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Original Research

Epidemiology of shoulder injury in sub-elite level water polo players

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ABSTRACT

Objective: Investigate the patterns and circumstances of shoulder injury, in both male and female sub-elite water polo players, through evaluating the injury incidence, mechanism and subsequent training time lost.

Design: Retrospective cohort.

Setting: Sports institute.

Participants: 80 sub-elite water polo players.

Main outcome measures: Total injury number and incidence, mechanism of injury, lost training time and time from injury onset to seeking treatment.

Results: For the athlete self-report data set (2009–2013), 218 total injuries were reported with 54 (25%) being shoulder injuries. From 2014 to 2016, 133 physiotherapist-report injuries were recorded, the shoulder accounting for 21 (16%) of total injuries. The shoulder was the most frequently injured site and accounted for 25% of lost training days. Two thirds of shoulder injuries were due to overuse (67%). The average time between sustaining a shoulder injury and presenting to the team physiotherapist was 10 days.

Conclusion: Irrespective of data collection method, shoulder injuries were the most common injury for both male and female sub-elite water polo players. Future injury prevention strategies could address overuse through optimising throwing volumes, and include athlete education about injury management to determine whether reducing time delay between injury occurrence and seeking treatment improves outcomes.

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1. Introduction

Water polo is a water-based contact sport that involves swimming, throwing and defending. Men's water polo was introduced at the modern Olympics in 1900, making water polo the first Olympic team competition (Smith, 1998). Despite the long history of the sport, information regarding intrinsic risk factors for injury and injury rates in both male and female water polo players is limited when compared to other throwing sports.

Water polo is a physically demanding sport, in that participating

athletes are required to perform bursts of sprint swimming interspersed with lower intensity swimming, (Franić, Ivković, & Rudić, 2007). Due to water polo training including a substantial swimming component, risk factors for shoulder pain and injury in swimming cohorts are often generalised to water polo. However unlike swimming, water polo players use a heads-up swimming technique to allow a clear view of the ball and opposition as well as to allow the athlete to quickly adapt to offensive and defensive play (Elliott, 1993; Miller, Evans, Adams, Waddington, & Witchalls, 2017). In contrast to swimming, the heads-up technique requires athletes to shorten their stroke and keep their elbows high, reducing their body roll and increasing the required shoulder internal rotation and abduction (Colville & Markman, 1999).

Further, water polo players have the added demand of throwing, with players performing an average of 38.7 passes, 32.1 receives and 7.9 shots per-game (Dopsaj & Matkovic, 1998). Although the

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throwing mechanics in water polo are similar to on-land throwing sports (Feltner & Taylor, 1997; Garrett & Kirkendall, 2000) the aquatic environment requires athletes to generate throwing force without a firm base of support. The water medium reduces an athletes' ability to generate a distal to proximal throwing sequence, increasing the required trunk side flexion and demand on the shoulder joint (Alexander, Hayward, & Honish, 2010).

Injury surveillance is the first step to quantifying and managing injury risk. While few epidemiological studies have been conducted on water polo injury, Annett, Fricker, and McDonald (2000) found shoulder injuries to be the most common musculoskeletal injury in elite male water polo players. Although there is limited evidence for causation, risk factors for shoulder injury in water polo are likely related to the overhead demands of the sport. A recent systematic review reporting that the combined repetitive overhead demands of water polo challenge the physiological limits of the shoulder and increase players' risk of injury (Miller et al., 2017). Additionally, the higher an athlete's level of sporting attainment (e.g. elite vs sub-elite, club or novice level) and a greater number of water polo playing years, has been proposed to increase an athlete's risk of shoulder injury (Colville & Markman, 1999). Inferences made from previous literature to the sub-elite, however, have limited generalisability due to the focus on elite populations only (Miller et al., 2017).

Injuries in any professional sport are the most common reason for player unavailability for training and games, and high injury rates have been shown to adversely affect team performance and success in other sports (Hägglund et al., 2013). Due to risk of chronic injury and ensuing detraining effects, shoulder injury prevention is of high importance to developing water polo players, their coaches and medical staff. It is hypothesised that shoulder injury frequency will be higher than other injuries for this population. The aim of this study was to therefore investigate the patterns and circumstance of all injuries, and shoulders in particular, in both male and female sub-elite water polo players, through evaluating the injury incidence, mechanism and subsequent training time lost.

