Tittle: The impact of swim training loads on shoulder musculoskeletal physical qualities

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WHAT DID I DO?

I Investigated the effects of swim training loads on physical qualities of the shoulder. The aim was to widen the knowledge of the interaction between training loads and potential risk factors for shoulder pain in competitive swimmers.

WHY DID I DO IT?

The aetiology of injuries is multifactorial including the dynamic interaction between multiple risk factors.[1] Competitive swimmers are exposed to large training loads, swimming up to 14,000 m/day.[2] Shoulder pain is the main reason for missed training,[3], with up to 91% prevalence.[3] Several modifiable risk factors for shoulder pain, relating to physical qualities of the shoulder (e.g., range of motion [ROM], flexibility, and strength), have been identified in swimmers.[4] Although there is consensus that shoulder pain in swimmers is mainly caused by excessive training loads, research is lacking investigating its interaction with physical qualities of the shoulder.

HOW DID I DO IT?

I performed 4 studies. Study 1 investigated the within-session and between-session (within-and between-day) intrarater reliability of tests of shoulder function. The tests included shoulder rotation ROM, joint position sense (JPS), rotation isometric peak torque (Figure 1), latissimus dorsi (LD) length, handgrip force (HGF), and combined elevation test (CET). Intraclass correlation coefficient (ICC), standard error of measurement (SEM), and minimal detectable change (MDC95%) were calculated for each test.

Studies 2 and 3 investigated the acute effects of a single swim session on the physical qualities of the shoulder. Study 2 examined the acute impact of swim-training intensity on shoulder physical qualities. Study 3 compared the baseline differences and post-swim changes in shoulder physical qualities between different levels of competition. To appreciate the cumulative effects of training loads, study 4 analyzed the changes in shoulder physical qualities over a training week. Also, comparing changes in these variables between different training volumes. Since injuries are multifactorial,[1] wellness factors were also included as an outcome measure in study 4. Training loads were calculated by the amount of work performed by the athlete (swim intensity and volume) and by the physical and psychological response (shoulder physical qualities, wellness, and rating of perceived exertion).

WHAT DID I FIND?

Study 1 found tests showed good to excellent reliability (ICC= 0.785 to 0.999). Depending on the time between measurements (i.e., longer periods, greater measurement error), the MDC for shoulder ER ROM ranged from 3.0°-10.6°, IR ROM 4.7°-9.6°, LD length 4.1°-6.7°, JPS 3.1°-9.1°, CET 2.6°-5.7°, isometric peak torque 5.6%-17.6% of body weight, and HGF 7.5%-20.3% of body weight.[5,6]

In study 2, the results showed that a high-intensity training session only decreased shoulder active external rotation (ER) ROM (-6.6° to -7.8°) and isometric torque (-6.6% to -11.4% internal rotator; -7.6% to -8.7% external rotator). Based on within-day analysis of study 1, ER ROM exceeded the MDC, whereas isometric torque only the SEM. After the low-intensity session, no changes in any of the physical qualities were identified. Our results identified intensity of a training session as an important factor that leads to maladaptive changes in the physical qualities of the shoulder.[5] Only the tests that showed a significant change on study 2 (shoulder ER ROM and isometric torque) were included in the next investigations. In study 3, the results showed that university swimmers had less shoulder rotator torque at baseline, and had greater decreases in shoulder ER ROM (change= -6.3° to -8.4°) and rotator torque (-15% to -21.0% internal rotator; -9.0% to -17.0% external rotator) after the training session than national-level counterparts (ER ROM= -1.9° to -5.7°; torque= -10.0% to -13.0% internal rotator and -3.7% to -9.1% external rotator). All changes in university swimmers exceeded the MDC, whereas in national-level counterparts isometric torque of the non-dominant side exceeded the MDC and the rest only the SEM. The results suggest that swimmers of a lower competitive level (i.e., lower chronic loads) have less shoulder rotation torque, which might then predispose them to greater changes after a high-intensity swim session.

