0	0	0
II	3	4	0	7
III	5	1	0	6

IV	0	0	3	3
VI	0	1	0	1
Total	8	6	3	17

Criteria for Evaluating the Studies

The included studies were organized into the Bethel University Graduate Nursing Program Matrix (Bethel University Graduate Nursing, n.d.). Categories included in the matrix were the purpose of the study, the study design, the methods, the sample and setting, design instruments, the results, and recommendations. The quality of the studies and level of evidence-based on the John Hopkins Appraisal tool was also included in the matrix. The John Hopkins Appraisal Tool indicates that a high-quality article has consistent and generalizable results with a sufficient sample size and results to draw definitive conclusions (Johns Hopkins Nursing Evidence-Based Practice, 2017). A good quality study has reasonably consistent results, a sufficient sample size, fairly definitive conclusions with reasonably consistent recommendations (Johns Hopkins Nursing Evidence-Based Practice, 2017). A low-quality study has little evidence with inconsistent results, and an inadequate sample size where conclusions cannot be deduced (Johns Hopkins Nursing Evidence-Based Practice, 2017).

Summary

Multiple databases were used to research the effectiveness of treating individuals with scapular dyskinesis with biofeedback and exercise or just exercise alone. The inclusion and exclusion criteria helped determine the usefulness of the 17 articles included. The studies were organized into a literature matrix where the purpose, methods, design, results, quality, and level of evidence were recorded.

Chapter III: Literature Review and Analysis

Synthesis of Matrix

This chapter's primary purpose is to analyze and review the 17 scholarly articles obtained regarding the research question introduced in chapter one. The matrix that will be used was created by the Bethel University Graduate Nursing Program (Bethel University Graduate Nursing, n.d.). The matrix format presents the purpose, sample, design, level of evidence and quality, and results of the study in an organized manner. Placing these scholarly articles into the matrix helped to easily compare and contrast the various types of biofeedback and scapular exercises to treat scapular dyskinesis. The synthesis of each article's significant findings will be organized according to the article's level of evidence as recorded by the "Hierarchy of Evidence for Intervention Studies" in Figure 1 and Table 1 (Fineout-Overholt et al., 2010). The articles were categorized into four of the seven levels of evidence. These levels are randomized controlled trials, controlled trials without randomization, case reports, and systematic reviews of qualitative studies. Located in Appendix A, the articles are listed in their respective hierarchy of evidence in alphabetical order based on the author's last name.

Synthesis of Major Findings

Level II Evidence: This level consists of randomized controlled trials. Seven articles fit into this category.

Kim et al. (2017) carried out a randomized controlled trial (RCT) to examine the influence of visual feedback during scapular stabilization exercises. Forty-five participants with shoulder impingement syndrome were randomly assigned to either a visual scapular stabilization group (VSSG) or a non-visual scapular stabilization group (NVSSG). Both of the group's sessions lasted 20 minutes, 3 times a week for 4 weeks; they also performed the same exercises. Evaluation tools were completed one week before the sessions started and one week after completion of the sessions. The evaluation tools used consisted of the Numeric Pain Rating Scale (NPRS), the Quick Disabilities of the Arm, Shoulder, and Hand Questionnaire (Q-DASH), a strength evaluation using the 0-5 manual muscle test rating scale from a clinician, and an evaluation of ROM using a digital inclinometer. The VSSG included scapular movement education and scapular stabilization exercises with visual feedback using 3D motion images software. The participants were provided with real-time visual feedback via a monitor. Small weights were used during the exercise according to the amount of weight that produced the largest distance between the 7th cervical vertebrae and the lower angle of the scapulae of the affected side during scaption (Kim, Shin, & Song, 2017). The scapular stabilization exercise was performed with the participants in horizontal abduction scaption with the elbows fully extended. While holding the preselected weight, participants held the position until asymmetry of the scapula was observable. The exercise was then cautiously restarted with symmetrical scapular positioning. The NVSSG performed the same exercise, however, without visual feedback. They were provided with verbal feedback by a physical therapist. Results after the intervention displayed a significant difference in the NPRS, ROM, strength of scaption, and Q-DASH score in both the NVSSG and VSSG. Thus, individuals had a significant decrease in pain and disability and an increase in shoulder ROM and strength. Furthermore, the VSSG exhibited a significantly greater difference in the NPRS, ROM, strength of scaption, and Q-DASH scores compared to the

NVSSG. The results suggest that visual feedback of 3D motion images could be beneficial during scapular stabilization exercises in treating individuals with SIS. The authors did note that they could not determine the effects of kinematic scapular motion, and a "longer research period and a study of the persistent effects" would help generalize the results on visual feedback about scapular movements in individuals with SIS (Kim, Shin, & Song, 2017, p. 47).

Moslehi, Lerafatkar, & Miri (2019) conducted a RCT to assess the influence of a scapular-focused treatment with feedback (SFTF) and without feedback (SFT) in individuals with shoulder impingement syndrome. Participants were randomly assigned to either a SFTF group (n=25), to a SFT group (n=25), or a control group (n=25); there were 75 participants total. Participants were evaluated before the intervention and then after the 8-week intervention. Outcome measures used to assess participants included the Visual Analog Scale (VAS) for pain and scapular function and kinematics were evaluated with the DASH Questionnaire and 3-D motion capture (Moslehi, Lerafatkar, & Miri, 2019). The SFT group had a routine that was also 8 weeks long and contained isometric stretching and intrinsic, eccentric isotonic exercises. The first week had a shoulder position training followed by rotator cuff muscle strengthening (2nd, 3rd, 5th, 6th, & 7th weeks) and flexibility exercises (4th & 8th weeks). Participants were instructed on how to perform the program's exercises focusing on ROM, strength, and function then evaluated at 8 weeks. The SFTF group had a 15-minute familiarization where the participants performed each exercise four times. A therapist used tactile and verbal feedback cues concerning the scapula and pre-scapular muscles and tried to help the participant maintain a posterior scapular tilt. The four exercises performed included towel slides with shoulder extension, maximum forward flexion, scapular movement counterclockwise, and scapular retraction. Participants were able to visualize their movements on a monitor in front of them. Results presented a significant improvement in DASH scores pre to post-intervention in both the SFT and the SFTF groups. There was also a significant difference in the reduction of pain between both groups. The scapula was also more upwardly rotated and posteriorly tilted in the SFTF group compared to the SFT group. Overall, the crucial findings are significant differences and a larger effect size between the SFT group and the SFTF group regarding pain, function, and scapular upward rotation and tilt (Moslehi, Lerafatkar, & Miri, 2019). The scapular stabilizing exercises used in this study are similar to a rehabilitation program for scapular dyskinesis. This connection makes it possible that these exercises used in conjunction with the verbal, visual, and tactile feedback could aid in improving function and reducing pain in individuals with scapular dyskinesis. The authors in the present study did not use EMG data to evaluate scapular kinematics. They suggested that doing so could result in an improvement of scapular muscle activity and reduce the subacromial space for future studies (Moslehi, Lerafatkar, & Miri, 2019).

Du, W.-Y., et al. (2020) organized a study to compare the effects of video feedback and EMG biofeedback by analyzing muscle activity of the UT, LT, and SA, muscle balance ratios between the UT/LT and UT/SA, and scapular kinematics in participants with SIS and scapular dyskinesis. All participants were overhead athletes, diagnosed with SIS, and displayed observable scapular dyskinesis. Participants were randomized into either an EMG biofeedback group (n=20) or a video feedback group (n=21). A Motion Monitor software was used to measure scapular kinematics, and surface EMG electrodes were used to measure the UT, LT, and SA muscles. Participants in both groups learned to use constant feedback to correct their scapular muscle activation and scapular kinematics; this learning specifically consisted of maintaining the scapula in a neutral position with their arms by their sides (Du et al., 2020). During the learning portion, the video feedback group was advised to decrease the prominence of the inferior scapular angle and medial border by visualizing it on the screen and with the cue “place the scapula tightly against the rib cage” (Du et al., 2020, p. 266). For the EMG biofeedback learning portion, this group was advised to focus on the UT/LT muscle balance ratios. Their goal was to keep this under a specific ratio (1 standard deviation). Once participants from each group were able to complete their learning task three times in a row, they could move on to the training portion. The training portion consisted of the same goals in the learning section; the video feedback group was instructed to decrease the prominence of the scapula, and the EMG biofeedback group was instructed to maintain the UT/LT muscle ratio below a specific threshold. The training portion consisted of an arm elevation and lowering task in scaption to 180 degrees within three seconds. Males held a 1 kg dumbbell and females held a 0.5 kg dumbbell. Verbal cues used were, “Do not over shrug the shoulder,” “Retract the scapula,” “Relax your shoulders,” and “Slightly squeeze the muscles between the scapula” (Du et al., 2020, p. 268). Results disclosed that both types of feedback had positive influences on a decreased UT/LT and UT/SA muscle ratio, UT muscle activity, and scapular internal rotation. Specifically, EMG biofeedback improved muscle activity compared to the video feedback group, and there was a higher scapular upward rotation in the video feedback group than the EMG biofeedback group. With this knowledge, EMG biofeedback may be most effective in learning to control muscle activity and video feedback may aid in improving scapular positioning correction (Du et al., 2020).

Ozer et al. (2018) conducted a study to look at the short-term effects of KT in regard to scapular dyskinesis with a sample of 72 elite asymptomatic athletes. As a feedback mechanism, KT stimulates cutaneous mechanoreceptors and provides continuous feedback on individuals' postures or attempts to achieve the correct movement patterns (Hajibashi et al., 2014). Participants were randomly assigned to either a rigid taping, KT, placebo, or control group; there were 18 participants in each group. At baseline, immediately after taping, and at 60-72 hours after taping, the Scapular Dyskinesis test with weights, scapular upward rotation, and pectoralis length was measured. The primary author of the study performed all taping and measuring. The taping techniques revealed that both the rigid taping group and the KT group had decreased scapular dyskinesis percentages immediately after taping, and these differences were maintained at 60-72 hours after taping (Ozer, Karabay, & Yesilyaprak, 2018). This displays the short-term effects of rigid and KT techniques could improve pectoralis minor length and scapular dyskinesis in asymptomatic overhead athletes with scapular dyskinesis. On the other hand, scapular upward rotation seemed to have no effect in regard to the taping techniques (Ozer et al., 2018).