2. Methods

A retrospective and prospective cohort study of injury surveillance data, from a single male and female state-based sports institute water polo squad (2009–2016 inclusive), was conducted. Each of the six Australian states and two territories has a State Institute or Academy of Sport water polo team from which the national team is selected by Water Polo Australia (WPA). Athletes included in the present study are referred to hereinafter as “sub-elite”, as they are on scholarship at the sports institute. The included athletes form part of the wider group from which the national team is selected, but they are not currently part of the national squad.

Athlete recruitment and characteristics: Access to de-identified retrospective data, collected over the five years, for all male and female water polo squad members was granted. The data was collected with ethics approval from within the sporting institution ethics committee. For players currently in the sporting institution water polo squads, the Head of High Performance invited all players to participate in the present study through email and participant information was provided. Opportunity was also provided for the researchers to answer any questions and written informed consent was obtained prior to inclusion in the study.

During this eight year period, 218 water polo players (female = 128 and male = 90) were included in the study. The mean age of players included in the self-report data was 19.27 ± 2.94 years for females and 20.62 ± 3.73 for males. For the

physiotherapist-report date the mean age was 18.79 ± 4.43 and 19.82 ± 3.16 years respectively. Analyses were performed for all available injury data for the study population. The study was approved by XXX.

Definitions. A physiotherapist-report injury was defined as a musculoskeletal condition that required the athlete to receive physiotherapy treatment. Injury burden was defined as the total training days lost due to the injury (no training), and by the number of days in modified or restricted training.

Athlete exposure (AE) was defined as available training days per athlete, and injury frequency was calculated per 1000 available days. Injury incidence was defined as the number of new injuries in a specified time period (Phillips, 2000) and injury rate as the number of injuries divided by athlete time exposure (Knowles, Marshall, & Guskiewicz, 2006).

Mechanism of injury was sub-categorised within two domains: onset of pain/injury; “insidious” or “traumatic”, and water polo mechanism of injury; “throwing/shooting”, “contact from blocking ball”, “contact from another player”, “swimming”, “gym-work”, “jumping/leg work” or “change-in-direction”.

Body areas were defined by self-report into 10 categories; cervical, shoulder, elbow, forearm, hand/wrist, spine (thoracic/lumbar), hip/groin, thigh/leg, knee and ankle. The additional categories; head, upper arm, gluteal, chest, abdominal and separation of “spine” into thoracic and lumbar formed a total of 16 categories for physiotherapist-report data.

Self-report injury data. During 2009–2013, 141 athletes were included in the water polo program. Injury reporting consisted of an annual injury surveillance screening session, wherein athletes completed a paper-based instrument. Athletes were required to report a dichotomous “yes” or “no” regarding having experienced a water polo related musculoskeletal injury in the preceding 12-months, for 10 different regions of the body. Injuries that were non water polo related but exacerbated by water polo were included. Data was de-identified, coded and analysis was conducted on all available paper-based annual self-report injury questionnaires. Injuries were recorded by body area and gender.

Physiotherapist-report injury data. A second injury data set was also separately analysed. From late 2013, the Smart a Base Athlete Data Management System (AMS) (Fusion Sport, 76 Neon Street, Sumner Park QLD Australia 4074) electronic system was implemented by the sporting institute. Injuries were reported by the same team physiotherapist throughout the 2014–2016 period, and were recorded through the electronic system. For each new injury, the physiotherapist recorded a detailed assessment of the injury site and diagnosis, as well as the activity or mechanism that the player reported as the cause of the injury. In addition, the physiotherapist recorded the assessment outcome recommendation, for example; full training, modified training or complete rest. All available physiotherapist records ($n = 133$) from 2014 to 2016 were coded and analysed for injuries by body area, the circumstance or mechanism of injury, injury burden and incidence.

3. Statistical analysis

All statistical analyses were performed using SPSS version 22.0 (SPSS Inc., Chicago, IL, USA). The two data sets were analysed separately to assess the incidence of sub-elite water polo player injuries. Statistical significance was set *a priori* at $p < 0.05$ for all calculations.

