

Throwing in the deep end: athletes, coaches and support staff experiences, perceptions and beliefs of upper limb injuries and training load in elite women's water polo

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ABSTRACT

To understand elite athlete, coach and support staff experiences, perceptions and beliefs in women's water polo with managing upper limb injuries and monitoring training loads. Inductive qualitative design. Twenty athletes, coaches and support staff were purposively recruited and participated in semistructured interviews. Participants either had experienced an upper limb injury or had experience managing athletes with upper limb injuries. Interviews were conducted in-person or virtually, audio-recorded, deidentified, transcribed verbatim and cleaned to ensure accuracy. Data were thematically analysed. Analysis identified five cohesive themes: (1) upper limb injury management is adequate—but prevention, communication and knowledge need improving, (2) current training load monitoring generates uncertainty and lack of consistency of processes—due to reliance on internal, and lack of external load monitoring, (3) optimal training load monitoring requires objective measurement of training load—that accurately measures the external load of athletes' upper limbs, (4) athlete-centred philosophy matters—including athlete-centred care to facilitate individually tailored rehabilitation programmes and their inclusion in management decisions, (5) mental, social and emotional aspects of upper limb injury management matter—acknowledging feelings of loss of team inclusion, fear of missing out and frustration felt by athletes as well as the emotional labour felt by coaches when supporting athletes with an upper limb injury. Upper limb injury management and training load monitoring are evolving areas where objective measurement of training load may assist in increasing consistency of communication, collaboration and coordination between all stakeholders, and to address uncertainty. Stakeholders placed value in intangible qualities such as trust and care in their relationships with other collaborators—facilitating athlete physical, mental and emotional recovery following upper limb injuries.

INTRODUCTION

Water polo is the oldest Olympic team sport with men's participation commencing in

Key messages

What is already known?

- Upper limb injuries pose a considerable burden to training and competition in elite women's water polo.
- Communication, teamwork and shared responsibility are likely key factors in successful injury prevention in elite sport.
- Individual and contextual stakeholder experiences/perceptions on injuries may inform future injury prevention programmes.

What are the new findings?

- Sports-specific knowledge, injury prevention programmes and guideline development are needed to further improve upper limb injury management in elite women's water polo.
- Communication, collaboration, consistency of processes and coordination of systems between stakeholders are essential attributes to optimise upper limb injury management.
- Objective measurement of training load was perceived as a potential mechanism for facilitating more consistent communication and thereby increasing opportunities for collaboration and coordination.
- Qualities such as care and trust in stakeholder relationships are perceived as optimising athlete physical, mental and emotional health during upper limb injury recovery.

1900 and women's participation in 2000.¹ The sport involves high volumes of swimming, throwing and contact skills, exposing players to upper limb injuries.² Women water polo athletes appear to have higher vulnerability to upper limb injuries than men athletes. In US collegiate water polo, women athletes were more than twice as likely to sustain a shoulder injury than their male counterparts (8.09 vs 3.4 injuries per 100 participant years).³ Women's water polo injury incidence has significantly increased over time (2004: 3.57



injuries/1000 player matches, 2009: 23.8 injuries/1000 player matches), possibly due to the intensity of the game increasing to that of the men's game.⁴ There is currently a dearth of information about out-of-competition injury data—likely underestimating injury incidence in training thereby impeding the development and implementation of possible prevention practices.^{5 6} During a video analysis of seven athletes at a national women's water polo camp, 74% of all shoulder soreness could be explained by increases in goal shooting volume and decreases in rest time between shots.⁷ It is apparent that there is a need to address shoulder injuries, which are prevalent in women athletes and likely related to training. If we are to effectively manage shoulder injuries in women water polo athletes, it is imperative that their experiences, perceptions and beliefs along with those of their coaches and support staff are understood.

In other sports such as swimming and athletics, stakeholder's perspectives on injury prevention have been investigated. *Bolling et al* found that communication, teamwork and shared responsibility were key factors in successful injury prevention within elite sport.⁸ Yet it is unknown whether water polo stakeholders, defined as athletes, coaches and support staff, have similar views and the context within which they operate. Injury prevention frameworks have advocated for individual, societal and contextual factors to be investigated and incorporated in the design of injury prevention programmes.⁹ Within this context, qualitative research is critical, as it provides insights on stakeholder experiences and perceptions, which can inform the design and implementation of future injury prevention programmes.¹⁰ The aim of this study was to investigate experiences and perceptions of water polo athletes, coaches and support staff with managing upper limb injuries and monitoring training loads—with a view to understanding any perceived individual and contextual barriers or enablers.

