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Shoulder Dysfunction in High School Tennis Players - An Exploratory Study

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ABSTRACT

Previous studies have investigated sports activity related shoulder dysfunction, such as scapular dyskinesis and glenohumeral internal rotation deficit (GIRD), mainly in high-level tennis players. The prevalence of these dysfunctions in comparatively low to moderate level tennis players, such as those at the high school level is poorly understood. The purpose of this study was to explore the prevalence of scapular dyskinesis and GIRD at the high school level and identify some of the factors that makes a high school tennis player more susceptible to developing shoulder dysfunction. A survey related to sports-related shoulder dysfunction was developed in collaboration with physical therapists and was completed by twenty-seven high school level tennis players. The results show that players who have more years of experience, played tennis more often on a weekly basis, and were on the varsity team are more likely to develop shoulder pain and dysfunction. The average number of symptoms increased with years of playing experience and a higher frequency of playing tennis every week, with more than 40% of players on the varsity team reporting a decrease in the velocity, control, and arm motion during their serve. While male players reported more symptoms related to pain, decreased performance and strength, female players reported almost three times more occurrence of lower shoulders compared to male players. Players who consistently did workouts for shoulder and back muscles were less likely to develop shoulder pain and dysfunction, regardless of their level of experience and gender.

Introduction

Players involved in sports that require extensive overhead action, such as tennis and handball, are said to be at higher risk for developing shoulder dysfunction such as scapular dyskinesis and glenohumeral internal rotation deficit (GIRD). Lehman (1988) reported that high-level tennis players had a 24% prevalence of shoulder pain, with prevalence increasing to 50% in middle aged participants. Similarly, Abrams et al. (2012) and Hutchinson et al. (1995) found that shoulder injuries were present in 4% to 17% of tennis players at all levels. Recently, Hickey et al. (2018) observed that athletes with scapular dyskinesis were at 43% greater risk for developing shoulder pain even if the athletes were asymptomatic.

Scapular dyskinesis is the altered control of the shoulder blade muscles (Ruotolo, 2014). The overhead action in throwing sports, specifically the serve motion in tennis, has been described as “unnatural and highly dynamic, often exceeding the physiological limits of the joint” (van der Hoeven and Kibler, 2006). There are 5 stages during a tennis serve (Figure 1): wind up, early cocking, late cocking, acceleration, and follow-through. During the cocking stages, the shoulder blade must retract as the racquet is brought back. The muscles that retract the shoulder blade must also control it as the racquet is swung through the acceleration stage to the follow-through stage within a fraction of a second. This motion causes the shoulder blade to be pulled forward, which then needs to be pulled back again for the following serve or shot. As it is repeatedly put under stress, the shoulder blade could sit in a protracted position and usually lower than the other shoulder, also known as the “SICK scapula” shoulder pathology. This positioning of the scapula leads to an abnormal movement of the

scapula during the overhead motion of a serve and a loss of muscular control (Ruotolo, 2014; van der Hoeven and Kibler, 2006).