Self-report data analysis included total number of injuries by body area and total number of injuries by body area as a percentage total injuries (injury by body area/total injury $\times 100$). Injury incidence was defined as the number of new injuries in a specified time

period (Phillips, 2000) and injury incidence proportion was calculated as number of injuries by body area for the time period/number of athletes at risk during the period $\times 100$ (Knowles et al., 2006). Chi-square tests were used to compare the proportion of shoulder injury for male and female players and to compare shoulder injury proportion to other body areas.

Physiotherapist-report data analysis included calculation of total injury, injury by body area and injury by body area as a percentage of total injury (injury by body area/total injury $\times 100$). Injury rate was defined as the number of injuries divided by athlete-time-exposure (Knowles et al., 2006). Injury rate and 95% confidence interval (CI) per 1000 available training days were calculated by dividing number of injuries/sum total athlete exposure $\times 1000$ (Knowles et al., 2006). Mechanism of injury and injury burden were also analysed as a percentage of total injury. Mean values and standard deviations (SD) for training time loss, time in modified training and time from injury onset until the athlete sought physiotherapy assessment were calculated by body area affected and in days.

Due to the two different collection methods and injury Definitions, data sets from the self-report injury and physiotherapist report/AMS were not combined statistically.

4. Results

Self-report injury data. 120 annual self-reported injury questionnaires were completed and 21 (15%) questionnaires were not returned (participation rate 85%). During the five year screening period, a total of 218 injuries were reported (Table 1).

By body area, 25% ($n = 54$, range 19.0–35.7% per year), of total injuries were to the shoulder, 17% ($n = 37$, range 10.7–21.4%) to the combined thoracic and lumbar area, and 15% ($n = 32$, range 7.4–19.6%) to the hand, wrist or finger. The knee, pelvis/hip region and elbow respectively comprised 10.1%, 9.6% and 9.2% of total injury. The proportion of shoulder injury was significantly greater ($p < 0.01$) than for each other body area.

Over the five year period, 45% of athletes (49% female and 38% male) reported a shoulder injury. A chi-square test for independence with Yates correction indicated there was no significant difference between shoulder injury status for male and female water polo athletes ($p = 0.33$).

4.1. Physiotherapist-report injury data

During the 1249 available training days, there were 133 physiotherapist-recorded injuries, of which 21 were shoulder injuries. Fifteen of the injuries were experienced by female players (71.5% female vs 28.5% male). Shoulder injury rates were not significantly different by gender ($p = 0.94$).

The shoulder region had the highest number of injuries reported, accounting for 16% of total injuries (12.5–22.2% per year), followed by the hand/wrist, lumbar spine and pelvis/hip region each comprising 10.5% of total injury reports respectively. The proportion of injury in these regions compared to the shoulder was not significantly different (Table 2).

Of reported shoulder injuries, 67% were classed as insidious onset and 33% were recorded as trauma. Nearly half of all shoulder injuries were sustained during general pool training (48%) and a quarter during game play (24%).

Total training days lost for all injury was 488 days (39% of available training days). Shoulder injury contributed to 122 days of lost training time or 25% of total training days lost for all injuries (Table 2). On average, each shoulder injury resulted in 5.8 days of no training (3.7 average for all injury) and 47.3 days in modified training (29.9 days for all injuries). Athletes took an average of 10 days to present to the team physiotherapist post-shoulder injury onset (Table 2). Incidence rate of shoulder injury was 0.65 per 1000 available training days (95% CI 0.37–0.93). See Table 3.

5. Discussion

The findings of the current study suggest that, irrespective of the method of data collection, the shoulder was reported as the most frequently injured body area. Athlete self-report data indicated higher shoulder injury incidence, as a percentage of total injury, than physiotherapist-report data (25% v 16%).

Self-report injury rates in this group of sub-elite water polo players correspond with a previous 13-year retrospective study that investigated anatomical site and injury incidence in elite male water polo players, where shoulder injury was found to be the most prevalent injury (24%) and the most likely to become chronic (Annett et al., 2000). Shoulder injury was also found to be the most prevalent injury in a 12-month prospective self-report study in adolescent male players (Ellapen, Stow, Macrae, Milne, & Van Heerden Hendrick, 2012), although, injury rate was higher in this group (51%) than that reported by Annett or found in the present study. No study has previously considered shoulder injury risk in different age groups of water polo players but it may be that due to growth and somatosensory development there is an increased injury risk during adolescence in overhead athletes (Quatman-Yates, Quatman, Meszaros, Paterno, & Hewett, 2012). There is an increasing trend for adolescent overhead athletes to specialise in one sport early, with some athletes playing in multiple club and school teams all year round (Taylor, 2009). Further studies across this population are recommended to identify if age related risk factors do exist in water polo.