Huang et al. (2018) organized a RCT to determine if conscious and visual feedback would improve scapular muscle activation in individuals with scapular dyskinesis and SIS. Thirty-eight overhead athletes with scapular dyskinesis and SIS were recruited for this study. They were randomly placed into either a visual feedback group or a control group. Surface EMG electrodes were used to measure UT, LT, and SA; an electromagnetic analysis system was used to capture scapular kinematics (Huang et al., 2018). Assessments of scapular muscle activation and scapular kinematics were taken once before the intervention and twice after the intervention. Both groups received progressive conscious control training. The visual feedback group was instructed on control training with the visual feedback of their scapular orientation during arm elevation. For conscious control, the cue "retract the chest slightly" was meant to aid in correcting the medial border prominence by focusing on flattening the scapula to the thorax (Huang et al., 2018, p. 1410). Furthermore, progressive control practice consisted of focusing on proper scapular orientation at rest, then at 0°-45°, and 0°-90° of arm elevation. The visual feedback group received real-time video feedback of themselves posteriorly. Participants practiced the arm elevation activity until they could achieve satisfactory control of the scapula and continuously reduce the UT/SA muscle ratio in two trials compared to their baseline standard. In conclusion, a specific improvement was found among the visual feedback group in the restoration of the UT/SA muscle ratio. In both the control and visual feedback groups, a progressive program with conscious control of scapular orientation adequately decreased UT activation, increased LT activation, reinstated the UT/LT ratio, and enhanced scapular internal rotation. The progressive control program can be useful in learning to control scapular orientation efficiently in individuals with SIS and scapular dyskinesis. In addition, visual feedback can improve the UT/SA muscle activation ratio (Huang et al., 2018).

Shih et al. (2018) conducted a study to determine the immediate effects of KT on scapular joint position sense, kinematics, and muscle activation in overhead athletes with SIS. Although this study is not focused on scapular dyskinesis, it is worth noting that scapular dyskinesis and alterations in scapular kinematics and muscle activation often occur in conjunction with SIS. A small subacromial space is common in both scapular dyskinesis and SIS. The main difference is that SIS is often more painful than scapular dyskinesis during dynamic shoulder movement (Shih et al. 2018). An electromagnetic tracking system was used to collect scapular kinematics and surface EMG electrodes were used to collect muscle activation data during two movement tasks. Measurements were taken before tape application and after the intervention with the tape still applied. The two movement tasks consisted of scapular elevation and scapular protraction; these were performed to a metronome three times each. Thirty overhead athletes with SIS were randomly assigned into either a KT group or a control taping group. Eye masks and earplugs were used to eliminate additional feedback. The KT group tape application technique was a Y tape applied to the LT and an I tape applied to the UT. "The Y tape was applied to encircle the LT from origin to insertion while the participant held the arm at 90° flexion with maximum scapular protraction. A fully stretched I-shaped tape was applied perpendicular to the muscle belly of the UT when the scapula was held in maximum retraction and depression" (Shih, Lee & Chin, 2018). The control taping was a tape applied without any stretch tension while the participant was seated in a relaxed position. Both groups consisted of 15 participants and results revealed that KT application improved scapular reposition accuracy and scapular kinematics during the two movement tasks (Shih, Lee & Chin, 2018). There was no effect on muscle activation; the authors suggested that this may be due to the simplicity of the movement tasks and due to the fact that no weight was used. These results propose that KT tape is effective as an aid for better scapular control during rehabilitation and training for athletes with SIS. Further studies should include larger sample sizes, randomize the exercise tasks, and include a longer period of follow-up to explain long-term effects (Shih, Lee & Chin, 2018).

Hajibashi et al. (2014) set out to investigate whether the effect of KT in conjunction with stretching can treat rounded shoulder posture compared to just stretching and no KT. A rounded shoulder posture is somewhat similar to scapular dyskinesis due to the deficiency of scapular movement and scapular muscle imbalance. In addition, a rounded shoulder posture can occur with shoulder impingement, tendinitis, or shoulder instability (Hajibashi et al., 2014). The treatment for a rounded shoulder posture is typically the same as a treatment for scapular dyskinesis; strengthening the scapular stabilizers and stretching shortened muscles. Twenty females with rounded shoulder posture ages 18-25 years old were included in the study. Participants were randomized equally into either a stretch group or a stretch plus KT group. Both groups were instructed on how to perform a PM stretch bilaterally; the stretch was held for 30 seconds, for 3 repetitions, once a day. The intervention lasted two weeks. The KT technique was applied with 50-100% tension. Participants were asked to flatten their back (thoracic extension) and a vertical KT strip was applied on both sides of the spine from T1 to T12. The participants fully depressed and retracted their shoulders while an oblique strip was applied from the acromion to the spinous process of T12 bilaterally. Tape was replaced every three days within the 2 week treatment period (Hajibashi et al., 2014). The forward shoulder angle was measured via a photograph and measuring the angle between a vertical line that crossed the C7 spinous process and another line that passed through the C7 spinous process and acromion. Forward shoulder angle was also measured pre-intervention, immediately after the first intervention, on the fourth day, and at the end of two weeks (Hajibashi et al., 2014). Measurements were taken with the KT during the first session immediately after the first intervention and measurements were taken with the KT off during the third and fourth measurement sessions. The KT group revealed a significant within-group decrease in forward shoulder posture angle between the pre-intervention measurement and the other three measurements taken (Hajibashi et al., 2014). Scapular KT used in combination with a PM stretch improved forward shoulder posture compared to just a stretch intervention. KT used as a complementary treatment could be beneficial due to its immediate effects and ability to maintain this corrective effect until the end of the treatment (Hajibashi et al.

2014). The author noted that future studies should include a larger sample size so that there is enough power to detect a possible improvement in the stretch group (Hajibashi et al., 2014).

Antunes et al. (2016) conducted a study to determine the effectiveness of 3D kinematic feedback on motor relearning transfer during shoulder flexion and daily activity. Thirty healthy participants were randomly allocated to either an experimental or control group. There were 15 participants in each group. The experimental group had 3 electromagnetic sensors placed on them and were also guided with verbal feedback during the exercises. Each group performed the same exercises. They first performed 5 repetitions of each task, shoulder flexion up to 45° in a sagittal plane and mimicking drinking a glass of water (Antunes et al., 2016). Then, each group rested for 2 minutes and performed 2 scapular-focused exercises, relocating the scapula towards the scapulothoracic neutral position for 5 repetitions and relocating the scapular to a neutral position while performing shoulder elevation in the free plane for 5 repetitions. They rested 2 minutes again and performed shoulder flexion up to 45° in the sagittal plane for 5 repetitions and mimicking drinking a glass of water for 5 repetitions in the sagittal plane (Antunes et al., 2016). The experimental group could visualize their scapular movements through the kinematic data by focusing on moving a yellow cross that represented their scapulothoracic orientation on an abscissa axis. Results revealed that the kinematic feedback developed immediate changes in scapular performance during shoulder flexion after the scapular-focused intervention (Antunes et al., 2016). Real-time kinematic feedback is a promising mechanism to assist participants in increasing their scapular motor control and performance (Antunes et al., 2016).

Level III Evidence: This level consists of controlled trials without randomization. There are six articles in this category.

In the first article, Mey et al. (2013) wanted to determine if conscious correction of scapula orientation influenced the muscle activation levels of the MT and LT while minimizing UT activation. A sample of 30 participants with asymptomatic scapular dyskinesis, who were all active in overhead sports were tested for baseline strength levels of the UT, MT, and LT using surface EMG in manual muscle test position for the specific muscle. Then participants were tested on four exercises that have low UT/MT and UT/LT muscle ratios. These exercises consisted of prone extension, side-lying external rotation, side-lying forward flexion, and prone horizontal abduction with external rotation. Without the conscious control intervention, participants first performed the 4 exercises randomly with handheld weights according to their gender and weight. Then, a conscious correction of scapular orientation was instructed to the participants. For the conscious correction, visual, auditory, and kinesthetic cues were implemented based on the participant's scapular resting position (Mey et al., 2013). Examples of cues included "gently bring the tip of your shoulder blade toward your spine", "gently lift the top of the shoulder", and "gently spread the front of your shoulder apart to draw your shoulder blade toward the midline" (Mey et al., 2013, p. 6). Cues like, draw the scapula down and in (retraction and depression) were avoided. Following this conscious control intervention, all participants were able to correct their scapular posture effectively and hold the corrected scapular position for 5 seconds without assistance. Then, participants performed the 4 exercises previously described in randomized order. The participants were instructed to perform each exercise starting from a neutral position while maintaining proper scapular orientation. If the proper scapular orientation was lost, the appropriate verbal cue was provided. Results displayed that the UT/MT and UT/LT muscle ratios were similar between no conscious control and conscious control. In addition, conscious control effectively increased the activation levels of the three sections of the trapezius muscle during the prone extension exercise. Overall, conscious correction of scapular orientation during the prone extension and side-lying external rotation exercises increased trapezius muscle activity in overhead athletes with scapular dyskinesis (Mey et al., 2013).

Juan et al. (2016), performed a controlled laboratory study to use EMG biofeedback to influence scapular kinematics in individuals who have daily routines where they are lifting overhead in large amounts. These participants did not have scapular dyskinesis. The authors hypothesized that EMG biofeedback would increase individuals' upward scapular rotation, external rotation, and posterior tilt (Juan et al., 2016). A surface EMG system was used to measure the UT, LT, SA, and lumbar paraspinals of the dominant arm. In addition, a 3D magnetic tracking system was used to analyze scapular kinematics, specifically upward rotation, posterior tilt, and external rotation. The scapular stabilization exercises performed with EMG biofeedback included I, W, T, and Y exercises; these exercises are known to recruit the LT and SA. Before the experiment, the 25 participants performed a warm-up of 10 pendulum swings with a 1.8 kg weight. Participants performed the scapular stabilization exercises while standing and looking at the EMG biofeedback (Juan et al., 2016). The EMG biofeedback aided the participants in being able to control and isolate the LT and SA muscles. During EMG biofeedback, the goal was to have twice the activity of the UT for the LT and SA muscles. Each scapular stabilization exercise was performed for 10 repetitions holding each repetition for 1 second. Participants were given a minute rest between each trial. Humeral elevation was performed before and after the scapular stabilization exercises (Juan, Gunderson, Kane-Ronning, & Suprak, 2016). Results revealed that in healthy individuals, scapular stabilization exercises combined with EMG biofeedback influenced the scapula towards a more externally rotated position. This position also places the shoulder in scapular retraction which can aid in preventing shoulder impingement injuries (Juan et al., 2016).