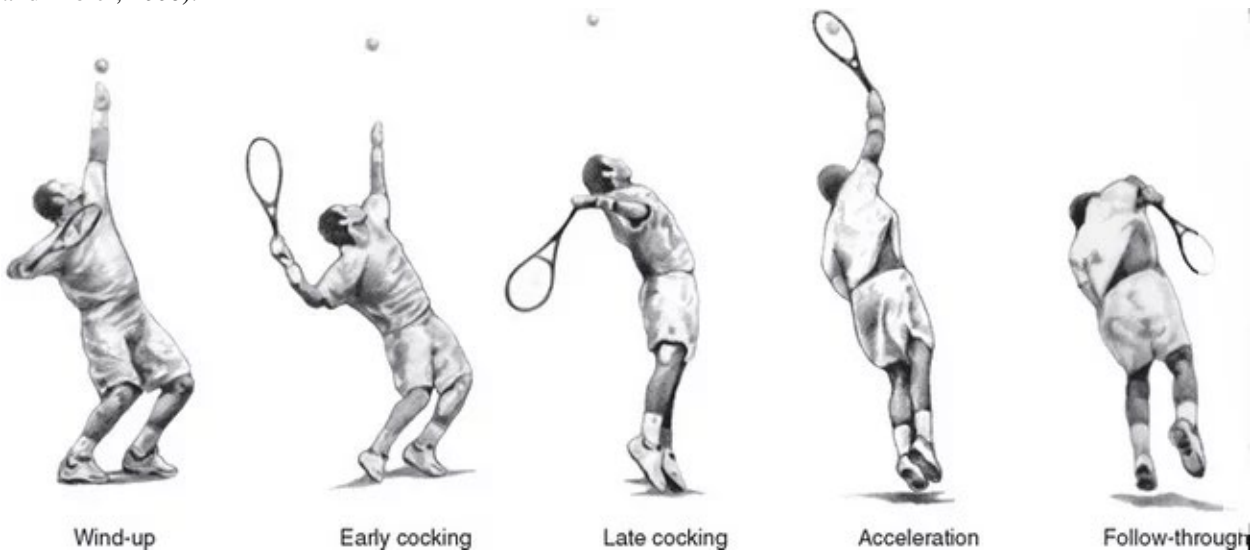

Figure 1. Five stages of a tennis serve (Ruddock, 2022)

GIRD is the tightening of the posterior capsule, or the tissue on the back of the glenohumeral (shoulder) joint. As stress is repetitively put on the back of the shoulder capsule from serving, the capsule will thicken, causing tennis players to lose internal rotation of their shoulder. The thickening of the capsule can affect how the shoulder rotates and can result in superior labrum tears or tears in the cartilage where the biceps tendon attaches to the top of the shoulder socket. A superior labral tear will cause a tennis player to drop significantly in performance level if they are even able to play at all (Ruotolo, 2014).

Studies have mainly investigated scapular dyskinesis, GIRD, and other shoulder injuries in high-level tennis players, but not much is known about their prevalence in comparatively lower-level tennis players, such as those playing at the high school level. Since overhead sports have a lower rate of return to sport than others due to the unnatural motion of an overhead action, such as a serve, it is crucial to take preventative measures as early as possible. The purpose of this study was to explore the prevalence of scapular dyskinesis and GIRD among students playing in high-school tennis teams and identify factors that make players more susceptible to developing shoulder dysfunction. A better understanding of the risk factors will allow high school tennis players to take preventive measures and possibly reduce the risk of developing shoulder dysfunctions such as scapular dyskinesis and GIRD.

Methods

A sample size of convenience was used for this exploratory study. Players from the tennis team of a high school located in greater Cleveland, Ohio were invited to participate in this study. Twenty-seven players agreed to participate. A survey to collect information related to sports activity related shoulder dysfunction was developed in collaboration with physical therapists associated with a local health system. The survey (Table 1) consisted of 16 questions that were based on studies done by Kekelekis et al. (2020), Geier (2018), Roche et al. (2015), Ruotolo (2017), and van der Hoeven and Kibler (2006). The survey collected information regarding participants' demographics, experience with tennis and/or other sports involving an overhead throwing motion, and shoulder/ back workouts. A series of questions were used to identify (self-reported) whether or not the participants demonstrated symptoms indicative of scapular dyskinesis, “SICK scapula”, and/or GIRD.

Table 1. Survey questions and responses.

Survey Questions	**Possible Responses**
Age (years)	
Gender	Male Female Other Prefer not to answer
How long have you been playing tennis? (years)	
Do you play any other sport that requires an overhead throwing motion?	Yes No
Do you work out/exercise your back and shoulders on a regular basis?	Yes No
How often do you play tennis (times a week)?	1 2 3 4 5 6 7
Which team are you on?	Varsity Junior Varsity
Which arm do you serve with?	Right Left
Have you been diagnosed with any type of shoulder injury/condition at some point in time? If yes, please name the injury/condition. If no, type "No".	Free text
Do you have any pain around your shoulder blade on your serving side?	Yes No
Have you noticed any muscle fatigue in your shoulder blade area on the side of your serving arm?	Yes No
Have you noticed any decreased velocity, control, or motion on your serves?	Yes No

Have you noticed any decrease in strength on your serving side?	Yes No
Have you noticed a limited range of motion on your serving side?	Yes No
Have you noticed any level of protrusion of your shoulder blade?	Yes No
Have you noticed that your serving shoulder sits lower than the non-serving shoulder?	Yes No

The survey responses were collected and transferred into a spreadsheet for analysis. Each subject was assigned a pseudo identification and only the de-identified data was used. Mean and percentages were calculated for the individual survey questions. Any relationship between player demographics, years/frequency of playing tennis, team placement, specific workouts and symptoms related to shoulder pain, scapular dyskinesis, and GIRD were explored.

