Introduction

Swimming consists of four strokes: freestyle, backstroke, breaststroke, and butterfly. Freestyle is the fastest of the four strokes and commands the majority of practice time. The average competitive swimmer practices 5-7 days a week, completes 6,000 – 10,000 meters a day and 60,000-80,000 meters a week.[1] With an average stroke count of 8-10 strokes per lap, each shoulder performs over 30,000 rotations a week. The upper extremities provide about 90% of the propulsive force, exerting tremendous amounts of stress on the glenohumeral joint and shoulder girdle.[1] Therefore, it is no surprise that shoulder pain is the most common musculoskeletal complaint among competitive swimmers. There is a wide incidence of shoulder pain reported throughout the literature. It is notable that 47% of 10-18 year olds, 66% of senior development swimmers, and 73% of elite swimmers have reported a history of shoulder pain that has interfered with training and competition.[1,9]

The term "swimmer's shoulder" describes the general, painful shoulder symptoms experienced throughout the year long season by competitive swimmers. These symptoms can be triggered by decreased muscle strength and endurance[4,5], muscle imbalances[1-4,6-8],altered scapular kinematics[3,5], improper swimming technique[1,6,7], poor posture[1,3,4], fatigue[5,6], and overuse[1,6]. The presence of these factors may place the swimmer at risk for injury.

Due to the relatively high incidence of shoulder pain and risk for injury, an injury prevention program should be implemented as additional training to prevent shoulder pain and injuries. The current literature recommends prevention training for competitive swimmers; however, there are a limited number of studies that investigate this issue.[1,10] The available evidence has multiple intervention focal points. It ranges from correcting muscle imbalances, strengthening weakened glenohumeral and scapular muscles, stretching tight musculature, to correcting poor posture. To date, there is no effective injury prevention program available to implement.[1,10]

This literature review will discuss causative factors that contribute to shoulder pain and the intervention methods that attempt to prevent its occurrence in competitive swimmers. The purpose of this review is to answer this clinical question: For competitive swimmers between 10-25 years old, does a scapular strengthening program vs. no strengthening program, decrease the risk of seasonal shoulder injuries? Conclusions from this review will 1) guide the creation of a shoulder injury prevention program for competitive swimmers and 2) to identify possible risk factors that may need to be addressed by the physical thearpist for preventative and rehabilitation services.

Article Discussion

The literature review for the prevention of seasonal shoulder injuries encompasses multiple approaches that differ in research design, inclusion/exclusion criteria, intervention, and outcome measures. This review is organized into three groups based on the intervention's focus which are functional exercise, posture, and muscle balance. The literature is compared and further discussed in the sections below.

Functional Exercise

The aim of functional exercise training is to improve neuromuscular control, encourage force couples to work in concert, and improve joint protection while mimicking the demands of the sport in a controlled environment.[6] The literature contained two randomized control studies that used functional exercise training to increase shoulder strength and prevent shoulder pain in collegiate swimmers. Both interventions were performed 3 days a week for 6 weeks during preseason training.[1,6] The presence of shoulder pain was assessed prior to the intervention.

Hibberd et al. excluded any type of shoulder pain prior to and during the intervention whereas Swanik et al. included subjects with shoulder pain who showed no training limitations. The control groups only participated in their normal swim[1,6] and dry land training[6]. The intervention groups had additional functional exercise training which involved glenohumeral and scapular strengthening[1,6] and stretching[1].

The targeted outcomes were isometric[1] and concentric[6] strength of select musculature, scapular kinematics[1] and the incidence of shoulder pain[6]. Both interventions resulted in strength gains. However, there were no significant strength improvements between the intervention and control groups.[1,6] The swimmers scapulae became more protracted, elevated, and internally rotated, which was attributed to sport adaptations.[1] The intervention group had significantly fewer reports of shoulder pain at the end of the intervention compared to the control group.[6]

Posture

Postural malalignments can cause muscle imbalances surrounding the shoulder and scapula, and are associated with painful shoulders in swimmers.[3,4] Interventions that target scapular strengthening and stretching of the tight anterior musculature is thought to improve posture, shoulder mechanics, and pain.[3,4] Two studies investigated the effects of this approach on collegiate and elite swimmers who exhibited forward head and rounded shoulder posture.[3,4] Both studies included subjects with shoulder pain that did not interfere with training. All subjects participated in normal swim[3,4] and dry land training[4]. The intervention groups performed additional training to lengthen the tight anterior musculature and strengthen the shoulder and scapular muscles.[3,4]

The first by Lynch et al. conducted a randomized control study that involved scapular strengthening 3 days a week for 8 weeks. They considered posture, isometric strength of the periscapular musculature, shoulder pain and function.[3] In a similar approach, Kluemper et al. performed a “pseudo-randomized” control trial that involved a comparable intervention 3 days a week for 6 weeks. This was the only study that scheduled to increase resistance and repetitions throughout the intervention. However, posture was the only measure assessed.[4]