Tooth et al. (2019) created a study to analyze the effectiveness of 2 different techniques of KT on scapular kinematics and the activity of scapular stabilizers in overhead athletes with asymptomatic scapular dyskinesis. Surface EMG electrodes were used to measure muscle activity of the UT, LT, and SA. Twenty participants experienced each condition; without tape (standard condition), taping 1 (KT1), and taping 2 (KT2), the order of the conditions was also randomized. Participants performed 10 active shoulder flexions in the sagittal plane and 10 active shoulder abductions in the frontal plane with and without loading (Tooth et al., 2019). For the KT1 taping technique the shoulder was placed in 60 degrees of flexion in the sagittal plane, the tape was applied to the coracoid process and firmly placed on the UT, and then on the inferior angle of the scapula. For the KT2 taping technique, two pieces of tape were used, the first piece was placed the same as KT1 and the second piece was placed from the thoracic spine to the inferior border of the scapula, with full tension being applied from the inferior border of the scapula to the lateral side, this promoted scapular upward rotation (Tooth et al., 2019). Results revealed that there was no change in SA activity in both the KT1 and KT2 groups. Both techniques did significantly increase scapular posterior tilt and upward rotation. The KT2 taping technique influenced a decrease in LT activity and greatly limited scapular external rotation. The KT1 taping technique influenced periscapular muscle activity and scapular kinematics while also decreasing UT activity. The effects of the KT1 technique could help improve the UT/LT muscle ratio in athletes with scapular downward rotation at rest or forward shoulder posture (Tooth et al., 2019).

Huang et al. (2019) performed a study to examine the effects of KT on the trapezius muscles during scapular kinematics in individuals with scapular dyskinesis. Surface EMG was used to measure muscle activity of the UT, LT, MT, and SA. Fifty-four participants were recruited and classified by their scapular position and movement patterns. Scapular kinematic and EMG data were collected for all participants without tape while performing arm elevation to a full-can position and back down. All taping techniques used a Y-shaped piece of KT applied in the distal to proximal direction. For the UT taping, participants side bent and rotated the head to the contralateral side. At the same time, tape was applied from the superior side of the acromion of the scapula to the upper cervical spine. Participants horizontally abducted their arm on the contralateral shoulder for the MT taping technique while tape was applied from the posterior side of the acromion to the upper thoracic spine. For the LT taping technique, participants horizontally adducted the arm and tape was applied from the root of the spine of the scapula near the acromion to the lower thoracic spine (Huang et al., 2017). The order of these 3 taping techniques was randomized for participants and they received 30 minutes of rest between each. Five trials of weighted arm elevation were performed in the scapular plane. Results showed that UT activity decreased with the UT taping technique in 72% of participants. MT activity increased with the MT taping in 48% of participants. LT activity increased with the LT taping in 54% of participants (Huang et al., 2017). EMG data revealed that the UT taping technique does reduce UT activity and posterior scapular tipping. Clinicians should be cautious when using the MT and LT taping technique due to increased UT activity (Huang et al., 2017).

Weon et al. (2011) carried out a study to investigate the effects of real-time visual feedback to facilitate SA activity in individuals with scapular dyskinesis. Nineteen participants with scapular dyskinesis performed a shoulder flexion exercise while seated. Each participant experienced real-time visual feedback and no visual feedback; real-time visual feedback was given using a camera placed in front of the participant. Surface EMG was used to measure UT, LT, and SA muscle activity, and a reflective marker was placed on the midpoint of the acromion to measure its displacement in the frontal and sagittal planes (Woen et al., 2011). "The distance of acromion movement was measured from the starting position to the end of the predetermined shoulder flexion position" (Woen et al., 2011, p. 104). Participants were instructed to flex the shoulder at 60 and 90 degrees and hold for 5 seconds, 3 times, with a 3 minute rest period between trials. Visual feedback participants were also allowed a 15 minute familiarization phase to practice. The angle of shoulder flexion was measured using a goniometer. Results showed that visual feedback significantly increased UT activity at 60 degrees, SA activity at 60 and 90 degrees, and movement of the acromion superiorly at 60 degrees and anteriorly at 60 and 90 degrees (Woen et al., 2011). Real-time visual feedback is beneficial in increasing the activation of the UT and SA and improving scapular kinematic during shoulder flexion compared to no visual feedback in individuals with scapular dyskinesis (Woen et al., 2011). To improve this study the authors suggested that future studies should focus on analyzing the long-term effects of real-time visual feedback.

Hsu et al. (2009) conducted a study to determine the effects of KT on scapular kinematics, muscle strength, and EMG activity in baseball players with SIS. A study that focuses on SIS instead of scapular dyskinesis is being used because of the similarity in conditions. Just like with scapular dyskinesis, the trapezius and SA are important force couples to control the movement of upward scapular rotation and posterior tilt (Hsu et al., 2009). An altered function of these two muscles has been shown to influence scapular movement negatively. In addition, these components of scapular movement are crucial to widening the subacromial space which often causes impingement if narrowed (Hsu et al., 2009). Lastly, the changes of scapular kinematic in individuals with SIS include an increase in scapular winging during arm elevation (Hsu et al., 2009). Seventeen baseball players with SIS were included in this study. An electromagnetic tracking system was used to collect 3D scapular kinematic data and surface EMG was used to collect UT, LT, and SA muscle activity. All participants received both the KT and placebo taping over the LT muscle and there were 3 days of separation between the two taping sessions. Measurements of muscle strength, EMG, and scapular kinematics were taken both before and after each taping session. The testing movement was shoulder elevation and lowering in the scapular plane (Hsu et al., 2009). Each cycle took 8 seconds and was paced by a metronome. Several practice movements were allowed before testing. The testing movement was performed with a 2 kg weight and there was a 3 min rest between trials. Results displayed that the KT group significantly increased scapular posterior tilting at 30 and 60 degrees of arm elevation. Also, there was an increase in LT activity during 60-30 degrees of arm lowering in comparison to the placebo taping (Hsu et al., 2009). In conclusion, KT can be a beneficial modality during rehabilitation to help treat baseball players with SIS (Hsu et al., 2009).

Level IV Evidence: This level consists of case reports or cohort studies and two articles fit into this category. It is worth noting that this is a weak level of evidence.

Turner (2019) carried out a case report with a 20-year-old female synchronized ice skater who experienced a mid supraspinatus tear (4 mm) in her left shoulder. Tests revealed that she had scapular dyskinesis of the injured shoulder. The purpose of this case report was to examine the effectiveness of conservative treatment for a supraspinatus tear accompanied by scapular dyskinesis. First, the athlete participated in 2 weeks of rehabilitation with a physical therapist. This program consisted of band-resisted internal rotation and external rotation, standing rows, and chest press. These exercises were performed daily for 3 sets of 15 repetitions. After two weeks, the athlete saw no improvement in pain, sleep quality, or activities of daily living (ADLs) (Turner, 2019). The athlete was then referred to the author of the case report for a 12-week program consisting of two 6 week programs with 11 exercises in each program; she completed 3 sessions a week. The first phase of the program contained the following exercises: a PM ball release, supine arm raise (lead with thumbs), open book (left arm only), prone shoulder retraction with external shoulder rotation (arms by sides), supine shoulder protraction (with shoulder flexed to 90 degrees), foam roller wall push, activation training for the SA muscle (standing and walking), dumbbell shrugs, lat pulldown (supine grip), seated cable row, and a prone dumbbell bench pull. The second phase included the PM ball release, supine arm raise, prone shoulder retraction with external shoulder rotation, foam roller wall push, arm elevation in the scapular plane, dumbbell shrugs, lat pulldown, seated cable row, prone dumbbell bench pull, and alternating dumbbell shoulder press (sagittal plane). The sets, reps, and weights ranged from 2-4 sets, 5-15 reps, and 8-20 kg (Turner, 2019). The author used verbal cues to aid in proper scapular positioning; one cue was, “stand tall with chest up, and imagine you are trying to tuck the bottom of your shoulder blade under your armpit” (Turner, 2019, p. 60). The author also used tactical feedback with the supine arm raise exercise; the floor provided tactical feedback by putting pressure onto the medial border of the scapula. Visual feedback was also used by the author by placing the athlete in front of a mirror during her exercises. After 4 weeks the athlete was pain-free during overhead tasks, revealed a normal scapular pattern, normal shoulder ROM, and reported no pain during sleeping or ADLs. She returned to her full level of sport within 9 weeks and her pain remained absent during her 6-month follow-up. Even though there wasn't a huge emphasis on the various types of feedback used, conservative treatment of a supraspinatus tear accompanied by scapular dyskinesis may produce a faster return to play compared to surgical interventions (Turner, 2019).

Ou et al. (2016) performed a study to examine whether participants with symptomatic scapular dyskinesis could actively alter their scapular orientation and muscle activity with conscious control. The sample consisted of 60 participants with symptomatic scapular dyskinesis. Surface EMG was used to measure scapular strength and an electromagnetic-based motion analysis system was used to observe scapular kinematics. Investigators used conscious control with verbal, auditory, and kinesthetic cues during the intervention. First, participants were instructed to achieve a neutral scapular position during rest for 5 seconds without assistance. Those who were unable were excluded from the study. Once the participants achieved this goal, they were instructed to perform three exercises: arm elevation in the scapular plane, side-lying flexion, and side-lying external rotation. These exercises were performed in a randomized order, participants were allowed a 3 minute rest period between subsequent exercises (Ou et al., 2016). Results showed that during these three specific exercises, conscious control aided in an improved alteration of scapular orientation and MT, LT, and SA muscle activation.

Specifically, there was an increase in SA activity during the side-lying external rotation exercise. Therefore conscious control combined with a scapular stabilization program can improve proprioception, normalize the scapular resting position, and promote trapezius muscle activity in individuals with scapular dyskinesis. In addition, conscious control paired with a scapular rehabilitation program can aid in improving scapular kinematics and muscle coordination in individuals with scapular dyskinesis.

Level VI Evidence: This level consists of descriptive and qualitative studies. There is one study that fits into this category.

Snodgrass et al. (2018) carried out a study to examine the influence of scapular taping with 15 participants. The study used surface EMG to measure the activity of the UT, LT, SA, and middle deltoid (MD). ROM of shoulder flexion and abduction was measured using a goniometer. For the experiment, participants attended 2 sessions approximately 24 hours apart. Surface EMG muscle activity and ROM was measured for active shoulder flexion and abduction at 4 points during the experiment; the first session consisted of, before application of the tape (pretaping), immediately after the application of tape (after taping), and the second session consisted of 24 hours after tape application with tape on, then with the tape removed (Snodgrass et al., 2018). The taping technique was a McConnell method using rigid athletic tape; the placement was "from the anterior aspect of the humeral head just lateral to the acromion process and exerted manual force to upwardly (laterally) rotate the scapula while securing the other end of the tape over the inferior angle of the scapula" (Snodgrass et al., 2018, p. 398). This taping technique aimed to retract the humeral head and upwardly rotate the scapula, it also aimed to facilitate muscle activation of the LT, UT, and SA. Results conveyed that in a population without shoulder pain, immediately after taping, contractions occurred earlier during abduction for the UT and during flexion for the LT. These results were not maintained 24 hours after taping, thus, the optimal time to perform rehabilitation exercises with the use of taping feedback may be immediately after taping (Snodgrass et al., 2018).