Results

Of the 27 players who completed the survey, 37% were 16 years of age and 59% were male (Table 2). 48% of the players had at least 4 years of experience playing tennis and 52% played at least 3 times a week. About 44% of the responses came from varsity level players and 56% came from junior varsity level players.

Table 2. Demographics and experience level for the survey respondents (n=27).

Player Demographics	
Years of tennis experience (mean ± SD, range)	3.3 ± 2.1, 0 - 8
Playing frequency, times a week (mean ± SD, range)	3.0 ± 2.0, 0 - 7
Age in years (mean ± SD, range)	15.9 ± 1.3, 14 - 18
Gender	Male (n = 16, 59%) Female (n = 11, 41%)
Participate in workout	Yes (n = 12, 44%) No (n = 15, 56%)
Play other sports	Yes (n = 11, 41%) No (n = 16, 59%)
School tennis team	Varsity (n = 12, 44%) Junior Varsity (n = 15, 56%)
Tennis serving arm	Right (n = 26, 96%)

	Left (n = 1, 4%)

Of the 27 players, 5 players reported having shoulder pain, 5 players reported a decrease in strength on their serving side and 7 players reported a decrease in the velocity, control, or motion during their serves. Almost half of the players reported at least one symptom of scapular dyskinesis or GIRD. The average number of symptoms increased with years of playing experience (Figure 2). The most common symptom overall was muscle fatigue (11 out of 27 players) with more than half of varsity level players reporting this symptom (Figure 3). More than 40% of varsity level players also reported a decrease in velocity, control or motion while playing. Overall, players reported 1.33 symptoms on average. Players who played tennis 4-7 times a week reported 2.56 symptoms on average while those who played 1-3 times a week reported 0.72 symptoms on average. Players on the varsity team reported 2.08 symptoms on average while players on the junior varsity team reported 0.73 symptoms on average. Male players reported 1.5 symptoms on average while female players reported 1.09 symptoms on average. Table 3 provides a breakdown of the number of players from various groups reporting symptoms related to shoulder dysfunction.

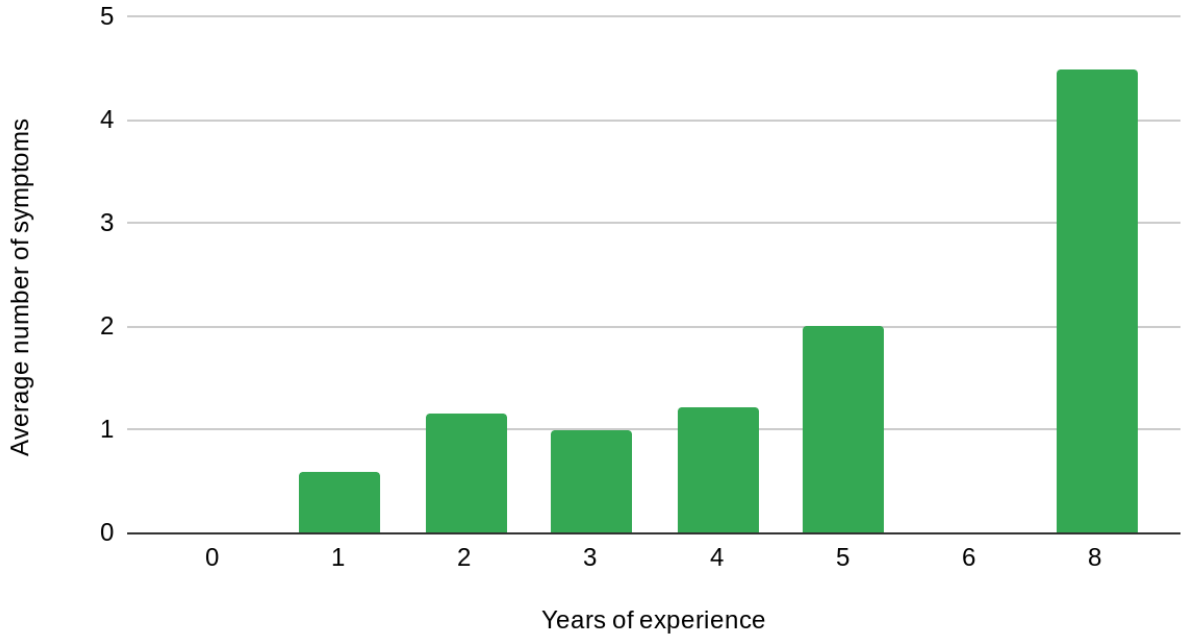

Figure 2. Average number of shoulder dysfunction symptoms reported increases with years of experience.