The applied interventions resulted in significant improvements in posture.[3,4] The most notable changes occurred in the Lynch et al. study where there were significant differences in posture between the intervention and control groups at post-testing.[3] All subjects experienced strength gains in the targeted muscles. Despite not having significant gains in strength, the subjects in the intervention group reported decreased shoulder pain following the intervention.[3]

Muscle Balance

The shoulder rotators play an important role in the mobility and stability of the glenohumeral joint. The repetitive adduction and internal rotation movements of the upper extremity while swimming can contribute to muscle imbalances, abnormal scapular kinematics, shoulder pain and injury.[2,7,8] Four studies further investigated this issue. The first two studies involved no intervention. A case control study by Bak et al. examined the concentric and eccentric strength of the internal and external rotators, shoulder strength in flexion and abduction, internal and external range of motion in elite swimmers with and without shoulder pain.[7] The authors found a significant difference between the two groups for eccentric external rotation to concentric internal rotation. They noted internal rotation strength deficits in the painful shoulders and no difference in external rotation.[7] Next, Batalha et al. performed a cohort study to discover what effects competitive swimming has on rotator cuff strength, muscle balance, and muscle endurance in swimmers with no shoulder pain.[8] The study compared elite swimmers who participated in normal swim training to non-swimmers of the same age over a 32 week season. The authors assessed peak torque for the internal and external rotators, the external to internal rotation ratio and endurance ratios. Significant group differences were apparent in internal and external rotation strength. The swimmer group showed an increase in internal rotation strength that exceeded that of the external rotators. This resulted in a noticeable decline in the external to internal rotator ratio at 16 and 32 weeks. Therefore, swim training caused muscle imbalances with weakness in the external rotators.[8]

The final two studies take a unique approach. Niederbracht et al. also focused on the relationship between the eccentric external to concentric internal rotation strength but with collegiate tennis players.[2] In this cohort study, subjects performed normal preseason training in the absence of shoulder pain. The intervention group also completed strengthening exercises with theraband tubing 4 times a week for 5 weeks.[2] Additionally, Van de Velde et al. conducted a randomized control trial in swimmers without shoulder pain to evaluate scapular muscle performance after strength and endurance based interventions.[5] Both groups performed normal swim training plus the intervention 3 times a week for 12 weeks; however, no control group was present.[5]

Strength (total work[2] and peak force[2,5]), fatigue[5], and scapular strength ratios[2,5] were the outcomes of interest. Both interventions resulted in strength gains.[2,5] Neiderbracht et al. noted a significant difference between the two groups in total work of eccentric external rotation. The ratio of eccentric external to concentric internal rotation was greater in the intervention group compared to the control, which demonstrates that this treatment can improve scapular muscle ratios in overhead athletes.[2] Whereas Van de Velde et al. found no group differences in any of the outcome measures and the protraction to retraction ratio only improved on the non-dominant side, but was successful in increasing muscular symmetry.

Discussion

Study Limitations & Critical Analysis of the Evidence

The functional exercise intervention contained the highest level of evidence, followed by the postural intervention. [2,3,4,6] Both interventions contain randomized control trials; however, a "pseudo-randomized" study was present in the posture section, which lowers its strength.[4] The muscle balance intervention had the lowest evidence. It was comprised of two cohorts, one case control, and one randomized control trial.[2,5,7,8] The randomized controlled trial by Van de Velde et al. did not contain a control group for comparison. This addition would have strengthened the results and allowed for additional comparisons.[5] As a whole, these studies displayed moderately strong evidence. However, the quality of the evidence was reduced due to the degree of blinding, the lack of proper blinding and randomization. Additionally, power analysis was not calculated or discussed in any of the articles. All of the sample sizes were relatively low and ranged from 12 to 44 participants. The lack of sample size justification calls to question the presence and potential of a true effect.

The results are specific to the age groups, genders, and swim abilities that were analyzed in each study.[5,8] Therefore, it may be difficult to generalize the results to other swim groups.[8] Moreover, the literature commonly groups overhead athletes together. The subjects from the Niederbracht et al. study were tennis players, not swimmers. Although the movements are similar, the unique forces involved in swimming may be overlooked. There is no known relationship between other overhead sports and swimming at this time.[2] Based on these factors, clinicians should use caution when applying these results to clinical practice.

The incidence of shoulder pain was reduced during functional exercise and postural focused interventions.[3,6] This may indicate that a strengthening program for the shoulder has a protective effect.[3,6] However, these are the only two identified studies that have tracked this outcome. It would be valuable to know if the other strengthening interventions have similar effects and if these results are reproducible in larger studies.