Critique of Strength and Weaknesses

The 17 appraised articles had various strengths and weaknesses. A strength all articles had in common was that they were all published within the last five years except for four articles (Mey et al., 2013; Weon et al., 2011; Hsu et al., 2009; Hajibashi et al., 2014). In addition, all articles were either of high or good quality except for 3 studies. Twelve articles used surface EMG to measure muscle activity during experiments. The remaining articles used a motion analysis system to measure scapular kinematics or a handheld dynamometer as another way to measure scapular strength. A few articles incorporated patient-reported outcomes using the DASH, VAS, NPRS, & FABQ; respectively these measured shoulder and arm disability, pain, and fear avoidance. Research findings similarly revealed the benefits of feedback during rehabilitation. This includes visual feedback, EMG biofeedback, verbal feedback, taping and conscious correction.

There were also weaknesses of the appraised studies. There were no systematic reviews on the research question. The lack of systematic reviews on the treatment of scapular dyskinesis reveals that more research should be explored pertaining to feedback mechanisms to help treat scapular dyskinesis. There was a lack of research on using surface EMG biofeedback with a rehabilitation program to help control scapular kinematics and scapular stabilizers. Furthermore, all articles had low sample sizes, the largest sample size consisted of 75 participants, and most sample sizes ranged from 20-40 participants.

Summary

Seventeen peer-reviewed articles were critically reviewed to establish the effectiveness of feedback combined with conservative rehabilitation to prevent future shoulder injuries in individuals with scapular dyskinesis. The reviewed articles were categorized according to the "Hierarchy of Evidence for Intervention Studies" into either level I, II, III, IV, and VI (Fineout-Overholt, Melnyk, Stillwell, & Williamson, 2010). Each article was appraised using the John Hopkins Nursing Appraisal Tool and labeled as either high, good, or low quality (Johns Hopkins Nursing Evidence-Based Practice, 2017). Overall, the various types of feedback combined with scapular dyskinesis rehabilitation helped facilitate an increase in scapular stabilization muscles and neutral scapular positioning. However, more studies including surface EMG biofeedback could be beneficial in this critical review of the literature.

Chapter IV: Discussion, Implications, and Conclusions

The purpose of this Critical Review of Literature is to establish if treatment combined with feedback has increased benefits compared to just treatment alone of individuals with scapular dyskinesis. This final, fourth chapter will focus on the above purpose regarding the gaps and trends found, the implications to athletic training practice, and any other recommendations for further research.

Literature Synthesis

This Critical Review of Literature aimed to answer the question, "In overhead athletes with scapular dyskinesis, does the use of an exercise program with biofeedback reduce the risk of shoulder injury versus exercise alone?" Overall, 17 articles were reviewed and appraised concerning this question. The subsequent paragraphs will incorporate the included articles into categories according to the feedback types used: taping, surface EMG biofeedback, conscious control, verbal feedback, and visual feedback. Some studies used two types of feedback.

Of the 17 articles, only 3 used surface EMG biofeedback. These were also of high quality (Juan et al., 2016; Du et al., 2020; Atunes et al., 2016). Jaun et al. (2016), found that in a population without scapular dyskinesis, EMG biofeedback during scapular stabilization exercises caused the scapula to be more retracted during the entire ROM. Du et al. (2020) discovered that in comparison to a video feedback group, EMG biofeedback successfully helped participants control their scapular stabilizers during an arm elevation and lowering task. Using real-time kinematic feedback in a healthy population, Antunes et al. (2016) revealed an improvement in scapular control and performance.

Seven of the 17 articles used taping techniques as a feedback mechanism. Five of these used KT while one used a rigid tape and one compared both KT and rigid tape (Snodgrass et al., 2018; Huang et al., 2017; Tooth et al., 2020; Hsu et al., 2009; Ozer et al., 2018; Hajibashi et al., 2014; Shih et al., 2018). Four of these articles were of high quality and two were of good quality.

All of the taping techniques revealed immediate positive effects on scapular kinematics but none of them conveyed any long-term benefits. Although different taping techniques and movement activities were used, four of the studies that looked at KT as a feedback mechanism found an immediate improvement in scapular kinematics as well as scapular muscle activity. These 4 studies were all of high quality (Hau et al., 2009; Shih et al., 2018; Huang et al., 2019; Tooth et al., 2020). Snodgrass et al. (2018) utilized a rigid McConnell taping technique that influenced an earlier onset of UT and LT muscle activity while also influencing an immediate improvement on shoulder abduction ROM. However, these benefits were not maintained 24 hours after taping (Snodgrass et al., 2018). Ozer et al. (2018) compared a KT technique to a rigid taping technique and revealed that both improved scapular dyskinesis and PM length. Nonetheless, these taping techniques did not improve upward scapular rotation (Ozer et al., 2018). Lastly, a KT technique used in addition to a PM stretch in a study by Hajibashi et al. (2014) demonstrated an improved rounded shoulder posture.

Four studies used visual feedback via a monitor and camera. Three of these studies were of good quality and 1 was of high quality (Weon et al., 2011; Huang et al., 2018; Moslehi et al., 2020; Kim et al., 2017). The 4 articles that investigated the influence of visual feedback used different outcome measurements, but all found benefits in using this feedback technique. Moslehi et al. (2020) acknowledged that visual feedback training with verbal and tactile cues provided by a therapist compared to no feedback significantly improved participants' pain and scapular kinematics. Kim et al. (2017) reported that real-time visual feedback via a monitor improved the influence of scapular stabilization exercises leading to reduced pain intensity, improved ROM, increased flexion muscle strength, and reduced disabilities. Another study using real-time visual feedback concluded that UT and SA muscles were properly recruited to help improve shoulder flexion movement (Weon et al., 2011). Huang et al. (2018) found that with real-time visual feedback, the UT/LT muscle ratio was reduced and scapular internal rotation improved during arm elevation. They also found that visual feedback decreased the UT/SA muscle ratio (Huang et al., 2018).

Two studies used a combination of verbal, visual, and tactile feedback but were low quality (Turner, 2019; Ou et al., 2016). A case report with one athlete revealed that verbal, visual, and tactile feedback resulted in a reduction of pain and scapular dysfunction while also aiding in a faster return to play compared to surgical interventions (Turner, 2019). Ou et al. (2016) incorporated verbal and kinesthetic feedback and established an altered scapular orientation while also improving scapular stabilization muscle activation.

One study used only verbal feedback to aid in conscious scapular orientation and affirmed a higher trapezius muscle activation (Mey et al., 2013).

Current Trend and Gaps in Literature

Various trends and gaps surfaced throughout this Critical Review of Literature. Trends will be mentioned first; 13 of the 17 articles were published within the last five years. Although not all articles had exact similarities, this reveals that the influence of feedback mechanisms to complement rehabilitation is being researched more presently. Next, 11 articles used surface EMG electrodes to measure muscle activity within their research studies and 10 articles used similar types of motion analysis systems to analyze scapular kinematics. This shows that of the

17 articles, 10 to 11 used similar instruments to measure outcomes of their studies. Lastly, there was a trend of eight of the 17 articles including overhead athletes into their population.

On the other hand, there were also gaps present throughout the research as well. The sample size varied between studies. Eight of the studies had populations that ranged from 15 to 30 participants and seven of the studies had populations ranging from 38 to 75 participants. There was only one case study included with one participant, where they used verbal, visual, and tactical feedback. The athlete made significant improvements within 9 weeks and had a successful return to play (Turner, 2019). Also, articles varied in what type of feedback they used as an intervention. Only two articles used surface EMG biofeedback (Juan et al., 2016; Du et al., 2020), seven of the articles used KT or rigid taping feedback techniques (Snodgrass et al., 2018; Huang et al., 2017; Tooth et al., 2020; Hsu et al., 2009; Ozer et al., 2018; Hajibashi et al., 2014; Shih et al., 2018), and the remaining articles used visual, verbal, or conscious feedback techniques. This shows a large gap in research on surface EMG biofeedback specifically on its effectiveness in treating scapular dyskinesis. Although the similarities between scapular dyskinesis and SIS were discussed previously; it is worth noting that 5 articles included in this review included a population with SIS or a population with SIS and scapular dyskinesis (Kim et al., 2017; Moslehi et al., 2020; Du et al., 2020; Shih et al., 2018; Hsu et al., 2009). In addition, one study used a population with rounded shoulder posture, which was also similarly related to scapular dyskinesis (Hajibashi et al., 2014).

Implications for Athletic Training

One of the necessary skills of an athletic trainer is to observe and recognize scapular dyskinesis in a patient. Due to the increased prevalence of scapular dyskinesis in overhead athletes, this condition may commonly be seen by athletic trainers (Burn et al., 2016). In addition, scapular dyskinesis involves reduced scapular stabilization strength and muscle imbalance along with scapular dysfunction and could potentially lead to further shoulder injuries (Burn et al., 2016; Giuseppe et al., 2020). Athletic trainers are essential to treating scapular dyskinesis and returning athletes to normal function and return to play. The current treatment for scapular dyskinesis includes scapular stabilization exercises to address any muscle imbalances and strengthen weak muscles and stretching of tight musculature (Giuseppe et al., 2020). However, each patient is unique and every treatment program should be customized to meet that patient's needs. There is little research on feedback mechanisms being used in combination with rehabilitation to treat scapular dyskinesis. Feedback is beneficial to help control scapular movements and influence proper muscle activation. For every study included in this review that compared a feedback intervention to just an exercise intervention, feedback interventions combined with rehabilitation programs revealed improved scapular muscle activity and scapular kinematics. This implies that feedback mechanisms are an effective addition to rehabilitation programs in treating or managing scapular dyskinesis.