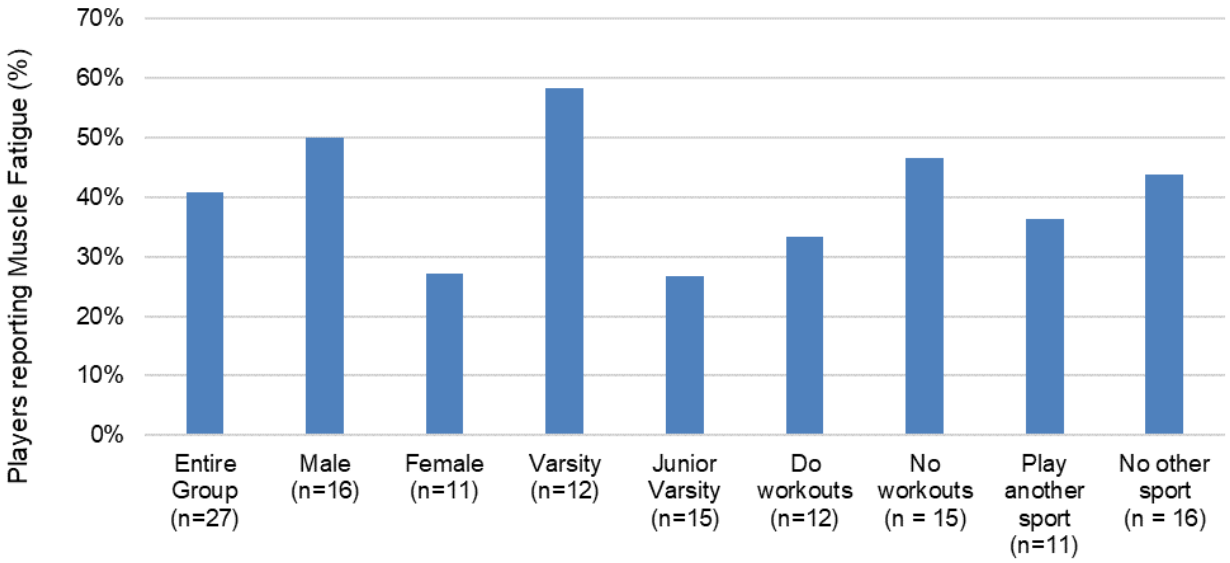

Figure 3. More than half of varsity level players reported muscle fatigue.

Table 3. Breakdown of players (n, % of players) reporting various symptoms for shoulder dysfunction.

Group	Pain	Decrease in velocity, control or motion	Decrease in strength	Limited range of motion	Shoulder Blade protrusion	Lower shoulder
Entire Group (n = 27)	5 (18.5%)	7 (25.9%)	5 (18.5%)	2 (7.4%)	1 (3.7%)	4 (14.8%)
Male (n = 16)	4 (25.0%)	4 (25.0%)	5 (31.3%)	2 (12.5%)	1 (6.3%)	1 (6.3%)
Female (n = 11)	1 (9.1%)	3 (27.3%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	3 (27.3%)
Varsity (n = 12)	3 (25.0%)	5 (41.7%)	3 (25.0%)	2 (16.7%)	1 (8.3%)	3 (25.0%)
Junior Varsity (n = 15)	2 (13.3%)	2 (13.3%)	2 (13.3%)	0 (0.0%)	0 (0.0%)	1 (6.7%)
Do workouts (n = 12)	0 (0.0%)	1 (8.3%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	3 (25.0%)