The timing of the intervention may play a role in the observed strength outcomes. With the control groups experiencing comparable strength gains as the intervention group, it is likely that significant differences are being masked. [1,2,3,5,6] Three studies implemented the intervention during preseason training.[1,2,6] The remaining studies failed to report this timing, but also had similar results.[3,5] It is also reasonable to suggest that the intensity of the strengthening programs was not high enough to produce significant strengthening effects. The study by Kluemper et al. neglected to measure strength, which restricts the applicability of its intervention. Additionally, it is important to note which muscles groups are hypertrophying. The muscular ratio may have a stronger relationship to the development of abnormal scapular kinematics, poor posture, shoulder pain, and risk of injury compared to general strength deficits.[5,7,8] Furthermore, strength was assessed in an upright, sitting position which does not accurately recreate the shoulder position where it is normally stressed during repetitive swim strokes. Therefore, the results may not accurately depict swimming specific strength.[2,5,6,7]

The duration of the intervention as well as the strengthening exercises included in the studies varied. The interventions ranged from 5 to 12 weeks.[1-6] Batalha et al. reveals that swimming causes a significant decline in external to internal strength ratio throughout the entire swim season.[8] Therefore, the duration of these studies may not be long enough to counteract the strong forces imposed by swim training alone.[1,4,6] Furthermore, the commonly implemented exercises involved internal and external rotation, rows, W, Y, and Ts.[1-4,6] The positioning and resistance of these exercises differed by study. The positions involved standing or prone on a stable or unstable surface. Select exercises used therabands and dumbbells for additional resistance.[1-6] These additional intervention parameters may contribute or deter the subject's ability to accurately activate and recruit the proper musculature, and make strength gains.

Reference to PICO Question & Future Research

This literature review revealed two strengthening interventions that successfully reduced the incidence of shoulder pain in competitive swimmers.[3,6] It is plausible that the initiation of either functional exercise or postural interventions prior to the development of shoulder pain would be successful in preventing its occurrence. However, more research is needed to make this correlation. This evidence is unable to definitively answer the proposed PICO question at this time. Nevertheless, the evidence has proven useful by demonstrating interventions that lower the incidence of shoulder pain, providing strengthening exercises to utilize in the clinic, and identifying swimming related factors at increase the risk of shoulder injuries. The next step is to implement shoulder strengthening programs in order to determine if it can prevent shoulder injuries.

There is limited research that investigates the impact of shoulder strengthening programs to reduce seasonal shoulder injuries in competitive swimmers. This literature review was able to identify gaps that need further exploration in order to find the best intervention approach in regards to the timing, duration, and focus. A season long intervention may result in greater strength improvements, identify long term outcomes, and success of the intervention.[1,4,6] Future clarification is needed to ascertain if targeting the generalized shoulder musculature or the specific scapular ratios has better results. Optimal strengthening exercises also need to be determined in order to make significant strength gains in the presence of high, repetitive swim forces. Furthermore, this research needs to contain a wider spectrum of subjects so that it can be generalized to various groups of swimmers. Therefore, the same question remains; can a strengthening intervention prevent seasonal shoulder injuries?

Application to Clinical Practice and Capstone Project

These studies offer relevant information to guide clinical practice. First, high frequency shoulder strengthening may be effective in correcting rotator cuff imbalances, but further research is necessary to determine the long term benefits.[2] This high frequency training may be attainable through a home exercise program and would further validate its prescription in the clinic. Next, it gives insight into the duration of the strengthening intervention. With strength gains becoming visible at 6 weeks of training, a longer period of time should be allotted to achieve significant strength gains.[6] Additionally, a focus on functional exercise or postural correction is successful in reducing the incidence of shoulder pain.[3,6] These studies show that multiple, successful methods exist and can provide treatment ideas in the clinic. General strengthening of the shoulder is able to increase strength and symmetry.[5] However, the consideration of the external to internal rotator ratio may identify muscles to target for strengthening.[6]

It is clear that the human body adapts to the repetitive swimming forces by increasing strength and muscle asymmetry, which can lead to shoulder pain and injuries.[5,8] These previous studies provide a framework for the creation of a shoulder strengthening program for current competitive swimmers. For my capstone project, I will develop and implement a shoulder strengthening program for a competitive swim team in Winston-Salem, NC based on the findings from these studies. My goal is to achieve strength gains, improve muscular asymmetries, decrease the incidence of shoulder pain, and therefore prevent shoulder injuries.

Conclusion

Competitive swimmers are at risk of shoulder injuries due to the repetitive nature of the sport and risk factors such as strength deficits, poor posture, and muscular imbalances. A shoulder injury prevention program needs to be implemented to reduce this risk. The research shows that strengthening interventions that focus on functional exercise, posture, and muscular balance can increase strength and reduce the incidence of shoulder pain. Further research is needed especially in regards to long term outcomes. However, this literature provides physical therapists with the basic treatment strategies when presented with this population in clinical practice.

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