International Scientific Journal of Engineering and Management (ISJEM) ISSN: 2583-6129
Volume: 04 Issue: 04 | April – 2025 DOI: 10.55041/ISJEM02683
An International Scholarly || Multidisciplinary || Open Access || Indexing in all major Database & Metadata

Optimizing Shoulder Health in Swimmers with generalised joint hypermobility: A Systematic Review of Exercise-Based Interventions for Prevention of pain & injury along with performance enhancement

Samiksha[1], Dr. Ishani Sinha[2]

[1]MPT Sports, Mewar University, Chittorgarh, Rajasthan
[2]Assitant Professor, Mewar University, Chittorgarh, Rajasthan

Abstract

Background: Shoulder pain and injury are common complaints among swimmers, affecting performance and overall well-being. This systematic review aimed to investigate the relationship between various factors, including generalized joint hypermobility (GJH), breathing exercises, strength training, exercise interventions, and dryland strength-power parameters, and shoulder pain and injury in swimmers. **Methods:** A comprehensive search of major databases yielded 11 studies that met the inclusion criteria. Studies were appraised for methodological quality, and data were extracted and synthesized. **Results:** The review found that GJH is associated with increased shoulder rotation width and flexibility, while swimmers with GJH exhibit reduced pectoralis major activity during breathing exercises. Strength training programs and exercise interventions can improve eccentric external total work and reduce the risk of shoulder injury. Dryland strength-power parameters are associated with breaststroke kinematics and can increase the risk of shoulder injury. **Discussion:** The findings of this review highlight the importance of considering GJH, breathing exercises, strength training, exercise interventions, and dryland strength-power parameters in the prevention and management of shoulder pain and injury in swimmers. Coaches, trainers, and healthcare professionals can use these findings to develop targeted training programs and reduce the risk of shoulder injury. **Conclusion:** This systematic review provides valuable insights into the relationship between various factors and shoulder pain and injury in swimmers.

Keywords: Generalized Joint Hypermobility (GJH), Injury Risk, Swimmers, Joint Instability, Injury Prevention.

1. Introduction

A competitive swimmer typically trains between 9 to 110 kilometers each week, with variations based on age, fitness level, and specific training needs. This extensive training results in numerous repetitive motions, which can lead to overuse injuries, particularly in the shoulder. Despite the popularity of competitive swimming among children and adolescents, there is a notable lack of epidemiological research focusing on shoulder injuries in this demographic within the sport.[1] Glenohumeral instability (traumatic) and shoulder pain have been linked to generalized joint hypermobility (GJH), a condition characterized by increased range of motion (ROM) in various joints due to excessive laxity in connective tissues, such as joint capsules and ligaments. The prevalence of GJH among adolescent competitive swimmers is approximately 32%. The increased glenohumeral ROM associated with GJH may enable swimmers to adopt a body position that minimizes drag and enhances stroke length, which is positively correlated with swimming performance.[2] Shoulder injuries are notably more prevalent than other musculoskeletal injuries among elite swimmers, with reported rates ranging from 40% to 91%. Additionally, the knee is a significant source of pain and injury, with 34% to 86% of elite swimmers experiencing at least one instance of knee pain or injury throughout their careers. The spine is also recognized as a vulnerable area for injury in elite swimmers, with prevalence rates between 22.2% to 47% for breaststroke and 33.3% to 50% for butterfly stroke. A greater range of motion is generally seen as beneficial, as it allows swimmers to achieve a body position that facilitates a longer stroke length, which is positively linked to swimming speed. Consequently, the shoulder is subjected to repetitive movements involving extension, horizontal abduction, and internal rotation. This repetitive action places significant stress on the anterior capsule and ligaments of the glenohumeral joint, potentially resulting in local shoulder laxity and/or an increased shoulder ROM.[3]

GJH is typically evaluated using the Beighton Tests (BT), which yield a score ranging from 0 to 9. For adults, a

score of 4 or higher (≥4/9) is recommended as the threshold for diagnosing GJH. However, no definitive cut-off has been established for classifying GJH in children or adolescents, leading to variations in the cut-off points used across different studies.[3]