No workouts (n = 15)	5 (33.3%)	6 (40.0%)	5 (33.3%)	2 (13.3%)	1 (6.7%)	1 (6.7%)
Play another sport (n = 11)	2 (18.2%)	3 (27.3%)	2 (18.2%)	1 (9.1%)	0 (0.0%)	3 (27.3%)
No other sport (n = 16)	3 (18.8%)	4 (25.0%)	3 (18.8%)	1 (6.3%)	1 (6.3%)	1 (6.3%)

Shoulder Dysfunction in Players Who Did Not Do Workouts or Play Other Sports

Out of the 27 players, 12 did not do shoulder and back muscle workouts on a consistent basis and did not play another sport that involved an overhead throwing motion. Nearly 40% of these players reported a decrease in their tennis performance, possibly related to shoulder dysfunction. In this group, players (n = 2) with 8 years of experience reported at least 3 symptoms of scapular dyskinesis, with one player reporting 5 symptoms of scapular dyskinesis and 1 symptom of GIRD. 80% of players (n = 5) with only a year of experience reported 0 signs of scapular dyskinesis or GIRD. The maximum number of symptoms exhibited by a male player in this group was 6 (n = 2), while the maximum number of symptoms exhibited by a female player was 3 (n = 1). Players that played tennis only once a week (n = 8) reported 0 symptoms of shoulder dysfunction, whereas 56% of those that played tennis 4 times a week or more (n = 9) reported at least 2 symptoms of shoulder dysfunction. Also, 100% of varsity level players reported at least 2 symptoms of scapular dyskinesis while only 25% of junior varsity players reported any symptoms for scapular dyskinesis and GIRD.

Shoulder Dysfunction in Players Who Did Workouts

Only 12 out of the 27 players did workout for their shoulder and back muscles on a regular basis. The players in this subset had 3.67 years of experience on average and played 2.83 times a week on average. The average number of reported symptoms in this subset was 0.75 per player, which was 0.58 symptoms lower than the entire group average and 1.05 symptoms lower than the players who do not workout regularly. 50% of players who regularly work out their shoulder and back muscles reported 0 symptoms of scapular dyskinesis or GIRD and the maximum number of symptoms reported by this group was 3 (n = 1).

Shoulder Dysfunction in Players Who Played Other Sports Involving Overhead Action

Of the 27 tennis players, 11 played another sport that involved an overhead throwing motion. The players in this subset had on average 3.18 years of tennis experience and played 3.91 times a week. The average number of symptoms reported in this subset was 1.45 per player, which was 0.12 symptoms higher than the entire group and 0.20 symptoms higher than the average of players who do not play another sport involving an overhead throwing motion. 64% of players who played another overhead sport reported at least 1 symptom, with the maximum number of symptoms in this group being 6 (n = 1).

Discussion

The purpose of this study was to explore the prevalence of scapular dyskinesis and GIRD in high school

tennis players and identify any relationship between various factors (years played, team level, practice frequency, workouts, playing other overhead sports) and shoulder dysfunction/pain in high school tennis players. The results indicate that those who have played tennis for a longer period of time, played more often on a weekly basis, and/or played on the varsity team are more likely to develop shoulder pain than those with less experience or played at a lower skill level. The results also show that males are more prone to developing shoulder problems compared to females. Players who regularly work out their shoulder and back muscles are less likely to exhibit symptoms of scapular dyskinesis and GIRD than those who do not, regardless of experience level.

Major symptoms of both scapular dyskinesis and GIRD are shoulder pain and muscle fatigue. A higher level of experience or exposure to tennis has been shown to increase the probability of a high school tennis player developing shoulder pain. 48% of players reported having at least one symptom of scapular dyskinesis or GIRD. 41% of all players and 42% of players who did not work out and did not play other sports requiring overhead motion reported having muscle fatigue in their scapular region. As stated by van der Hoeven and Kibler, the tennis serve is an overhead throwing motion that exceeds the physiological limits of the shoulder joint, which increases the probability of high school tennis players developing shoulder pain. 75% of all varsity players and 100% of varsity players in the no workout or other sport group reported at least 1 symptom of scapular dyskinesis or GIRD, whereas only 33% of all junior varsity players and 25% of junior varsity players in the no workout or other sport group reported at least 1 symptom. With almost half of all players reporting at least 1 symptom of either pathology, it is not surprising that varsity level players, with longer and more frequent exposure to tennis, are at higher risk of developing shoulder pain and other shoulder dysfunctions. The results of this study are similar to those reported by Kekelekis et al. (2020).