Visual feedback is most effective when trying to improve and control scapular movement but also exposed changes in scapular muscle activity (Kim et al., 2017; Du et al., 2020; Weon et al., 2011; Huang et al., 2018). Surface EMG biofeedback is most useful when aiming to improve scapular muscle control, scapular muscle activity, and tackle specific scapular muscle ratios (Du et al., 2020; Juan et al., 2016). EMG biofeedback can also aid in placing the shoulder in a more retracted position (Juan et al., 2016). Conscious correction typically involved verbal and or visual feedback. This feedback mechanism helped influence scapular muscle ratios and muscle coordination, improve scapular function, and reduce pain (Mey et al., 2013; Ou et al., 2016; Huang et al., 2018). Taping feedback mechanisms were most helpful in reducing unwanted muscle activity or scapular motion, increasing scapular posterior tilting and ROM (Huang et al., 2019; Tooth et al., 2020; Hsu et al., 2009; Hajibashi et al., 2014). Taping may also help with scapular movement and control (Shih et al., 2018). Taping is most beneficial as an immediate feedback mechanism. There are multiple techniques of taping and thus every taping method has a purpose, and the purpose should benefit the athlete and their specific needs.

The type of feedback mechanism used during a rehabilitation program can depend on the athlete's deficiencies. Whether it be scapular movement control, scapular muscle activity, scapular position, pain, or ROM, the feedback mechanisms explored in this review can better assist an athlete in managing or treating scapular dyskinesis while also preventing future shoulder injuries.

Recommendations for Future Research

Throughout this Critical Review of Literature regarding 17 articles, gaps were revealed which led to various ideas and recommendations for future research. One of the most shared suggestions was the need for a larger sample size. Larger sample sizes for some studies would help clarify long-term benefits, other studies mentioned this same suggestion to determine specific differences between groups (Shih et al., 2018; Hajibashi et al., 2014; Huang et al., 2019; Ozer et al., 2018). Another common suggestion was to include a long-term follow-up period to determine if the long-term benefits of feedback were maintained or to generalize the results (Mey et al., 2013; Du et al., 2020; Ou et al., 2016; Weon et al., 2011; Kim et al., 2017). Other studies mentioned including a more generalizable population, however, these studies included college-aged overhead athletes which was the focus population for this research question. Furthermore, a few articles could have been of higher quality rather than low or good quality. Some articles were lacking a detailed methods section which made it difficult to understand. Even though the similarities have been previously discussed, participants with SIS were included in addition to participants with scapular dyskinesis in this review. It would be beneficial to study populations with only scapular dyskinesis in the future.

Conclusion

The subsequent findings included in this Critical Review of Literature corroborate the inclusion of feedback mechanisms into a rehabilitation program to be more effective than just exercise in treating and managing overhead athletes with scapular dyskinesis. The development of this conclusion resulted from analyzing 17 peer-reviewed articles using the Bethel University Graduate Nursing Program matrix format (Bethel University Graduate Nursing, n.d.). The articles were also evaluated using the John Hopkins Appraisal tool (Johns Hopkins Nursing Evidence-Based Practice, 2017). All seventeen articles recommended feedback mechanisms are effective when used in conjunction with a rehabilitation program rather than just rehabilitation exercises alone when treating or managing individuals with scapular dyskinesis. Various types of biofeedback were included: EMG biofeedback, taping feedback, verbal and visual feedback. Some feedback mechanisms may be more beneficial than others to certain individuals. These feedback mechanisms were beneficial in improving scapular function, scapular muscle activity, scapular positioning, and shoulder ROM. In conclusion, this topic does lack research specifically on surface EMG as a feedback mechanism but includes more research on taping, verbal, or visual feedback in a population of individuals with scapular dyskinesis or SIS. However, these articles have revealed that feedback mechanisms benefit individuals more when paired with a rehabilitation program rather than a rehabilitation program alone.

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Appendix A: Literature Review Matrix

Source: Antunes, A., Carnide, F., & Matias, R. (2016). Real-time kinematic biofeedback improves scapulothoracic control and performance during scapular-focused exercises: A single-blind randomized controlled laboratory study. *Human Movement Science, 48*, 44-53. doi:10.1016/j.humov.2016.04.004			
Design Methodology/Purpose	**Sample/Setting**	**Design Instruments**	**Results**
Randomized Controlled Trial **Purpose**: To determine the effectiveness of 3D kinematic feedback on motor relearning transfer during shoulder flexion and a daily activity, on the quality of scapular focused exercise performance throughout a cognitive and associative phase of shoulder relearning process. **Method**: 15 in the control group (no	30 healthy participants randomly and blindly distributed. No scapular dyskinesis **John Hopkins Evidence Appraisal** **- Level: II** **- Quality: high**	3-D kinematic data via an electromagnetic system. The only difference between groups was the kinematic biofeedback provided during scapular-focused exercises in the experimental group.	The experimental group (used kinematic biofeedback) saw immediate changes in scapular performance during shoulder flexion after the scapular-focused intervention. “Kinematic biofeedback is a productive and promising real-time extrinsic source of feedback to assist subjects in increasing their ST motor

feedback) and 15 in the experimental group (real-time visual feedback). 3 electromagnetic sensors were placed on each participant. Visual and verbal feedback was provided to reach a neutral scapular position. Each group performed the same exercises. They first performed 5 reps of each task. Shoulder flexion up to 45 degrees in a sagittal plane and mimicking drinking a glass of water. Then rested 2 minutes and performed Then 2 scapular-focused exercises were performed; relocating the scapular towards scapulothoracic neutral position for 5 reps and relocating the scapula to a neutral position when performing shoulder elevation in the free plane while holding this scapular position for 5 reps. Then they performed shoulder flexion up to 45 degrees in the sagittal plane for 5 reps and mimicked drinking a glass of water in the sagittal plane.		Participants focused on moving a yellow cross that represented scapulothoracic orientation on the abscissa axis Some verbal feedback too	control and performance”

Source: Du, W.-Y., Huang, T.-S., Chiu, Y.-C., Mao, S.-J., Hung, L.-W., Liu, M.-F., Lin, J.-J. (2020). Single-Session Video and Electromyography Feedback in Overhead Athletes With Scapular Dyskinesis and Impingement Syndrome. *Journal of Athletic Training*, *55*(3), 265–273. https://doi.org/10.4085/1062-6050-490-18			
Design Methodology/Purpose	**Sample/Setting**	**Design Instruments**	**Results**
Randomized Controlled Trial **Purpose**: determine the immediate effects of video feedback and EMG biofeedback on muscle activity, muscle balance ratios, and scapular kinematics in patients with impingement and scapular dyskinesis during arm elevation and lowering. **Method**: 41 participants were randomized into either an EMG biofeedback group or a video feedback group. Participants first had to successfully decrease the prominence of the medial border of the scapula	Research laboratory. 41 **overhead** with SIS or scapular dyskinesis. Video feedback: 21 patients EMG biofeedback: 20 patients. **John Hopkins Evidence Appraisal** **- Level: II** **- Quality: high**	Electromagnetic motion-analysis system with Motion Monitor software to collect 3-D scapular kinematics with 3 sensors. Surface EMG electrodes on the UP, LT, and SA.	EMG biofeedback training improved muscle activity. Video feedback produced higher scapular upward rotation in participants with SIS. Overall, both feedback trainings had positive effects. Decreases in UT/LT and UT/SA muscle ratios, UT muscle activity, and scapular internal rotation.

(video feedback) or lower the magnitude of muscle ratios below the threshold (EMG biofeedback) 3 times in a row. Then they performed the elevation and lowering task 9 times focusing on goals of decreasing the prominence of the scapula (video feedback) or maintaining the UT/LT muscle balance ratios below the threshold.			More specifically EMG biofeedback could help in muscle control and video feedback can improve the correction of scapular upward rotation.
Recommendations: This was a one-session intervention and long-term effects should be investigated. The limitations note that the multiple external cues may have divided the participant's attention leading to a decreased learning effect.			

Source: Hajibashi, A., Amiri, A., Sarrafzadeh, J., Maroufi, N., & Jalaei, S. (2014). Effect of Kinesiotaping and Stretching Exercise on Forward Shoulder Angle in Females with Rounded Shoulder Posture. *Journal of Rehabilitation Sciences and Research, 1*(4), 78-83.			
Design Methodology/Purpose	**Sample/Setting**	**Design Instruments**	**Results**
Randomized Controlled Trial **Purpose**: to investigate whether the effect of KT in conjunction with stretching can treat rounded shoulder posture compared to just stretching and no KT. **Method**: Participants were randomized equally into either a stretch group or a stretch + KT group. Both groups were instructed on how to perform a PM stretch bilaterally. They performed this stretch at home for 2 weeks. The KT group received tape on the scapular area. They held the stretch for 30 s, 3 repetitions in each session with one session a day. The stretch group performed the PM stretch at home, bilaterally, for two weeks. The KT + stretch group: tape was applied with 50-100% tension. Participants were asked to flatten their back (thoracic extension). Vertical KT was applied on both sides of the spine from T1 to T12. Then the participant fully depressed and retracted shoulders	20 females with rounded shoulder posture Age 18-25 **John Hopkins Evidence Appraisal** **- Level: II** **- Quality: good**	The forward shoulder angle was measured via photography. The angle between a vertical line that crossed the C7 spinous process and a line that passed through the C7 spinous process and acromion was measured. Forward shoulder angle was measured pre-intervention, immediately after the first intervention, on the fourth day, and at the end of two weeks. "In the second session, measurements were performed while the KT was on the body but in the third and fourth sessions it was done immediately after removing the KT for the combined group."	The KT group revealed a significant within-group decrease in forward shoulder angle between the pre-intervention measurement and the other three measurements taken. Scapular KT used in combination with a PM stretch improved forward-rounded shoulder posture compared to just a stretch intervention. KT used as a complementary treatment could be beneficial due to its immediate effects and ability to maintain this corrective effect until the end of the treatment.

and an oblique KT strip was applied from acromion to T12 spinous process bilaterally, tape was replaced every three days in the treatment period.			
Future studies should include a larger sample size.			

Source: Huang, T.-S., Du, W.-Y., Wang, T.-G., Tsai, Y.-S., Yang, J.-L., Huang, C.-Y., & Lin, J.-J. (2018). Progressive conscious control of scapular orientation with video feedback has improvement in muscle balance ratio in patients with scapular dyskinesis: a randomized controlled trial. *Journal of Shoulder and Elbow Surgery*, *27*(8), 1407–1414. https://doi.org/10.1016/j.jse.2018.04.006			
Design Methodology/Purpose	**Sample/Setting**	**Design Instruments**	**Results**
Randomized Controlled Trial **Purpose**: To determine if progressive conscious control of scapular orientation with visual feedback would improve scapular muscle activation during elevation in patients with SIS and SD. **Method**: participants were randomly assigned to either a visual feedback group or a control group. Both groups received a conscious control intervention but only 1 received visual feedback. 1 pre-intervention assessment was taken and 2 post-intervention assessments.	Recruited patients from an outpatient clinic. Video feedback group: 19 Control group: 19 **John Hopkins Evidence Appraisal** **- Level: II** **- Quality: good**	An electromagnetic analysis system captured scapular kinematics. Surface EMG assessed UT, LT, and SA.	Video feedback can improve and restore the UT/SA muscle ratio. The conscious control of scapular orientation decreased UT activation, increased LT activation, restored the UT/LT ratio, and improved scapular internal rotation.
Recommendations: this progressive control program can help assist patients with scapular dyskinesis and SIS learn how to control scapular orientation correctly and efficiently.			