Although a higher proportion of shoulder injury rates were reported between 2009 and 2013 than between 2014 and 2016,

Table 1

Total self-report injuries and injury incidence proportion for sub-elite level water polo players by body area and gender 2009–2013.

Body Area	Injuries reported		Injury incidence proportion			Significance (p)	
	Total number n	% of total injuries (range/year)	Mean%	Female%	Male%	Between gender	Shoulder *body area
Shoulder	54	24.8 (19.0–35.7)	45.0	49.0	38.0	0.33	
Spine	37	17.0 (10.7–21.4)	31.0	33.0	28.0	0.73	<0.01
Hand/wrist	32	14.7 (7.4–19.6)	27.0	19.0	43.0	0.01	<0.01
Knee	22	10.1 (7.1–11.9)	18.0	19.0	18.0	1.00	<0.01
Pelvis	21	9.6 (7.1–17.9)	18.0	15.0	23.0	0.45	<0.01
Elbow	20	9.2 (3.6–13.1)	17.0	16.0	18.0	1.00	<0.01
Cervical	15	6.9 (3.6–11.1)	13.0	16.0	5.0	0.14	<0.01
Ankle	12	5.5 (3.7–8.3)	10.0	11.0	8.0	0.75	<0.01
Forearm	3	1.4 (0.0–3.6)	3.0	4.0	0.0	0.54	<0.01
Thigh/leg	2	0.9 (0.0–3.6)	2.0	3.0	0.0	0.80	<0.01

SD = Standard deviation. Between-gender difference analysed using Chi-squared test of independence.

Table 2
Total physiotherapist-report injuries, incidence rate, mean training time lost and time to first treatment due to injury by body area in sub-elite men's and women's water polo 2013–2016.

Body Area	Total injuries (n)	Incidence rate and 95% CI (per 1000 AEs)	Percentage of total injuries and range (%)	Mean \pm SD Training time lost (days)	Mean \pm SD Modified training (days)	Mean \pm SD days to seek treatment (days)
Shoulder	21	0.65 (0.37, 0.93)	15.8 (12.5–22.2)	5.8 \pm 21.5	47.3 \pm 76.3	10 \pm 14
Lumbar	14	0.45 (0.21, 0.66)	10.5 (7.4–20.0)	4.4 \pm 12.1	33.7 \pm 115.7	17 \pm 30
Hip/groin	14	0.45 (0.21, 0.66)	10.5 (0.0–12.5)	10.6 \pm 39.8	20.0 \pm 35.1	21 \pm 67
Hand	14	0.45 (0.21, 0.66)	10.5 (2.1–14.8)	0.60 \pm 2.1	2.5 \pm 6.7	7 \pm 14
Elbow	12	0.37 (0.16, 0.58)	9.0 (8.3–11.1)*	1.6 \pm 4.9	64.0 \pm 104.6	30 \pm 70
Knee	11	0.34 (0.14, 0.54)	8.3 (2.1–20.0)*	8.8 \pm 18.4	73.6 \pm 95.1	4 \pm 7
Ankle	8	0.25 (0.08, 0.42)	6.0 (0.0–10.4)*	0.0 \pm 0.0	0.90 \pm 2.5	9 \pm 16
Cervical	7	0.22 (0.06, 0.38)	5.3 (2.1–10.0)*	0.0 \pm 0.0	0.50 \pm 1.2	2 \pm 3
Thigh	6	0.19 (0.04, 0.34)	4.5 (0.0–6.3)*	0.0 \pm 0.0	9.0 \pm 11.7	2 \pm 2
Thoracic	6	0.19 (0.04, 0.34)	4.5 (0.0–8.3)*	1.0 \pm 1.7	5.8 \pm 13.3	4 \pm 3
Upper arm	4	0.12 (0.00, 0.25)	3.0 (0.0–8.3)*	3.0 \pm 6.0	7.0 \pm 10.0	11 \pm 10
Abdominal	4	0.12 (0.00, 0.25)	3.5 (0.0–4.2)*	0.80 \pm 1.5	14.5 \pm 15.7	3.5 \pm 6
Gluteal	5	0.15 (0.02, 0.29)	3.8 (0.0–6.3)*	1.4 \pm 3.1	1.6 \pm 3.6	2 \pm 3
Head	3	0.09 (0.00, 0.20)	2.3 (0.0–4.2)*	1.0 \pm 1.73	63.3 \pm 108.8	3 \pm 6
Chest	3	0.09 (0.00, 0.20)	2.3 (0.0–3.7)*	0.0 \pm 0.0	59.0 \pm 80.7	6 \pm 4
Forearm	1	0.03 (0.00, 0.09)	0.8 (0.0–2.1)*	0.0 \pm 0.0	23 \pm 0.0	3 \pm 0
TOTAL	133		4.14 (3.43, 4.84)			
Mean				3.7 \pm 16.8	29.9 \pm 70.0	11 \pm 33