A substantial amount of evidence has emerged that highlights various factors associated with pain and the risk of injury. Struyf et al. conducted a review focusing on the differences in musculoskeletal dysfunctions between the shoulders of injured and non-injured swimmers. They identified four critical areas that clinicians should consider when evaluating and treating shoulder issues in swimmers: (i) shoulder range of motion (ROM), (ii) shoulder laxity and instability, (iii) shoulder posture, and (iv) scapular dyskinesis. Additionally, Hill et al. previously reviewed shoulder pain and injury risk factors, identifying 18 distinct factors categorized into four groups: (i) shoulder joint anatomy and strength, (ii) activity history, (iii) demographics, and (iv) musculoskeletal determinants.

The Beighton criteria for assessing joint hypermobility is as follows: [5]

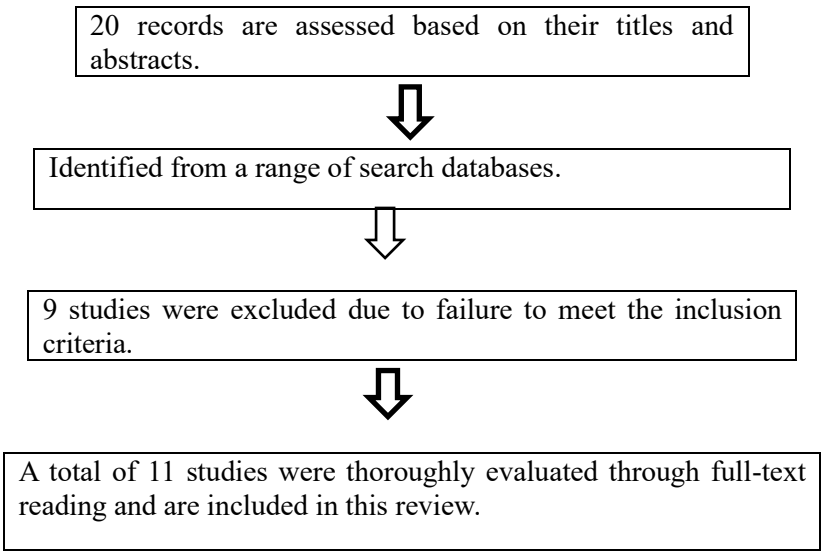
1. Passive dorsiflexion of the little fingers beyond 90° (one point awarded for each hand), resulting in a maximum of two points.
2. Passive apposition of the thumbs to the flexor surfaces of the forearms (one point for each thumb), yielding a total of two points.
3. Hyperextension of the elbows exceeding 10° (one point for each elbow), allowing for a total of two points.
4. Hyperextension of the knees surpassing 10° (one point for each knee), contributing to a total of two points.
5. Forward flexion of the trunk with knees fully extended, enabling the palms to rest flat on the floor—awarding one point.

This review is essential for enhancing our understanding of shoulder injury risk factors in swimmers. There is a pressing need to consolidate this information to assist practitioners in athlete screening and injury prevention efforts. Consequently, this review aims to systematically compile the existing literature and provide an updated overview of shoulder pain and injury risk factors in competitive swimmers.[4]

2. Methods

Research was conducted using the following search engines: PubMed, Google Scholar, ResearchGate, and the Cochrane Library to examine the existing literature. The studies focus on identifying the risk factors associated with hypermobile swimmers.

The keywords employed to search for studies include hypermobility, swimmers, and risk factors.