In the study by van der Hoeven and Kibler (2006) it was noted that GIRD can lead to shoulder pain and dysfunction in tennis players. 30% of the tennis players who responded to the survey reported GIRD symptoms with 75% of them reporting shoulder pain as well. Geier (2018) and Roche et al. (2015) observed decreased control and velocity during throwing and changes in shoulder function such as decreased strength and arm motion as a result of scapular dyskinesis in tennis players. In the current study, around 30% of players reported decreased control and velocity during their serves or decreased shoulder motion and strength in general with 63% of these players also reporting shoulder pain as well.

A high school singles tennis player is expected to serve at least 24 times throughout a three-set match, assuming that they win every single point. The minimum number of serves drops down to 16 for doubles players. However, the chances of any tennis player winning every point is extremely low, be it at the high school, college, or professional level. A study conducted by Myers et al. (2016) noted that tennis players typically serve 40 times per set on average regardless of age and gender. Thus, the average number of serves per match for high school tennis players would be about 80-120 within a very short period. In addition to matches, the number of serve repetitions during practices will be even higher, in the order of hundreds of serves each week. When a tennis player repeats a serve motion in such high volumes, the scapula does not fully retract back to its original position. This can result in weakness of the muscles that stabilize the scapula (serratus anterior, rhomboids, levator scapulae, trapezius) as they do not contract to adduct the scapula as often after the follow-through stage of a tennis serve. In this study, since varsity level players tend to play more matches and have more experience than junior varsity level players, the varsity players were more susceptible to scapular dyskinesis and GIRD.

Also, while male players reported more symptoms related to pain, decreased performance and strength, female players reported almost three times more occurrence of lower shoulders compared to male players.

An interesting observation in this study was the potential protective effect of doing shoulder and back workouts on shoulder pain and dysfunction. The players who consistently performed shoulder and back workouts reported less symptoms on average than those who do not. Scapular dyskinesis results from certain muscles being too weak to stabilize the scapula. Routinely performing shoulder and back exercises to strengthen

these muscle groups could be a possible scapular dyskinesis prevention technique. In fact, Saini et al (2020) observed that "The mainstay of treatment for scapular dyskinesis remains an extensive course of physical therapy involving scapular proprioceptive retraining, strengthening, and sport-specific exercises". Professional tennis players play, practice, and serve much more than players at the high school level but do not suffer from shoulder dysfunction as often as would be expected, possibly due to the customized workouts and game techniques followed by their personal coaches/therapists.

Tennis players who played another sport that involved an overhead throwing motion reported more symptoms on average than those who did not. Overhead sports require players to transfer large amounts of kinetic energy through their shoulders at high speeds with high precision and large ranges of motion. "These demands may explain the high prevalence of shoulder pain in these populations, with reports of 12% in amateur golf, 16% in volleyball, 22% to 36% in elite handball" (Hickey et al., 2018). The combination of multiple overhead sports with the cumulative stress put on the shoulder could lead to a higher probability of developing shoulder dysfunction.

Seventy five percent of varsity players self-reported at least one symptom of scapular dyskinesis or GIRD, yet none of them reported being diagnosed with shoulder dysfunction. If the shoulder dysfunction awareness level increases among high school tennis players, proper training regimens and prevention techniques could be integrated into their respective programs and reduce the risk of developing injuries. Further studies are needed to investigate the awareness among players and coaches regarding shoulder conditions and appropriate preventive measures that can be taken.

Limitations

The sample size for this study was based on convenience. The survey was only sent to tennis players who attended a certain school, and the results cannot be generalized to the entire high school tennis player population or to players from other age groups or with various levels of tennis experience. Statistical tests were not conducted as the sample size used in the study was too small and included a number of confounding variables. The study findings are based on self-reported symptoms by high school students who are not familiar with assessing or diagnosing shoulder conditions unlike medical professionals (sports medicine physicians and physical therapists). Further research is needed to understand the protective effect of specific workouts on shoulder dysfunction at the high school levels of tennis.

