

Prevalence of Swimming Overuse Injuries in Elite Competitive High School Swimmers in Pune Region- A Cross-Sectional Study

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ABSTRACT

Background: Swimming is a widely practiced sport that offers comprehensive physical benefits. However, the repetitive nature of swimming strokes can lead to overuse injuries, particularly among elite competitive high school swimmers. Understanding the prevalence, anatomical distribution, gender differences, and associations with training characteristics is crucial for effective injury prevention and management.

OBJECTIVES: 1. Prevalence Assessment: To determine the prevalence of overuse injuries in elite competitive high school swimmers in Pune region. 2. Injury Distribution: To identify which specific overuse injuries occur most frequently among these athletes in Pune region. 3. Gender-Based Analysis: To examine gender differences in the occurrence of overuse injuries in Pune region. 4. Training Characteristics Association: To assess the relationship between training characteristics, such as stroke specialty, and the occurrence of region-specific overuse injuries in Pune region. **METHODOLOGY:** A cross-sectional study was conducted to assess the prevalence of musculoskeletal injuries among elite competitive high school swimmers in Pune region. Data were

collected through surveys and medical records to identify overuse injuries, their anatomical locations, and associated training characteristics. Statistical analyses were performed to determine prevalence rates, gender differences, and associations with training variables. **RESULTS:** The findings revealed that a significant proportion of high school athletes in Pune region experienced overuse injuries. **Prevalence:** Overuse injuries were prevalent among swimmers, with shoulder injuries being the most common. Other frequently affected areas included the knee and lower back. **Gender Differences:** Female swimmers exhibited a higher incidence of overuse injuries compared to their male counterparts. Factors such as hormonal fluctuations and biomechanical differences may contribute to this disparity. **Training Characteristics:** Swimmers specializing in certain strokes, particularly butterfly and breast stroke, had a higher occurrence of specific overuse injuries. The repetitive motions inherent in these strokes may increase the risk of injury in certain anatomical regions. These injuries are often attributed to factors such as poor stroke mechanics, inadequate flexibility, muscle imbalances, and insufficient rest periods. **CONCLUSION:** Preventative measures are crucial in mitigating the risk of overuse

injuries. Emphasis on proper technique, regular strength training, adequate warm-up routines, and balanced training schedules can enhance performance and reduce injury rates. Additionally, incorporating cross-training and ensuring sufficient recovery time are vital components of an effective injury prevention strategy.

Keywords: Swimming overuse injuries, high school athletes, gender differences, training characteristics, injury prevention.

INTRODUCTION

Swimming is a globally popular sport that offers comprehensive physical benefits and serves as an effective therapeutic exercise for individuals with physical disabilities. It engages the entire body, providing both strength and cardiovascular conditioning in a low-impact environment. Competitive swimming includes four primary strokes: freestyle, backstroke, breaststroke, and butterfly. Each stroke requires specific techniques, and competitions are governed by strict regulations to ensure proper execution. While variations like single and double-arm drills exist, only these four strokes are recognized in official competitions.

Despite its benefits, swimming is associated with a high incidence of overuse injuries, particularly among elite and adolescent swimmers. These injuries typically result from repetitive movements and can affect various parts of the body: **Shoulder Injuries:** Often referred to as "swimmer's shoulder," these injuries are among the most common, with prevalence rates ranging from 40% to 91% in elite swimmers. They are primarily caused by repetitive overhead motions and poor stroke mechanics. **Knee Injuries:** Known as "breastroker's knee," these injuries are prevalent in breaststroke swimmers due to the unique kicking motion. Studies have shown that the 200–400 meter breaststroke events significantly increase the risk of knee overuse injuries. **Spine Injuries:** Swimmers, especially those specializing in butterfly and breaststroke, are prone to low

back pain due to hyperextension and repetitive movements.

Several factors contribute to the high incidence of overuse injuries in swimmers like Poor Technique which includes incorrect stroke mechanics can lead to undue stress on joints and muscles. **Overtraining:** Excessive training without adequate rest increases the risk of injury. **Lack of Strength and Flexibility:** Weak core and shoulder muscles, along with limited flexibility, can predispose swimmers to injuries. **Repetitive Movements:** The nature of swimming involves repetitive motions that can strain specific muscle groups over time

While swimming is an excellent full-body workout with numerous health benefits, swimmers must be mindful of the risk of overuse injuries. By focusing on proper technique, balanced training, and adequate recovery, swimmers can minimize these risks and continue to enjoy the sport safely. Therefore, the Prevalence of overuse injuries in elite competitive high school swimmers in Pune region provides us with a more comprehensive understanding of its source and a method to establish preventative measures and specific Physiotherapy rehabilitation protocols.