3. Literature Review

Author, journal, Year	Objective	Design	Characteristics of participants sample size	Method	Outcome measures	Results
2016[1]	To examine the relationship between generalized joint hypermobility (GJH) and active horizontal shoulder abduction (AHSA) among young competitive swimmers, as well as to establish normative values for AHSA within this population	Cross-sectional	92 subjects (10-15 years)	GJH was assessed using the Beighton Tests (BT) to determine joint hypermobility. The maximum shoulder mobility was quantified as AHSA. A multiple regression analysis was conducted to examine the relationships between GJH and AHSA.	Generalized joint hypermobility and active horizontal shoulder abduction	A positive correlation was identified between generalized joint hypermobility (GJH) and the angle of hip abduction in standing alignment (AHSA). Specifically, an elevation in the Beighton Test (BT) score corresponded to a rise in AHSA, with increases of 3.9°, 5.7°, and 7.9° observed at BT cutoff points of ≥5/9, ≥6/9, and ≥7/9, respectively. The normative range for AHSA varied from 40° to 52°, contingent upon age.
1996[3]	To check the potential correlation between glenohumeral joint (GHJ) hyperlaxity and the volume of swimming training, the researchers assessed both elite and recreational swimmers to identify variations in GHJ laxity and overall joint hypermobility (GJH)	Randomized controlled trial	It was carried out to compare thirty elite swimmers, comprising both males and females aged 15 to 25 years, with thirty recreational swimmers, utilizing five clinical assessments to evaluate glenohumeral joint laxity	A total of 64 participants were randomly assigned to three groups. Group A, consisting of 15 subjects, underwent reciprocal inhibition therapy. Group B, also with 15 subjects, received post-isometric contraction treatment, while Group C received conventional intervention. The treatment spanned 12 sessions over a period of two weeks.	Group variations in GHJ laxity and GJH were examined through chi-square analysis.	In contrast to recreational swimmers, elite swimmers exhibited markedly higher generalized joint hypermobility (GJH) and significantly increased glenohumeral joint (GHJ) laxity in three out of five laxity assessments. The distinct patterns of enhanced GHJ laxity observed in elite swimmers compared to their recreational counterparts indicate that these differences in laxity may be

						acquired. Conversely, the findings from the GJH evaluation imply that these variations in laxity may be intrinsic.
2012	To assess whether there are differences in physical attributes, exposure levels, or training factors between swimmers who experience shoulder pain or disability and those who do not	Cross-sectional	236 competitive female swimmers aged 8 to 77 years.	Participants completed the Penn Shoulder Score and underwent assessments of core endurance, range of motion, muscle force production, pectoralis minor muscle length, and the Scapular Dyskinesis Test. For the purpose of analysis, swimmers were categorized by age into the following groups: 8 to 11 years (n=42), 12 to 14 years (n=43), 15 to 19 years (high school, n=84), and 23 to 77 years (masters, n=67). Comparisons were conducted between groups experiencing pain and those without, utilizing independent t-tests for continuous data, along with $\chi 2$ analyses and Fisher's exact tests for categorical data.	ROM, Strength, Scapular dyskinesia, Endurance, Pectoralis minor length	A total of nine swimmers (21.4%) aged between 8 and 11 years, eight swimmers (18.6%) aged 12 to 14 years, nineteen high school swimmers (22.6%), and thirteen masters swimmers (19.4%) reported experiencing shoulder pain and disability. Notable differences observed among two or more age groups between athletes with and without shoulder pain and disability included increased swimming exposure, a higher prevalence of prior traumatic injuries, self-reported shoulder instability, and lower participation in other sports among those with symptoms (P<.05). Additionally, symptomatic females in specific age groups exhibited reduced shoulder flexion, weakness in the middle trapezius and internal rotation, shortened pectoralis minor and latissimus muscles, participation in water polo, and diminished core endurance (P<.05)...

2018[2]	To investigate whether competitive swimmers with GJH including shoulder hypermobility (GJHS) differ in shoulder sensorimotor control and muscle activity from those without GJH and no shoulder hypermobility (NGJH)	Cross-sectional	Competitive swimmers (aged 13-17)	The study used the Beighton score and Rotès-Quérol test to classify participants into Generalized Joint Hypermobility Syndrome (GJHS) or Non-Generalized Joint Hypermobility (NGJH) groups. Participants underwent shoulder stabilometric tests and surface electromyography (SEMG) to assess muscle activity and co-contraction. The data were analyzed using a mixed effects model to compare differences between the GJHS and NGJH groups.	Sensiromotor control , neuromuscular activity, GJH.	A total of thirty-eight swimmers participated in the study, divided into two groups: GJHS (n=19) and NGJH (n=19). No significant differences were observed between the groups regarding stabilometric parameters or CCI. However, GJHS exhibited a notable reduction of 29% in pectoralis major activity during BL-EO when compared to NGJH, with values of 5.35±1.77%MVE for GJHS and 7.51±1.96%MVE for NGJH (p=0.043).
2018[6]	to investigate the association of GJHS with shoulder strength, fatigue development and muscle activity during swimming-related shoulder rotations.	Cross-sectional	13–17 years old competitive swimmers (highest national level)	13–17 years old competitive swimmers (highest national level) with GJHS and control swimmers without GJHS, individually matched on age, sex and swimming club. Participants were recruited from local sports clubs by initial email and phone contacts with	Concentric isokinetic force in medial and lateral rotations, Electromyographic activity GJH.	In total, 97 competitive swimmers were screened for eligibility, of which 38 swimmers, 11 girls and eight boys in each group, completed the study. The groups