Source: Kim, J., Shin, D., & Song, C. (2017). Visual Feedback to Improve the Effects of Scapular Stabilization Exercises on Pain Intensity, Range of Motion, Strength, and Disability in Patients with Shoulder Impingement Syndrome. *Medical Science and Technology*, *58*, 42–48. https://doi.org/10.12659/mst.904039			
Design Methodology/Purpose	**Sample/Setting**	**Design Instruments**	**Results**
Randomized controlled trial **Purpose:** Examine the influence of visual feedback to improve the effects of scapular stabilization exercises on patients with shoulder impingement syndrome.	50 patients with shoulder impingement syndrome were recruited from N Hospital in Incheon, Korea, and 45 patients met the inclusion criteria.	Patients were evaluated with the numeric pain rating scale (NPRS), ROM (digital inclinometer), strength (MMT), and the Quick Disabilities of the Arm,	Pain, ROM, muscle strength, and disability of patients with shoulder injuries showed significant improvements in the VSSE group compared to the NVSSE group. The NPRS,

Method: 45 patients with shoulder impingement syndrome were randomly allocated and placed into either a visual scapular stability exercise group (n=23) or a non-visual scapular stabilization exercise group (n=22). Both groups trained for 20 minutes a day, 3 times a week for 4 weeks. Both groups performed the same exercises. Evaluations were performed twice, one week before training started and one week after its completion.	**John Hopkins Evidence Appraisal** **- Level:** II **- Quality: good**	Shoulder, and Hand Questionnaire (Q-DASH). 3D motion images software (Poser).	ROM, strength, and Q-DASH scores showed significant differences in both groups. Visual information using real-time visual feedback and 3D motion images appears to change patients' scapular exercise strategy and improve their control of scapular movement.
Recommendations: The improvement of kinematic motion of scapulas could not be determined; therefore to generalize the results of this study a longer research period and examination of the persistent effects would be needed.			

Source: Moslehi, M., Letafatkar, A., & Miri, H. (2020). Feedback improves the scapular-focused treatment effects in patients with shoulder impingement syndrome. *Knee Surgery, Sports Traumatology, Arthroscopy*. https://doi.org/10.1007/s00167-020-06178-z			
Design Methodology/Purpose	**Sample/Setting**	**Design Instruments**	**Results**
Randomized Controlled Trial **Purpose:** Evaluate the effects of a scapular-focused treatment with and without feedback on pain, function, and scapular kinematics in patients with shoulder impingement syndrome (SIS). **Method:** 75 patients with SIS were randomly assigned to either the scapular focused treatment with feedback group (n=25) or the scapular focused treatment without feedback group (n=25) or a control group (n=25). Outcomes were measured at baseline and after the 8-week intervention.	75 patients were recruited by orthopedic physicians via flyers displayed at hospitals and a university. **John Hopkins Evidence Appraisal** **- Level:** II **- Quality:** Good	Visual Analog Scale (VAS) for pain. Function and scapular kinematics assessed by the DASH Questionnaire and 3-D motion capture.	There were significant differences with a larger effect size between SFTF and SFT in pain, function, and scapular upward rotation and tilt. A rehabilitation program with verbal feedback is effective to reduce pain and improve function and scapular kinematics in patients with SIS.
Recommendations: No limitations stated			

Source: Ozer, S. T., Karabay, D., & Yesilyaprak, S. S. (2018). Taping to Improve Scapular Dyskinesis, Scapular Upward Rotation, and Pectoralis Minor Length in Overhead Athletes. *Journal of Athletic Training*, *53*(11), 1063–1070.

https://doi.org/10.4085/1062-6050-342-17.			
Design Methodology/Purpose	**Sample/Setting**	**Design Instruments**	**Results**
Randomized controlled trial **Purpose**: Analyze the short term effects of rigid and Kinesio taping on scapular dyskinesis, scapular upward rotation, and pec minor length **Method**: Participants were randomly assigned to either a rigid taping, Kinesio taping, placebo, or control (no tape) group. All groups were evaluated immediately after taping and at 60-72 hours after taping.	72 elite asymptomatic **overhead** athletes. **John Hopkins Evidence Appraisal** **- Level: II** **- Quality: high**	Observable scapular dyskinesis. Digital inclinometer: scapular upward rotation. Pec minor length: pec minor index at baseline.	The scapular dyskinesis percentage decreased and the pec minor index increased both immediately after taping and 60-72 hours after taping in both the rigid and Kinesio tape group. These tape techniques did not affect scapular upward rotation. Both types of taping (rigid and kinesio technique) are recommended to improve scapular dyskinesis and pec minor length in overhead athletes.

Source: Shih, Y., Lee, Y., & Chen, W. (2018). Effects of Kinesiology Taping on Scapular Reposition Accuracy, Kinematics, and Muscle Activity in Athletes With Shoulder Impingement Syndrome: A Randomized Controlled Study. *Journal of Sport Rehabilitation, 27*, 560-569. https://doi.org/10.1123/jsr.2017-0043			
Design Methodology/Purpose	**Sample/Setting**	**Design Instruments**	**Results**
Randomized controlled study **Purpose**: To determine the immediate effects of kinesiology taping (KT) on scapular joint position sense, kinematics, and muscle activation in overhead athletes with SIS. **Method**: Participants were randomized into either a KT group or a control group (control taping). Baseline assessment: measurement of scapular reposition errors, scapular kinematics, and muscle activation during scaption. Then the tape was applied. The immediate effect of taping on baseline assessment was measured after the intervention, with tape on. 2 movement tasks: scapular elevation and scapular protraction. Were performed 3 times.	30 overhead athletes with SIS **John Hopkins Evidence Appraisal** **- Level: II** **- Quality: high**	An electromagnetic tracking system was used to collect 3D scapular/glenohumeral motion. Surface EMG was used to collect UT, LT, and SA muscle activity. During functional activity (scaption).	Both groups had 15 people. "Compared with the control group, the KT group improved the reposition errors for scapular tilt, UR/DR" "The findings of this study supported our hypothesis that a combination of Y and I scapular KT immediately decreased scapular reposition errors (scapular tilt and UR/DR, and scapular displacement along the y-axis during the protraction task)" "no significant immediate effect of combined Y and I KT on scapular muscle activation" Conclusions: KT application improved scapular reposition

"Vision and hearing were shielded by eye masks and earplugs to minimize the possible influence from additional feedback." KT Group: "both the UT (I tape) and LT (Y tape) using the KT. The Y tape was applied to encircle the LT from origin to insertion while the participant held the arm at 90° flexion with maximum scapular protraction. A fully stretched I-shaped tape was applied perpendicular to the muscle belly of the UT when the scapula was held in maximum retraction and depression." Control Tape: without any stretch tension, this tape was applied with the participant in a relaxed sitting position.			accuracy and scapular kinematics during scapular elevation and protraction in individuals with SIS. There was no taping effect on scapular muscle activation. KT Tape can be used as an aid for better scapular control during rehab and training athletes with SIS.
Recommendations: "Our taping, which caused immediate improvements in scapular position sense and kinematics, might provide better proximal stability for athletes performing overarm activities and therefore potentially might lead to better performance and a reduced risk of injury." Arm elevation tasks were done without weight. This and the less challenging tasks might explain why there was no effect on scapular muscle activation. Limitations: Small sample size, exercise tasks were not randomized. Future studies could include larger sample sizes, a longer period of follow-up to clarify long-term benefits.			

Source: Hsu, Y., Chen, W., Lin, H., Wang, W., & Shih, Y. (2009). The effects of taping on scapular kinematics and muscle performance in baseball players with shoulder impingement syndrome. *Journal of Electromyography and Kinesiology, 19*, 1092-1099. doi:10.1016/j.jelekin.2008.11.003			
Design Methodology/Purpose	**Sample/Setting**	**Design Instruments**	**Results**
Controlled laboratory study **Purpose**: determine the effects of elastic taping on scapular kinematics, muscle strength, and EMG activity in baseball players with SIS. **Method**: Measurements of muscle strength, EMG, and scapular kinematics were taken for both the placebo and KT sessions. The testing movement was shoulder elevation and lowering in the scapular plane. Each cycle took 8 seconds and	17 baseball players with SIS **John Hopkins Evidence Appraisal** **- Level: III** **- Quality: high**	An electromagnetic tracking system collected 3D scapular kinematic data. Surface EMG was used to collect UT, LT, and SA.	Results showed that the KT significantly increased scapular posterior tilting at 30 and 60 degrees of arm elevation. Also, there was an increase in LT activity during 60-30 degrees of arm lowering in comparison to the placebo taping. KT can be a beneficial modality during rehabilitation to help treat baseball players with SIS.

was paced by a metronome. Several practice movements were allowed before testing. The testing movement was performed with a 2 kg weight. There was a 3 min rest between trials. . All subjects received both the elastic taping (Kinesio TexTM) and the placebo taping (3 M Micropore tape) over the lower trapezius muscle. More than three days of separation between the two taping sessions was adequate			
Future studies should include more exercise training rather than this one elevation task. They also mentioned that EMG and kinematic data were recorded using skin-based methods and taping also functions via the skin, thus the validity of their data should be closely monitored in the future.			