Despite the apparent high injury rates in swimming, there aren't many epidemiologic research available. Studies that are now in the public domain typically assess the frequency of musculoskeletal injuries in particular joints, particularly the shoulder complex, specific specialisations of stroke, or injuries associated with a sport's biomechanics. However, the prevalence of Swimming overuse injuries in young high school swimmers which includes widespread spectrum of injuries is yet to be studied.

Hence a detailed understanding of swimming overuse injuries and its prevalence in particularly the high school going swimmers will aid in the early recognition of injury, the initiation of treatment, and the design of optimal prevention and rehabilitation strategies for

the swimmers. Considering this age group to be more active and skeletally growing in nature correct physical therapy exercises and ergonomic advices to be followed during swimming will largely affect their performance.

Therefore, the current study is carried out to know the prevalence of swimming overuse injuries in elite competitive high school swimmers in pune region which will aid to give targeted physical therapy exercises and ergonomic advices to be followed during swimming to the elite high school swimmers which will largely affect their performance and prevent occurrence of such overuse injuries.

MATERIALS & METHODS

- Study design: Cross sectional study
- Study setting: Swimming training academies and Swimming clubs in and around Pune region.
- Sample population: 188
- Sample size with justification: 188 by the formula $(Z^2) * pq / (L^2)$ Where, $p = 0.49$, where p is prevalence $q = (1-p) = 0.6$, where q is incidence $L = 0.05$ where L is precision $Z = 1.96$, where Z is statistic for level of confidence

Study Procedure: Before beginning the project, the ethical committee provided its approval. Prior to beginning the study, participants' written informed consent was obtained post which selection was done based on the inclusion criteria. A self structured peer review questionnaire was formed. The self-structured, peer-reviewed questionnaire consisted of 3 domains: Domain 1: Demographic data. Domain 2: Swimming Training characteristics, Domain 3: Pain and discomfort. Content validation was taken from 2 competitive swimmers. The questionnaire was circulated to competitive swimming high school trainees for data collection. After the completion data was analysed statistically.

CRITERIA FOR SELECTION OF SAMPLES: High schoolers in the age group of 11-16 years (as by the standards of

- CBSE, STATE & ICSE board norms)
- Subjects having at least 1 year of training experience.
- Subjects who attended the swimming academy for minimum 2 hours a day and at least 4 times a week.
- Subjects at inter-region level competition.
- Swimmers who have had pain complaints for the past 3 months immediately after training sessions.
- Both genders were included.

Statistical Analysis The result of the above study was represented statistically.

The demographic characteristic that is age, gender, Years of experience were presented through graphical pie chart in the form of percentage.

2. The prevalence of swimming overuse injuries in Elite competitive high school swimmers in Pune region was expressed as percentages in the form of graphical pie charts and bar diagrams.

3. Also, the highest occurrence of swimming overuse injuries was expressed in the form of percentage.

4. Chi-square test for association was used to determine the association between swimming training characteristic (stroke specialty) and occurrence of region wise pain in Elite competitive high school swimmers.

RESULTS

The results of the study were represented by the data received via the completed questionnaires in the form of three domains from the participating high school swimmers across Pune region. A total of 188 elite high school swimmers in and around Pune participated among which 10 were dropouts and 178 completed the survey and their data was analysed.

Domain 1 consisted of demographic data (age and gender) of the high school swimmers

Domain 2 consisted of the data representation consisted of questions related to swimming training characteristics.

Domain 3 consisted of the data representation of the Pain and discomfort experienced by high school swimmers.

DOMAIN 1: DEMOGRAPHIC DATA-

TABLE NO. 1 – Representation of age groups:

Age	No. high School Swimmers
11 to 13 years	60
14 to 16 years	118

TABLE NO. 2: Representation of Gender of Swimmers:

Genders	No. high School Swimmers
Males	146
Females	32

TABLE NO. 3: Presentation of years of experience of Swimming in high school:

Years of experience	No. high School Swimmers
1 to 3 years	85
4 to 6 years	78
7 to 9 years	15

DOMAIN 2: SWIMMING TRAINING CHARACTERISTICS:

TABLE NO.4: Number of sessions per week

No. of session per week	No. of high School swimmers
Upto 2 days	87
3 to 4 days	80
More than 4 days	11

TABLE NO. 5: Period of training session:

Training period	No. of high School swimmers
30 mins to 1 hour	110
1 to 2 hours	57
More than 2 hours	11

TABLE NO. 6: Primary stroke performed by the swimmers

Strokes	No. of high School swimmers
Butterfly stroke	62

Free-style/front crawl stroke	92
Back stroke	14
Breast stroke	10

DOMAIN 3: PAIN AND DISCOMFORT

TABLE NO. 7: Representation of pain experienced while swimming or immediately after swimming.