				coaches and parents.		were comparable on demographics (age, height, body mass, sports participation, previous and current pain levels, WOSI and clinical tests for shoulder instability) except for the Beighton and Rotes-Querol tests, as expected due to the study design.
2020[7]	to investigate the in-season changes of shoulder IR and ER PTs and ratios and the incidence of shoulder injury among adolescent swimmers	Cohort study	All swimmers from an adolescent elite group, defined as national level competitors (in their age categories), training twice daily.	The evaluations were carried out twice at a 40-week interval: (1) at the beginning of the competitive season (preseason visit), and (2) at the end of the competitive season (postseason visit). At the preseason visit, all 18 swimmers completed a self-administered questionnaire about their sociodemographic status, training habits, swimming performance and previous injuries. A standardized clinical examination including specific physical examination tests of the shoulder was performed by a sport medicine physician (JD). The shoulder strength profile was assessed by isokinetic testing as described above.	self-administered questionnaire isokinetic testing	Swimmers with a lower preseason conventional eccentric eccER:eccIR ratio and functional eccER:conIR ratio had an increased risk of shoulder injury during the season. A preseason functional eccER:conIR ratio below 0.68 was associated with a significant 4.5-fold increased risk of developing a shoulder injury (RR = 4.50 $p < 0.05$). Both IR and ER PTs were positively associated with age in all modes (ecc and con) and highly related to sport participation, as the normalized PT was stable in

				The follow- up was carried out over 38 weeks (October 2016 to July 2017). At the postseason visit, all swimmers included in the follow-up had the same evaluations as those at the preseason visit, with the same examiner (JD).		the control population between 13 and 36 years
2008[8]	to assess the effects of a nonisokinetic dynamometer-based strength training program on eccentric strength of the external shoulder rotator muscles.	Cross-sectional	One collegiate women varsity tennis team (n = 6) was recruited as an experimental group Another collegiate women varsity team (n = 6) was recruited as a control group USTA ranking as assessed by the team's coaches according to USTA self-ranking standards	A pretest-posttest, 2 group design involving 2 collegiate women tennis teams was employed. Both teams were pre and post-tested on an isokinetic dynamometer using 5 maxi mal eccentric external immediately followed by concentric internal contractions.	USTA self-ranking scale. iso kinetic dynamometer—Kin-Com AP Muscle Testing System.	The 5-week strength training program demonstrated statistical significant gains in eccentric external total work per formed by the experimental group versus the control group (P = 0.017). Concentric internal total work performed, con centric internal mean peak force, and eccentric external mean peak force did not change. Relative changes in eccentric

						external/concentric internal total work ratios resulted in a tendency to decrease for the control group and to increase for the experimental group
2009[9]	To examine the correction of posture, increase in strength and decrease in shoulder pain and dysfunction in varsity swimmers.	Randomised clinical trial.	28 National Collegiate Athletic Association division	Two testing sessions were conducted before and after an 8-week time period. Posture, strength and shoulder pain and function were assessed. Forward head angle was measured using a digital inclinometer, forward head translation was measured using a ruler and total scapular distance was measured with unmarked string. Average and peak values (N) of strength were measured with the hand-held dynamometer. The intervention subjects then participated in an 8-week exercise training programme to	Posture, strength and shoulder pain and function. A digital inclinometer, A ruler and total scapular distance was measured with unmarked string	The exercise intervention was successful at decreasing forward head and rounded shoulder postures in elite swimmers. This study supports the theoretical basis for clinical rehabilitation of posture and the shoulder.