Study 4 highlighted that the accumulation of training loads over a week negatively affected shoulder ER ROM (-8.4° to -12.2°) and wellness factors (muscular soreness, fatigue, sleep quality, and overall wellness). Based on between-day analysis of study 1, ER ROM exceeded the MDC on the dominant side, but only the SEM on the non-dominant side. Regarding swim volume, only the perception of training loads was different between swimmers performing different swim-volume, showing, although performing higher swim volumes was perceived as harder, this did not reflect significant differences in general wellness and shoulder physical qualities between groups.[6]. To illustrate the results, we can be 95% confident that the changes in physical qualities were attributable to the swim training and not due to measurement error if they exceeded the MDC and only 68% if they exceed the SEM.

WHAT IS THE MOST IMPORTANT CLINICAL IMPACT/PRACTICAL APPLICATION?

This work demonstrates the complex, multifactorial, and dynamic interactions between training loads and risk factors for shoulder pain in swimmers. These studies provide knowledge about which factors to monitor and when:

1. In-season monitoring of shoulder ER ROM and rotation isometric peak torque before and after a high-intensity swim-training session, is relevant as these physical qualities have been reported as potential modifiable risk factors for shoulder pain in swimmers.[4]
2. Higher chronic loads and well-developed physical qualities seem to be a protective factor of post-swim drops in shoulder physical qualities. Lower-level swimmers (i.e., lower load capacity) are possibly at higher risk of shoulder injury after swim-training.
3. Importance of regular monitoring of multiple factors including shoulder physical qualities and wellbeing to assess swimmers' response to the accumulation of training loads.
4. Monitoring and subsequent load management (i.e., secondary prevention) has been associated with reduced risk of injury in other sports,[7] monitoring modifiable risk factors in swimmers could help to decrease the risk of shoulder pain.

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L.H designed the project with the support of T.M and M.Y. M.Y collected and analysed the data. M.Y wrote the manuscripts with the support of L.H and T.M. L.H and T.M supervised the project and contributed to the interpretation of the results.

REFERENCES

1 Bittencourt NFN, Meeuwisse WH, Mendonça LD, *et al.* Complex systems approach for sports injuries: moving from risk factor identification to injury pattern recognition—narrative review and new concept. *Br J Sports Med* 2016;**50**:1309–14. doi:10.1136/bjsports-2015-095850

2 Sein ML, Walton J, Linklater J, *et al.* Shoulder pain in elite swimmers: primarily due to swim-volume-induced supraspinatus tendinopathy. *Br J Sports Med* 2010;**44**:105–13. doi:10.1136/bjsm.2008.047282

3 Chase KI, Caine DJ, Goodwin BJ, *et al.* A Prospective Study of Injury Affecting Competitive Collegiate Swimmers. *Res Sports Med* 2013;**21**:111–23. doi:10.1080/15438627.2012.757224

4 Hill L, Collins M, Posthumus M. Risk factors for shoulder pain and injury in swimmers: A critical systematic review. *Phys Sportsmed* 2015;**43**:412–20. doi:10.1080/00913847.2015.1077097

5 Yoma M, Herrington L, Mackenzie TA, *et al.* Training Intensity and Shoulder Musculoskeletal Physical Quality Responses in Competitive Swimmers. *J Athl Train* 2021;**56**:54–63. doi:10.4085/1062-6050-0357.19

6 Yoma M, Herrington L, Mackenzie TA. Cumulative Effects of a Week's Training Loads on Shoulder Physical Qualities and Wellness in Competitive Swimmers. *IJSPT* 2021;**16**:1470–84. doi:10.26603/001c.29875

7 Wollin M, Thorborg K, Drew M, *et al.* A novel hamstring strain injury prevention system: post-match strength testing for secondary prevention in football. *Br J Sports Med* 2020;**54**:498–9. doi:10.1136/bjsports-2019-100707

Legends to figures

Figure 1. Shoulder isometric peak torque: a) internal rotation; b) external rotation.
Torque was measured using a handheld dynamometer (model Hoggan MicroFET2; Scientific LLC, Salt Lake City, UT). Force was converted into torque (in newton meters) by multiplying the force (in newtons) by the lever arm length (meters). Torque was normalized to body mass (Nm/kg) and expressed as the percentage of change between the baseline and follow-up measurements.