Responses	No. of high School swimmers
Yes	86
No	92

TABLE No. 8: Representation of swimmers who have suffered from any repetitive injury to the same body part during their swimming training program

Responses	No. of high School swimmers
Yes	64
No	114

TABLE NO. 9: Representation of No. of swimmers experiencing pain in any specific stroke.

Stroke Type	No. of high School swimmers
Freestyle/Front crawl	20
Back stroke	20
Butterfly stroke	22
Breast stroke	7
Side stroke	1

TABLE NO. 10: Representation of region wise pain experienced while performing specific strokes by swimmers.

Strokes	Shoulder	Neck	Back	Ankle	Knee
Butterfly Stroke	5	2	8	4	1
Breast stroke	2	1	2	1	1
Back stroke	7	2	8	1	2
Freestyle/front crawl stroke	5	4	8	2	1

TABLE NO.11: Representation showing awareness among swimmers for any physiotherapy interventions for swimming overuse injuries

Awareness	No. of high School Swimmers
YES	140
NO	38

Table 12 shows Chi-square test of association between swimming training characteristic (stroke specialty) and occurrence of region wise pain in Elite competitive high school swimmers:

Chi-Square	Degree Of Freedom	P-Value
6.731	12	0.875

The aforementioned data displays that the chi-square value is 6.731 with 12 degrees of freedom and a P-value of 0.875, which is more than $P = 0.5$, indicating that there was no association between swimming training (stroke specialty) and the occurrence of regional pain. However, Shoulder, back and neck were the most affected parts of the body in all the four strokes.

DISCUSSION

This study investigated the prevalence and characteristics of swimming overuse injuries in a cohort of 178 elite high-school swimmers in Pune region with (77% male; mean age \approx 14 years). The key findings and their implications are discussed below:

Domain 1 is demographic data showing that out of 178 swimmers 77% were males and 23% were females as shown in table no. 2. The swimmers were divided in two age groups, Group 1: 11 to 13 years and Group 2: 14 to 16 years. Group 1 consisted of 60 swimmers i.e., 34% of the total sample size and group 2 consisted of 118 swimmers i.e., 66% of the total sample size as shown in table no. 1. The mean age of these swimmers was 14 years. Table no. 3 shows years of experience which reflected that 85 swimmers have 1 to 3 years of experience, 78 of the Swimmers have 4 to 6 years of experience and 14 have 7 to 9 years of experience.

Domain 2 consisted of questions related to swimming training characteristics. Table no.

4 represents number of sessions attended by the swimmers per week which reflected that out of 178 swimmers, 87 (49%) swimmers attended the academy 2 days per week, 80 (45%) of them attended 3 to 4 days per week and 11 (6%) attended for more than 4 days. Some questions were asked on swimmer's training hours, 110 (61.8%) swimmers trained for 30 minutes to 1 hour per day, 57 (32%) trained for 1 to 2 hours and 11 (6.2%) of them trained for more than 2 hours as shown in Table no. 5. Table no. 6 represents primary strokes of the swimmers which shows 62 (34.8%) swimmers performs Butterfly stroke, 92 (51.7%) of them performs Freestyle/front crawl stroke, 14 (7.9%) performs back stroke and 10 (5.6%) performs Breast stroke.

Domain 3 represents Pain and discomfort experienced by swimmers. 86 (48.3%) Swimmers experienced pain while swimming or immediately after swimming and 92 (51.7%) of them did not experience pain as shown in Table no.7. Almost 48% of participants reported experiencing pain during or immediately after swimming. These findings are in accordance and comparable to similar literature, where similar prevalence rates have been noted in youth swimmer populations. The upper back (31.6%) and lower back (30.4%) were the most commonly affected regions, followed by the right shoulder (24.1%), neck (21.5%), and ankle/foot (15.2%). These findings are in accordance with the previous

study by Matheus Oliveira de Almeida, PT, PhD Luiz Carlos Espanyol, Junior PT, MS Alexandre Dias Lopes, PT, PhD et al.