				correct posture. The procedures were then repeated in the post-test.		
2002 [10]	To develop a physical profile and evaluate the relationship between dryland strength–power and stroke kinematic variables in elite breaststroke swimmers	Cross-sectional	11 elite-level breaststroke specialists (6 female and 5 male athletes)	A series of range-of-motion, dryland strength–power, and anthropometric measures were assessed in 11 elite-level breaststroke specialists and used to establish group-based averages and expected variance within an elite breaststroke population.	ROM, dryland strength–power, and anthropometry Force Decks Dual Force Plate System	
2021 [11]	To determine the association between shoulder complex mobility and shoulder pain in young male and female swimmers,	Cohort study	16 competitive swimmers	The shoulder rotation width, which was the index of shoulder complex mobility, shoulder internal and external rotation range, and middle finger distance of the back-scratch test were measured. An examiner regularly visited the swimming clubs to evaluate the development of shoulder pain and swimming distance. Logistic regression analysis was used to determine the	shoulder rotation width Back scratch test Logistic regression analysis	Analysis of the relationships between dryland strength–power parameters and breaststroke kinematics revealed strong associations ($r > .7$, minimum 95% confidence range of $g > 0.80$ or < -0.80) most frequently at 100-m and maximal paces. Sixteen participants, composed of 8 males and 8 females, developed shoulder pain. The overall swimming distance of the

				physical characteristics related to the overall development of shoulder pain in both female and male swimmers. The cutoff value was calculated using receiver operating characteristic curves.		male (odds ratio [OR]: 1.0007, *P* = .01) and female (OR: 1.0018, *P* = .02) swimmers and the shoulder rotation width of the male (OR: 1.0952, *P* = .04) and female (OR: 0.888, *P* = .03) swimmers were identified as risk factors for shoulder pain. The cutoff value for swimming distance was 6000 m. Shoulder rotation width was more than 88 cm in males and <54 cm in females.

4. Result

This systematic review included 11 studies that investigated the relationship between various factors and shoulder pain and injury in swimmers. The results showed that:

- Generalized joint hypermobility (GJH) is associated with increased shoulder rotation width and flexibility (2016, 2018)
- Swimmers with GJH exhibit reduced pectoralis major activity during breathing exercises (2018)
- A lower preseason conventional eccentric external rotation to internal rotation (eccER:eccIR) ratio and functional ecc ER:concentric internal rotation (conIR) ratio are associated with an increased risk of shoulder injury during the season (2018)
- A 5-week strength training program can improve eccentric external total work and reduce the risk of shoulder injury (2018)
- Exercise interventions can improve posture and reduce the risk of shoulder pain and injury in swimmers (2018, 2020)
- Dryland strength-power parameters are associated with breaststroke kinematics, and swimming distance and shoulder rotation width are risk factors for shoulder pain in swimmers (2020, 2021)

5. Discussion

The results of this systematic review suggest that GJH, breathing exercises, strength training, exercise interventions, and dryland strength-power parameters are all associated with shoulder pain and injury in

swimmers. The findings of this review have important implications for the prevention and management of shoulder pain and injury in swimmers. GJH is a common condition in swimmers, and the results of this review suggest that it is associated with increased shoulder rotation width and flexibility. This may increase the risk of shoulder injury, particularly if proper warm-up and cool-down exercises are not performed. Strength training programs can also improve eccentric external total work and reduce the risk of shoulder injury in swimmers. Exercise interventions, such as posture correction and shoulder stabilization exercises, can also improve posture and reduce the risk of shoulder pain and injury in swimmers. Dryland strength-power parameters, such as concentric internal rotation and eccentric external rotation, are associated with breaststroke kinematics and can increase the risk of shoulder injury if not properly trained.

6. Conclusion

In conclusion, this systematic review highlights the importance of GJH, breathing exercises, strength training, exercise interventions, and dryland strength-power parameters in the prevention and management of shoulder pain and injury in swimmers. Coaches, trainers, and healthcare professionals should be aware of these factors and incorporate them into their training programs to reduce the risk of shoulder injury and improve overall performance in swimmers. Further research is needed to fully understand the relationships between these factors and shoulder pain and injury in swimmers.