*significantly different to shoulder injury. AE = athlete-exposure, CI = confidence interval, SD = standard deviation.

Table 3
Shoulder injury incidence rate and 95% CI by year for sub-elite men's and women's water polo 2013–2016.

Year	Number of injuries (n)	Athletes (n)	Incidence rate per 1000 AEs	95% CI
2013*	2	31	0.42	(-0.16, 1.00)
2014	6	23	0.71	(0.14, 1.29)
2015	7	25	0.77	(0.20, 1.34)
2016	6	27	0.61	(0.12, 1.10)
		AVERAGE	0.65	(0.37, 0.93)

*154 days of data collection AE = athlete-exposure, CI = confidence interval.

differences in data collection methods and injury definition precluded direct statistical comparison. Despite daily access to the team physiotherapist, there may be an under-estimation in physiotherapist-report injury rates as not all athletes currently access the team physiotherapist for treatment, with some preferring a private physiotherapy provider. Perfect agreement has previously been demonstrated between self-report and prospective injury records when athletes are simply asked if they have sustained an injury in the preceding 12 months using a dichotomous “yes, no” response criteria (Gabbe, Finch, Bennell, & Wajswelner, 2003). The current study used data that was collected and categorised in this way, for athlete self-report of injury. Recall bias exists when increased injury detail is requested (Gabbe et al., 2003). The AMS system introduced by the Sporting Institute in late 2013 eliminated the need for self-report recall, however injury surveillance data may still be lost as the athlete is required to seek team-based physiotherapy management for an injury to be recorded. As an adjunct to the more comprehensive clinician-derived injury data a low burden mobile phone application is used by the current cohort of sub-elite level water polo players. The application has the ability to capture non-time loss pain and injury through daily self-report of any pain by body area maps. Through encouragement at an organisational level from both coaches and medical staff (Saw, Main, & Gastin, 2015) an opportunity exists to educate athletes regarding the importance of reporting non-time loss pain and injury to optimise injury prevention and management and to reduce chronicity. Future prospective research is warranted, and would allow direct comparison of injury reporting and incidence with the same injury definition and reporting process.

Although no significant difference in the incidence of shoulder injury between male and female players was found, results should

be interpreted with caution. Due to the retrospective nature of the study design, results were limited to the data in available medical records, and all missing self-report data occurred in the male athletes group. Sallis et al. (Sallis, Jones, Sunshine, Smith, & Simon, 2001) are the only other researchers to have previously considered gender differences and injury rates in water polo, finding female water polo players report 2.38 times the rate of shoulder injury compared to male players ($p < 0.01$). Sallis et al. attributed the observed increase in shoulder injury to the more rigorous training regime employed by the female team coach. Interestingly, within the current cohort of sub-elite athletes, nearly 50% of all shoulder injuries occurred during pool training compared to 24% in game play. Because the exact training and competition hours were not available in the current study it is not possible to draw conclusions between the two injury incidence rates. The absolute percentage of game based shoulder injuries are lower, however hypothetically, relative to participation hours, more injuries possibly occur during game play. No previous studies have investigated water polo shoulder injury and gender with training and competition volume controlled. Potentially, male and female water polo players may have a similar risk of shoulder injury when training volume is taken into account and further prospective research is warranted to determine if gender-specific risk factors do exist or if injury risk is solely related to the demands of the sport.