Notably, 36% of participants reported repeated injuries to the same anatomical site, suggesting that chronic stress or inadequate recovery may play significant roles. No gender-based differences were observed (48% in males vs 50% in females), indicating that biological sex did not influence overuse injury risk in this cohort. Similarly, stroke speciality (butterfly, freestyle, backstroke, breaststroke) showed no significant association with regional injury patterns, implying that general training load and biomechanical factors might supersede stroke type in determining injury risk. Elite competitive high school swimmers often undergo highly individualized training programs according to their stroke specialties, this could be a reason of no association found between specific strokes and region wise pain.

Table 10 showed the Representation of region wise pain experienced while performing specific strokes by swimmers. It shows that the back, shoulder and neck are more affected by the backstroke, freestyle/front crawl, breaststroke. This is probably due to essential upper back muscles such as the trapezius, latissimus dorsi, rhomboids, etc. are used to their maximum capacity while performing different swimming strokes. Less attention is paid to these muscles' strengthening, poor stroke mechanics, lack of correct ergonomic, inadequate core strengthening which plays a pivotal role in regulation of correct kinetic chain (distal to proximal). So, lack of core strengthening and neck strengthening may have resulted in higher preference of back and neck injuries in Elite competitive high school swimmers. In order to propel the body forward through water smoothly, the shoulder is largely responsible for applying propulsive forces hence, affection in shoulder is justified.

The findings from our study are consistent with similar study carried out on high school swimmers in Brazil who showed

high musculoskeletal pain (~60% reporting at least one injury in the preceding year), with the shoulder as the most frequently affected region. Notably, consistent injury patterns across geographies highlight the global nature of this issue. As reported in our study results, the high rates of back and shoulder pain in high school swimmers may stem from faulty stroke mechanics, muscular imbalances, and training overload. Over-reliance on repetitive motion without sufficient recovery or complementary strength work can contribute to microtrauma accumulation-exacerbated by inadequate core, scapular, and neck stabilization. These findings are consistent with literature linking overuse injuries in young athletes to early specialization and excessive training hours without diversification. Also, the study showed that awareness and practice of correct warm up and cool down exercises prior and post swimming sessions proves to be a key factor for prevention of overuse injuries in related to swimming. The study results indicate about 154 (87%) out of 178 swimmers performed warm up before every swim session, Also out of 178 participants, 139 (78%) carry out a cool-down exercise after each swimming session. Based on this data, swimmers are generally aware of the importance of warm-up and cool-down exercises.

There was no association found between swimming training characteristics (Stroke specialty) and occurrence of region wise swimming overuse injuries in elite competitive high school swimmers. Elite competitive high school swimmers often undergo highly individualized training programs according to their stroke specialties, this could be a reason of no association found between specific strokes and region wise pain.

A higher proportion of elite competitive high school swimmers in the current study are aware about Physiotherapy interventions and its importance for swimming overuse injuries. In order to ensure correct, follow up of physiotherapeutic exercises and ergonomic advices during swimming

sessions a Physiotherapist should be appointed who would teach and offer guidance to the high schoolers about Ergonomic coaching and stroke refinement, Dry-land strength training, Warm-up/cool-down standardization, Load management so that risk of musculoskeletal injury while swimming can be minimized in high schoolers through targeted exercises.

CONCLUSION

The study documents a substantial burden of overuse injuries ($\approx 48\%$) among elite adolescent swimmers, predominantly affecting the spine and shoulder regions. The absence of gender or stroke-type effects highlights a need for interventions targeting training mechanics, core strength, and load management rather than stroke-specific training alone. Implementing structured preventive strategies-including ergonomic coaching and physiotherapist-led programming could significantly reduce injury risk and support well-being and performance of high school swimmers in Pune region.

LIMITATIONS

- ❖ Limited injury scope → The study only examined overuse injuries in high school swimmers, potentially overlooking other important categories such as acute injuries, trauma-related injuries, or conditions not attributable to repetitive strain.
- ❖ Limited generalizability → Findings may not apply beyond swimmers in Pune, nor be relevant for different regions, skill levels, competitive contexts, or swimmer demographics.
- ❖ Missing ergonomic guidance → No information was provided on correct stroke ergonomics, posture, or prevention of musculoskeletal disorders, which could be critical in injury mitigation.
- ❖ Cross-sectional design: The study lacks longitudinal follow-up, limiting conclusions about recovery, chronic

progression, or the effectiveness of ergonomic or therapeutic interventions.

- ❖ No follow-up or outcomes tracking → Swimmers reporting pain received no treatment follow-up, making it impossible to assess recovery, effectiveness of interventions, or long-term outcomes.

Declaration by Authors

Ethical Approval: Approved. Ethical approval obtained by the institutional ethics committee of MAEER MIT Pune's Physiotherapy College.

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