References

1. Junge T, Henriksen P, Andersen HL, Byskov LD, Knudsen HK, Juul-Kristensen B. The association between generalized joint hypermobility and active horizontal shoulder abduction in 10-15 year old competitive swimmers. BMC Sports Sci Med Rehabil. 2016 Jul 12;8:19. doi: 10.1186/s13102-016-0044-y. PMID: 27413535; PMCID: PMC4942936.
2. Frydendal T, Eshøj H, Liaghat B, Edouard P, Søgaard K, Juul-Kristensen B. Sensorimotor control and neuromuscular activity of the shoulder in adolescent competitive swimmers with generalized joint hypermobility. Gait Posture. 2018 Jun;63:221-227. doi: 10.1016/j.gaitpost.2018.05.001. Epub 2018 May 5. PMID: 29775909.
3. Schlueter KR, Pintar JA, Wayman KJ, Hartel LJ, Briggs MS. Clinical Evaluation Techniques for Injury Risk Assessment in Elite Swimmers: A Systematic Review. Sports Health. 2021 Jan/Feb;13(1):57-64. doi: 10.1177/1941738120920518. Epub 2020 Jul 10. PMID: 32649842; PMCID: PMC7734355.
4. McKenzie A, Larequi SA, Hams A, Headrick J, Whiteley R, Duhig S. Shoulder pain and injury risk factors in competitive swimmers: A systematic review. Scand J Med Sci Sports. 2023 Dec;33(12):2396-2412. doi: 10.1111/sms.14454. Epub 2023 Jul 28. PMID: 37515375.
5. Reuter PR, Fichthorn KR. Prevalence of generalized joint hypermobility, musculoskeletal injuries, and chronic musculoskeletal pain among American university students. PeerJ. 2019 Sep 11;7:e7625. doi: 10.7717/peerj.7625. PMID: 31565567; PMCID: PMC6744937.
6. Lynch SS, Thigpen CA, Mihalik JP, Prentice WE, Padua D. The effects of an exercise intervention on forward head and rounded shoulder postures in elite swimmers. Br J Sports Med. 2010 Apr;44(5):376-81. doi: 10.1136/bjsm.2009.066837. PMID: 20371564.
7. Drigny, Joffrey & Gauthier, Antoine & Reboursière, Emmanuel & Guermont, Henri & Gremeaux, Vincent & Edouard, Pascal. (2020). Shoulder Muscle Imbalance as a Risk for Shoulder Injury in Elite Adolescent Swimmers: A Prospective Study. Journal of human kinetics. 75. 103-113. 10.2478/hukin-2020-0041.
8. Yvonne Niederbracht,1 Andrew L. Shim,1 Mark A. Sloniger,1 Madeline Paternostro-Bayles,1 And Thomas H. (2008) the TM Journal of Strength and Conditioning Research.
9. Lynch SS, Thigpen CA, Mihalik JP, Prentice WE, Padua D. The effects of an exercise intervention on forward head and rounded shoulder postures in elite swimmers. British Journal of Sports Medicine. 2010 Apr;44(5):376-381. DOI: 10.1136/bjsm.2009.066837. PMID: 20371564.
10. Nicol, E., Pearson, S., Saxby, D., Minahan, C., & Tor, E. (2022). The Association of Range of Motion, Dryland Strength–Power, Anthropometry, and Velocity in Elite Breaststroke Swimmers. International Journal of Sports Physiology and Performance, 17(8), 1222-1230. Retrieved Apr 4, 2025, from https://doi.org/10.1123/ijspp.2021-0544
11. Mise T, Mitomi Y, Mouri S, Takayama H, Inoue Y, Inoue M, Akuzawa H, Kaneoka K. Hypomobility in Males and Hypermobility in Females are Risk Factors for Shoulder Pain Among Young Swimmers. J Sport Rehabil. 2022 Feb 1;31(1):17-23. doi: 10.1123/jsr.2020-0488. Epub 2021 Sep 20. PMID: 34544902.