Conclusion

The purpose of this study was to explore the prevalence of scapular dyskinesis and GIRD and identify some of the factors that make a high school tennis player more prone to developing shoulder dysfunction. The results show that players who have more years of experience, play more often, and are on the varsity team are more likely to develop shoulder pain and dysfunction. Males are also more likely to develop shoulder pain and dysfunction compared to females. Players who regularly workout their shoulder and back muscles are less likely to develop shoulder pain and dysfunction, regardless of their level of experience and gender. High school tennis programs should start implementing shoulder and back workouts into their practice schedules as a precaution to help prevent future shoulder dysfunction and injuries. Future research should expand the sample demographics by including a larger group of players from multiple schools with various sports backgrounds, skill levels as well as physically examining and diagnosing the players by trained clinicians instead of self-reports of symptoms.

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References

Abrams, G. D., Renstrom, P. A., & Safran, M. R. (2012). Epidemiology of musculoskeletal injury in the tennis player. British journal of sports medicine, 46(7), 492–498. https://doi.org/10.1136/bjsports-2012-091164

Athwal, G. S., Sciascia, A. D., & Kibler, W. B. (2022, June). Scapular (Shoulder Blade) Problems and Disorders. OrthoInfo - AAOS. Retrieved July 11, 2022, from https://orthoinfo.aaos.org/en/diseases--conditions/scapular-shoulder-blade-disorders

Geier, D. (2018, November 1). Glenohumeral Internal Rotation Deficit - GIRD. Dr. David Geier - Feel and Perform Better Than Ever. Retrieved July 8, 2022, from https://www.drdavidgeier.com/glenohumeral-internal-rotation-deficit-gird/

Hickey, D., Solvig, V., Cavalheri, V., Harrold, M., & Mckenna, L. (2018). Scapular dyskinesis increases the risk of future shoulder pain by 43% in asymptomatic athletes: a systematic review and meta-analysis. British journal of sports medicine, 52(2), 102–110. https://doi.org/10.1136/bjsports-2017-097559

Hutchinson, M. R., Laprade, R. F., Burnett, Q. M., 2nd, Moss, R., & Terpstra, J. (1995). Injury surveillance at the USTA Boys' Tennis Championships: a 6-yr study. Medicine and science in sports and exercise, 27(6), 826–830.

Importance of Scapular (Shoulder) Stability. (2021, March 3). Westcoast SCI Physiotherapy. Retrieved August 2, 2022, from https://westcoastsci.com/blog/importance-of-scapular-shoulder-stability/

Kekelekis, A., Nikolaidis, P. T., Moore, I. S., Rosemann, T., & Knechtle, B. (2020). Risk Factors for Upper Limb Injury in Tennis Players: A Systematic Review. International journal of environmental research and public health, 17(8), 2744. https://doi.org/10.3390/ijerph17082744

Myers, N. L., Sciascia, A. D., Kibler, W. B., & Uhl, T. L. (2016). Volume-based Interval Training Program for Elite Tennis Players. Sports health, 8(6), 536–540. https://doi.org/10.1177/1941738116657074

Roche, S. J., Funk, L., Sciascia, A., & Kibler, W. B. (2015). Scapular dyskinesis: the surgeon's perspective. Shoulder & elbow, 7(4), 289–297. https://doi.org/10.1177/1758573215595949

Ruddock, J. (2022, July 19). Serving yourself up a problem, is your tennis serve causing you pain? Align Body Clinic. Retrieved July 5, 2022, from https://alignbodyclinic.co.uk/serving-yourself-up-a-problem-is-your-tennis-serve-causing-you-pain/

Ruotolo, C. (2017, September 23). Tennis Injury Prevention: Tennis Elbow is Not the Only Injury to Avoid. Long Island Tennis Magazine. Retrieved July 4, 2022, from https://longislandtennismagazine.com/article6690/tennis-injury-prevention-tennis-elbow-not-only-injury-avoid

Saini, S. S., Shah, S. S., & Curtis, A. S. (2020). Scapular Dyskinesis and the Kinetic Chain: Recognizing Dysfunction and Treating Injury in the Tennis Athlete. Current reviews in musculoskeletal medicine, 13(6), 748–756. https://doi.org/10.1007/s12178-020-09672-6

van der Hoeven, H., & Kibler, W. B. (2006). Shoulder injuries in tennis players. British journal of sports medicine, 40(5), 435–440. https://doi.org/10.1136/bjsm.2005.023218