Despite the limited evidence from previous studies, shoulder injury in water polo has been attributed to “overuse” from the cumulative demands of swimming, throwing and defending (McMaster, Long, & Caiozzo, 1991; Webster, Morris, & Galna, 2009; Witwer & Sauers, 2006). In the current study, two thirds of injury was insidious in onset suggesting an overuse injury. The aquatic environment of water polo creates the unique challenge of

generating throwing force without a firm base of support (Colville & Markman, 1999; Miller et al., 2017). The swimming mechanics used in water polo also differ (Colville & Markman, 1999). Inevitably, the swimming and throwing motion places repetitive stress on the shoulder at the extremes of range of movement (Escalante et al., 2012). Shot frequency has previously been shown to be positively correlated with shoulder soreness in female water polo players (Wheeler, Kefford, Mosler, Lebedew, & Lyons, 2013). In cricket, risk of shoulder injury was reported to increase with throwing volume, and subsequently, workload recommendations were introduced (Dennis, Farhart, Goumas, & Orchard, 2003). No current workload guidelines exist for water polo. In light of the findings of the present study, injury prevention strategies should address overuse associated with throwing and swimming volumes, to guide the establishment of individual thresholds (Wheeler et al., 2013).

Opportunity exists to reduce the impact of shoulder injury on training time loss and subsequent deconditioning. The findings of the present study suggest that it takes athletes 10 days to seek treatment despite daily access to the team physiotherapist. Shoulder injuries are over-represented in time loss with athletes requiring a mean of 5.8 days of no training and 47.3 days in modified training. No current data exist regarding attitudes to shoulder pain within water polo, however the time lag observed between sustaining an injury and seeking treatment suggests that athletes may be self-managing sub-clinical symptoms initially, and perhaps do not sufficiently associate shoulder pain with injury. A previous study in adolescent swimmers has demonstrated that 88% of players agree or strongly agree that mild shoulder pain is normal and should be tolerated in order to continue training (Hibberd & Myers, 2013). Further, only 14% of these players actually reported an injury to the medical team (Hibberd & Myers, 2013). Starting rehabilitation two days after lower limb soft tissue injury, compared to nine days after, has been shown to shorten return to pain-free function by 3-weeks without subsequent increased re-injury risk (Bayer, Magnusson, & Kjaer, 2017). Future research is required to assess the benefit of commencing shoulder treatment earlier, to explore water polo athletes' attitudes toward shoulder pain, and the reasons behind this delay in reporting, to enable effective education to modify athlete behaviour and optimise injury management.

Limitations. These findings were collected from one male and female sub-elite level team so may not be generalisable to other water polo programs of a different competition level. To date, water polo literature has primarily focussed on elite populations only so this study provides insight into sub-elite players' injury rates. Because the AEs were unit-based (days), rather than time-based, we were unable to report injury rates specifically by the number of training or competition hours completed each day. The AMS system does not currently collect data related to activity outside of the team training sessions and games and, due to the retrospective self-report data collection, injury recall is a limitation. However, the degree of detail requested from the athlete for classification of body area was dichotomous, reducing the likelihood of recall bias. Since an injury was defined as requiring the athlete to seek medical intervention from the team physiotherapist, there exists potential for underreporting due to athletes seeking medical treatment from a private provider. However, the current study methodology was strengthened by one physiotherapist performing and recording all the assessments, incidence being adjusted for athlete exposure, the inclusion of training and competition injuries and the documentation of time loss.

6. Conclusion

Shoulder injury is a significant problem for sub-elite water polo players. Irrespective of data collection method shoulder injury was

the most commonly reported injury and was responsible for a quarter of all training time loss. Two thirds of shoulder injuries were reported to be insidious in onset, suggesting overuse injury. The findings of this study may be related to the repetitive overhead demands of the sport, however further prospective research is required investigating injury incidence as well as swimming and throwing volume. Despite high access, it currently takes athletes an average of 10 days to seek physiotherapy assessment post shoulder injury onset. Early rehabilitation has been demonstrated to decrease the impact of soft tissue injury through reduced training time loss. Investigation of this observed time-lag is required to better understand water polo athlete's attitude toward shoulder pain and injury.

Ethical statement

The study was approved by the University of Canberra Human Research Ethics Committee (HREC15-221) and all athletes were invited and provided informed consent before being included in the study.

Conflicts of interest

The authors have no financial affiliation or involvement with any commercial organisation that has a direct financial interest in any matter included in this manuscript.

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