Source: Huang, T.-S., Ou, H.-L., & Lin, J.-J. (2019). Effects of trapezius kinesio taping on scapular kinematics and associated muscular activation in subjects with scapular dyskinesis. *Journal of Hand Therapy*, *32*(3), 345–352. https://doi.org/10.1016/j.jht.2017.10.012			
Design Methodology/Purpose	**Sample/Setting**	**Design Instruments**	**Results**
Crossover repeated-measure design **Purpose**: To evaluate the influence of kinesio taping on the trapezius muscles during scapular kinematics and muscle activation in those with SD. **Method**: subjects were classified in movement patterns; inferior angle prominence, medial border prominence, abnormal upward rotation/elevation, and normal movement. Then subjects randomly received 1 of the three kinesio tapings (UT, MT, LT). Participants elevated arms over 3 seconds in the full can position and held a dumbbell weight (3 or 5 lb) depending on body weight. Kinematics and EMG data in the no taping condition were received.	54 participants were recruited from an outpatient clinic. **John Hopkins Evidence Appraisal** **- Level: III** **- Quality: high**	Surface EMG on UT, LT, MT, and SA.	Kinesio tape over the UT in SD patterns of inferior angle prominence and both medial border and inferior angle prominence showed reduced UT activity and scapular posterior tipping. Carefulness should be noted when applying tape to MT and LT muscles due to an increase of UT, especially for those with medial border prominence.
Recommendations: Combining or adjusting taping methods needs further investigation			

Source: Juan, J. G. S., Gunderson, S. R., Kane-Ronning, K., & Suprak, D. N. (2016). Scapular kinematic is altered after electromyography biofeedback training. *Journal of Biomechanics*, *49*(9), 1881–1886.

https://doi.org/10.1016/j.jbiomech.2016.04.036			
Design Methodology/Purpose	**Sample/Setting**	**Design Instruments**	**Results**
Controlled laboratory study **Purpose**: determine the effects of scapular stabilization exercises using EMG biofeedback training on scapular kinematics in healthy individuals. **Method**: patients performed a warm-up, then the scapular stabilization exercises, and were assessed by EMG data throughout. Scapular stabilization exercise = I W T Y. with a 1.8 kg weight. Performed while standing.	23 volunteers. **John Hopkins Evidence Appraisal** **- Level: III** **- Quality: high**	Surface EMG electrodes placed on UT, LT, SA, and lumbar paraspinals. A 3D magnetic tracking system was used to collect scapulothoracic and thoracic-humeral kinematic data.	No significant changes in scapular upward rotation and posterior tilting. Scapular stabilization exercises combined with EMG biofeedback training caused the scapula to be in a more ER position during the entire ROM. This places the shoulder in a retracted position and helps decrease the chance of SIS.
Recommendations:			

Source: Mey, K. D., Danneels, L., Cagnie, B., Huyghe, L., Seyns, E., & Cools, A. M. (2013). Conscious Correction of Scapular Orientation in Overhead Athletes Performing Selected Shoulder Rehabilitation Exercises: The Effect on Trapezius Muscle Activation Measured by Surface Electromyography. *Journal of Orthopaedic & Sports Physical Therapy*, *43*(1), 3–10. https://doi.org/10.2519/jospt.2013.4283			
Design Methodology/Purpose	**Sample/Setting**	**Design Instruments**	**Results**
Controlled laboratory study **Purpose**: To determine if conscious correction of scapula orientation influences the absolute and relative muscle activation levels during 4 exercises that promote high MT and LT muscle activation levels while minimizing UT activation in overhead athletes with scapular dyskinesis. **Method**: 30 patients were tested for baseline MVIC levels without scapular orientation education. They were then educated on proper scapular orientation and assessed for maximal voluntary isometric contraction (MVIC) levels again. Average EMG activation of the UT, MT, and LT was determined over a window of 2 seconds after the start of each exercise, then normalized according to the MVIC method.	30 (18 men and 12 women) healthy subjects with asymptomatic scapular dyskinesis observed by a clinician and classified as either prominence of the inferior medial scapular angle (type 1), the entire medial border (type 2), or the superior border of the scapula (type 3). **All subjects were active in overhead sports.** **John Hopkins Evidence Appraisal** **- Level:** III **- Quality: low**	Bipolar surface electromyographic (EMG) electrodes were placed at a 2 cm interelectrode distance over the UT, MT, and the LT of the dominant shoulder and connected to an EMG receiver. EMG signal quality was completed for each muscle by having each patient perform an MVIC 3 times for 5 seconds against manual resistance.	Conscious correction of scapular orientation significantly increased the absolute muscle activation levels in the 3 sections of the trapezius for the prone extension and sidelying ER exercises. The UT/MT and UT/LT ratios were not changed by the intervention for any of the 4 exercises. These 4 exercises remain relevant for trapezius muscle balance rehabilitation when conscious scapular orientation is performed.

Recommendations: More studies are needed to define the ability of individuals to maintain a corrected scapular position during each exercise by measuring multiple muscles (rhomboids and serratus anterior). Studies examining the effect of exercises focusing on high activation levels of scapular stabilizers compared to those focusing on correction of the 3-D dynamic movement patterns would be useful knowledge. The long-term effect of scapular orientation and trapezius muscle balance rehabilitation exercises should be examined. It is unclear how conscious correction of scapular orientation influences the activation of the trapezius muscle during dynamic movements under loaded conditions. The 4 exercises = prone extension, side-lying external rotation, side-lying forward flexion, and prone horizontal ABD with ER.

Source: Tooth, C., Schwartz, C., Colman, D., Croisier, J.-L., Bornheim, S., Brüls, O., Forthomme, B. (2020). Kinesiotaping for scapular dyskinesis: The influence on scapular kinematics and on the activity of scapular stabilizing muscles. *Journal of Electromyography and Kinesiology*, *51*, 102400. https://doi.org/10.1016/j.jelekin.2020.102400			
Design Methodology/Purpose	**Sample/Setting**	**Design Instruments**	**Results**
Quasi-experimental **Purpose**: Examine the effectiveness of 2 different kinesiotaping techniques on scapular kinematics and the activity of scapular stabilizing muscles in individuals with asymptomatic SD. **Method**: Each individual experienced standard (no tape), KT1 tape technique and KT2 taping technique.	20 volunteer **overhead** athletes. **John Hopkins Evidence Appraisal** **- Level: III** **- Quality: high**	EMG activity of the upper and lower trap and the serratus anterior during an isometric contraction at 6 different positions.	KT2 technique decreased lower trap activity (increasing scapular dysfunction) and resulted in negative effects on scapular external rotation. KT1 technique: during upward rotation it reduces rotator cuff compression and increases subacromial space in patients with downward rotation at rest. Both KT1 and KT2 significantly increased posterior tilt and upward rotation. KT1 technique (shoulder at 60° ABD, tape from coracoid process then firmly on the upper trap and on the inferior angle of the scap) was the most effective technique to increase the subacromial space. KT2 shows a decrease in lower trap activity and limits external rotation of the scap.
Recommendations: The KT1 technique is the most effective for SD and a muscle imbalance of UT/LT, this could be useful in reducing shoulder injuries in overhead athletes with downward rotation at rest or forward shoulder posture by increasing the subacromial space.			

Source: Weon, J., Kwon, O., Cynn, H., Lee, W., Kim, T., & Yi, C. (2011). Real-time visual feedback can be used to activate scapular upward rotators in people with scapular winging: An experimental study. *Journal of Physiotherapy, 57,* 101-107.

Design Methodology/Purpose	Sample/Setting	Design Instruments	Results
Controlled laboratory study **Purpose**: to investigate the effects of real-time visual feedback to facilitate SA activity in individuals with scapular dyskinesis. **Method**: Participants were seated and asked to flex the shoulder to 60 and 90 degrees and hold for 5 seconds. Either with or without real time visual feedback. The angle and feedback conditions were randomized. Visual feedback via video cameras. Shoulder angle was measured via a goniometer. "If shoulder depression, tilting, or winging were observed during shoulder flexion, the investigator encouraged the subject to protract and elevate the scapula. " Participants were allowed a 15 min familiarization phase using visual feedback. The shoulder flexion task was performed 3 times with a 3 min rest period between trials.	19 individuals with scapular dyskinesis **John Hopkins Evidence Appraisal** **- Level: III** **- Quality: high**	Surface EMG measured UT, LT, and SA. "A reflective marker (14 mm in diameter) was placed on the skin at the midpoint of the acromion to measure its displacement in the frontal and sagittal planes during shoulder flexion" "The distance of the acromion movement was measured from the starting position to the end of the predetermined shoulder flexion position in cm by the video motion analysis system software"	Each participant experienced all aspects of the intervention according to random allocation of testing conditions. Visual feedback significantly increased UT activity at 60 degrees, SA activity at 90 and 60 degrees, and movement of the acromion superiorly at 60 degrees and anteriorly at 60 and 90 degrees. Thus, real-time visual feedback is beneficial in increasing activation of the UT and SA and improving scapular kinematics during shoulder flexion compared to no visual feedback in individuals with scapular dyskinesis.
Future studies should analyze long term effects of real-time visual feedback.			

Source: Ou, H., Huang, T., Chen, Y., Chen, W., Chang, Y., Lu, T.,. Lin, J. (2016). Alterations of scapular kinematics and associated muscle activation specific to symptomatic dyskinesis type after conscious control. *Manual Therapy, 26*, 97-103. doi:10.1016/j.math.2016.07.013			
Design Methodology/Purpose	**Sample/Setting**	**Design Instruments**	**Results**
Cross-sectional study Cohort study **Purpose**: To examine whether subjects with symptomatic scapular dyskinesis can actively alter scapular orientation and associated muscle activities via conscious control. **Method**: 60 subjects with symptomatic SD performed 3 exercises (arm elevation, side-lying elevation, and side-lying ER) with and without conscious control.	60 subjects with symptomatic SD. Exclusion criteria included previous rotator cuff tear and surgical stabilization of the shoulder. **John Hopkins Evidence Appraisal** **- Level: IV** **- Quality: low**	Electromagnetic-based motion analysis system. Surface EMG to measure maximal voluntary isometric contraction.	Conscious control of the scapula can alter scapular orientation and MT, LT, and SA activation during the 3 selected exercises. Conscious control during the side-lying ER exercise can be applied to increase SA activity. Conscious control can improve proprioception, normalize the scapular resting position, and promote trapezius muscle activation. In this study, conscious control

			had an impact on scapular kinematics and muscle coordination The cue "retract the scapula" promoted MT and LT muscle activation but not SA activation.

Limitations: no control group, lacked long term follow-up, therefore it is unknown if conscious control can translate to long term benefits. Only 3 exercises were examined.

"Many patients demonstrated abnormal movement patterns during daily activity, sports-related shoulder exercise, and functional movements. Whether conscious control of the scapula can alter those abnormal movement patterns is still unknown."
"This study demonstrated that conscious control of the scapula can alter scapular orientation and associated muscle activation in symptomatic subjects during 3 selected exercises such that it is closer to that exhibited in healthy individuals."

Source: Turner, A. (2019). Conservative Treatment of a Rotator Cuff Tear With Accompanying Scapular Dyskinesis: A Case Report. *International Journal of Athletic Therapy and Training, 24*(2), 54-63. doi:10.1123/ijatt.2018-0103

Design Methodology/Purpose	**Sample/Setting**	**Design Instruments**	**Results**
Case Report **Purpose**: Examine the conservative treatment of a supraspinatus tendon tear with accompanying scapular dyskinesis in a synchronized ice skater. **Method**: The individual participated in 2 weeks of conservative PT with exercises including band-resisted IR and ER, standing rows, and chest press performed daily for 3 sets of 15 reps. The patient did not experience any improvement in pain, sleep quality, or ADLs. The participant was referred to the author of this case report. A 12 week program included two 6-week programs with 11 exercises each. Sessions were completed 3 times a week.	20 y/o national-level ice skater with SD only in the left shoulder and a supraspinatus tear (4 mm). **John Hopkins Evidence Appraisal** **- Level: IV** **- Quality: low**	NONE….	The patient was able to return to full level of sport in 9 weeks. Pain subsided after 4 weeks of treatment and remained absent at the 6-month follow-up. For non-throwing athletes, treatment of SD in the presence of a rotator cuff tear can alleviate pain and dysfunction followed by a faster RTP when compared to surgical interventions.

Exercise program - phase 1
- Pectoralis minor ball release
- Supine arm raise (lead with thumbs)
- Open book (left arm only)
- Prone shoulder retraction with external shoulder rotation (arms by sides)
- Supine shoulder protraction (w/ shoulder flexed at 90)
- Foam roller wall push
- Activation training for SA muscle (standing and walking)

- DB shrugs - Lat pull-down (supine grip) - Seated cable row - Prone DB bench pull Exercise program - phase 2 - Pectoralis minor ball release - Supine arm raise (lead with thumbs) - Prone shoulder retraction with external shoulder rotation (arms by sides) - Foam roller wall push - Arm elevation in scapular plane (performed standing) - DB shrugs - Lat pull-down (supine grip) - Seated cable row - Prone DB bench pull - Alternating DB shoulder press (sagittal plane)

Source: Snodgrass, S. J., Farrell, S. F., Tsao, H., Osmotherly, P. G., Rivett, D. A., Chipchase, L. S., & Schabrun, S. M. (2018). Shoulder Taping and Neuromuscular Control. *Journal of Athletic Training*, *53*(4), 395–403.			
Design Methodology/Purpose	**Sample/Setting**	**Design Instruments**	**Results**
Descriptive laboratory study **Purpose**: Examine changes in the timing and amplitude of scap muscle contraction during shoulder flexion and abd. Determine changes in corticomotor excitability of scap and middle delt muscles after tape application. **Method**: 2 sessions were attended and outcomes were measured before tape, immediately after tape application, 24 hours after tape application and then with tape removed during the 2nd session.	15 volunteers with no hx of shoulder pain **John Hopkins Evidence Appraisal** **- Level: VI** **- Quality: good**	Surface EMG to measure contraction of upper trap, lower trap, and serratus anterior in comparison to the middle trap during shoulder flexion and abduction.	Shoulder taping led to an earlier onset of upper and lower trap muscle contractions during shoulder abd and flexion. An increase in shoulder ABD ROM immediately after taping could be due to the facilitation of upward scap rotation. These changes were not maintained 24 hours after tape application.
Recommendations: If using scapular taping to manage shoulder pain, clinicians should consider combining rehabilitative exercises. More research is required to determine the neurophysiologic response to scapular taping in a population with shoulder pain.			

Appendix B: Quality Assessments and Level of Evidence Chart

Hierarchy of Evidence for Intervention Studies

Type of evidence	Level of evidence	Description
Systematic review or meta-analysis	I	A synthesis of evidence from all relevant randomized controlled trials.
Randomized controlled trial	II	An experiment in which subjects are randomized to a treatment group or control group.
Controlled trial without randomization	III	An experiment in which subjects are nonrandomly assigned to a treatment group or control group.
Case-control or cohort study	IV	Case-control study: a comparison of subjects with a condition (case) with those who don't have the condition (control) to determine characteristics that might predict the condition. Cohort study: an observation of a group(s) (cohort[s]) to determine the development of an outcome(s) such as a disease.
Systematic review of qualitative or descriptive studies	V	A synthesis of evidence from qualitative or descriptive studies to answer a clinical question.
Qualitative or descriptive study	VI	Qualitative study: gathers data on human behavior to understand *why* and *how* decisions are made. Descriptive study: provides background information on the *what*, *where*, and *when* of a topic of interest.
Expert opinion or consensus	VII	Authoritative opinion of expert committee.

Adapted with permission from Melnyk BM, Fineout-Overholt E, editors. Evidence-based practice in nursing and healthcare: a guide to best practice [forthcoming]. 2nd ed. Philadelphia: Wolters Kluwer Health/Lippincott Williams and Wilkins.

Johns Hopkins Nursing Evidence-Based Practice
Research Evidence Appraisal Tool

Evidence Level and Quality:____________________

Article Title:		Number:
Author(s):		Publication Date:
Journal:		
Setting:	Sample (Composition & size):	
Does this evidence address my EBP question?	☐Yes	☐No Do not proceed with appraisal of this evidence

Level of Evidence (Study Design)			
A. Is this a report of a single research study? ***If No, go to B.***		☐Yes	☐No
1. Was there manipulation of an independent variable?		☐Yes	☐No
2. Was there a control group?		☐Yes	☐No
3. Were study participants randomly assigned to the intervention and control groups?		☐Yes	☐No
If Yes to all three, this is a Randomized Controlled Trial (RCT) or Experimental Study →	☐ LEVEL I		
If Yes to #1 and #2 and No to #3, OR Yes to #1 and No to #2 and #3, this is Quasi Experimental (some degree of investigator control, some manipulation of an independent variable, lacks random assignment to groups, may have a control group) →	☐ LEVEL II		
If No to #1, #2, and #3, this is Non-Experimental (no manipulation of independent variable, can be descriptive, comparative, or correlational, often uses secondary data) **or Qualitative** (exploratory in nature such as interviews or focus groups, a starting point for studies for which little research currently exists, has small sample sizes, may use results to design empirical studies) →	☐ LEVEL III		
NEXT, COMPLETE THE BOTTOM SECTION ON THE FOLLOWING PAGE, "STUDY FINDINGS THAT HELP YOU ANSWER THE EBP QUESTION"			

Johns Hopkins Nursing Evidence-Based Practice
Research Evidence Appraisal Tool

Quality Appraisal of Research Studies			
• Does the researcher identify what is known and not known about the problem and how the study will address any gaps in knowledge?	☐Yes	☐No	
• Was the purpose of the study clearly presented?	☐Yes	☐No	
• Was the literature review current (most sources within last 5 years or classic)?	☐Yes	☐No	
• Was sample size sufficient based on study design and rationale?	☐Yes	☐No	
• If there is a control group:			
o Were the characteristics and/or demographics similar in both the control and intervention groups?	☐Yes	☐No	☐NA
o If multiple settings were used, were the settings similar?	☐Yes	☐No	☐NA
o Were all groups equally treated except for the intervention group(s)?	☐Yes	☐No	☐NA
• Are data collection methods described clearly?	☐Yes	☐No	
• Were the instruments reliable (Cronbach's α [alpha] $\geq$ 0.70)?	☐Yes	☐No	☐NA
• Was instrument validity discussed?	☐Yes	☐No	☐NA
• If surveys/questionnaires were used, was the response rate $\geq$ 25%?	☐Yes	☐No	☐NA
• Were the results presented clearly?	☐Yes	☐No	
• If tables were presented, was the narrative consistent with the table content?	☐Yes	☐No	☐NA
• Were study limitations identified and addressed?	☐Yes	☐No	
• Were conclusions based on results?	☐Yes	☐No	

Quality Appraisal of Systematic Review with or without Meta-Analysis or Meta-Synthesis		
• Was the purpose of the systematic review clearly stated?	☐Yes	☐No
• Were reports comprehensive, with reproducible search strategy?	☐Yes	☐No
o Key search terms stated	☐Yes	☐No
o Multiple databases searched and identified	☐Yes	☐No
o Inclusion and exclusion criteria stated	☐Yes	☐No
• Was there a flow diagram showing the number of studies eliminated at each level of review?	☐Yes	☐No
• Were details of included studies presented (design, sample, methods, results, outcomes, strengths and limitations)?	☐Yes	☐No
• Were methods for appraising the strength of evidence (level and quality) described?	☐Yes	☐No
• Were conclusions based on results?	☐Yes	☐No
o Results were interpreted	☐Yes	☐No
o Conclusions flowed logically from the interpretation and systematic review question	☐Yes	☐No
• Did the systematic review include both a section addressing limitations and how they were addressed?	☐Yes	☐No

QUALITY RATING BASED ON QUALITY APPRAISAL

A **High quality:** consistent, generalizable results; sufficient sample size for the study design; adequate control; definitive conclusions; consistent recommendations based on comprehensive literature review that includes thorough reference to scientific evidence

B **Good quality:** reasonably consistent results; sufficient sample size for the study design; some control, and fairly definitive conclusions; reasonably consistent recommendations based on fairly comprehensive literature review that includes some reference to scientific evidence

C **Low quality or major flaws**: little evidence with inconsistent results; insufficient sample size for the study design; conclusions cannot be drawn

Johns Hopkins Nursing Evidence-Based Practice
Research Evidence Appraisal Tool

B. Is this a summary of multiple research studies? ***If No, go to Non-Research Evidence Appraisal Form.***		☐Yes	☐No
1. Does it employ a comprehensive search strategy and rigorous appraisal method (**Systematic Review**)? ***If No, use Non-Research Evidence Appraisal Tool; if Yes:***		☐Yes	☐No
a. Does it combine and analyze results from the studies to generate a new statistic (effect size)? (**Systematic review with meta-analysis**)		☐Yes	☐No
b. Does it analyze and synthesize concepts from qualitative studies? (**Systematic review with meta-synthesis**)		☐Yes	☐No
If Yes to either a or b, go to #2B below.			
2. For Systematic Reviews and Systematic Reviews with meta-analysis or meta-synthesis:			
a. Are all studies included RCTs? →	☐ LEVEL I		
b. Are the studies a combination of RCTs and quasi-experimental or quasi-experimental only? →	☐ LEVEL II		
c. Are the studies a combination of RCTs, quasi-experimental and non-experimental or non-experimental only? →	☐ LEVEL III		
d. Are any or all of the included studies qualitative? →	☐ LEVEL III		
COMPLETE THE NEXT SECTION, "STUDY FINDINGS THAT HELP YOU ANSWER THE EBP QUESTION"			

STUDY FINDINGS THAT HELP YOU ANSWER THE EBP QUESTION:

NOW COMPLETE THE FOLLOWING PAGE, "QUALITY APPRAISAL OF RESEARCH STUDIES", AND ASSIGN A QUALITY SCORE TO YOUR ARTICLE