METHODS

Study design

This study used an inductive qualitative design where we drew meaning and concepts from participants' responses.¹¹ Our knowledge and patterns of meaning did not begin with a preconceived theory but emerged organically out of the process of interviewing, coding and thematically analysing the data.¹² Our study's methodological underpinning was centred in relativist-contextualist paradigm—acknowledging that multiple realities exist both within and between individuals and that knowledge and understanding are viewed through an individual's interpretation and context.^{13 14} In this study, we were interested in gaining a comprehensive understanding of both the lived experience and context of participants, as their insights will inform the future development of tools and resources to address their needs.¹⁵

Participants

Participants were included in our study if they were: athletes who had sustained an upper limb injury, and coaches and support staff who had managed an upper limb injury over the previous 12 months. Athletes who had not sustained an upper limb injury and coaches and support staff not involved with state or national athletes were excluded.

Participants were recruited over 3 months (December 2020 to March 2021) as a purposive sample by two Australian water polo staff who were not involved in the study. These staff were informed of the selection criteria and sought a broad representation of athletes, coaches and support staff in elite level water polo. We sought to include athletes from different geographical locations, different training ages, playing position and levels of injury experience as well as support staff and coaches who had different levels of coaching experience and philosophies from different geographical locations. The two Australian water polo staff emailed potential participants within the high-performance system database. Those interested in participating replied by email and received a participant information and consent form. We ceased participant recruitment when sufficient saturation was reached, that is, when there was sufficient depth and repetition in the themes that addressed the study aims.

Data collection

Semistructured interviews were conducted from December 2020 to March 2021, either in-person or via Zoom. One of the investigators (MHK) works as a physiotherapist in elite women's water polo and was known to some of the interviewees. To protect participants' confidentiality and ensure the trustworthiness of the data, we engaged a physiotherapist with extensive experience in qualitative research (NC) who was not known to the interviewees. Two investigators (MHK and NC) interviewed participants. To ensure consistency of the data collection, MHK, NC and BV cowrote the interview guide (online supplementary appendix 1). A series of consistent prompting and clarifying questions were formulated in case participants did not elaborate on their responses. MHK and NC conducted mock interviews with each other to ensure commonality in interview structure and prompting questions. NC then checked both the transcript and audio recordings of MHK's first two interviews to ensure consistency of interview technique and appropriateness of structure. Both MHK and NC read the transcripts of each other's interviews during the data collection period to ensure consistency of interview structure and content. No one else apart from the participant and the investigator (MHK or NC) was involved in the interview process.

Athlete's lived experience of having an upper limb injury were explored through questions about training, rehabilitation, return to play and perceived factors that influenced their experiences within this context. Athletes were also questioned regarding their perceptions of

current training load monitoring and what they believed could be done to improve both the management of upper limb injuries and training load monitoring. As water polo within Australia currently has significant financial limitations towards resource development, we were particularly interested in stakeholder perceived wishes in terms of resources or tools to improve upper limb injury management and training load monitoring, both with or without financial limitations. We prompted them to elaborate on their thoughts using hypothetical scenarios (eg, ‘blue sky scenarios’ with no resources constraints and also scenarios with limited resources available). Coaches and support staff were asked similar questions, with minor changes in wording to adjust to their experiences (online supplementary appendix 1). MHK and NC wrote field notes after each interview. In order to validate accuracy and to empower participant’s control of transcription content,¹⁶ the interview transcript was sent to each participant, who then could provide further input. Findings were not sent to participants because these were finalised during a competition season and most participants were unavailable to provide feedback. No repeat interviews were conducted.

Data analysis

Interviews were audio recorded and transcribed verbatim. Interview transcriptions were deidentified and cleaned for accuracy. Interviews were inductively and thematically analysed,¹² allowing us to explore participants’ experiences at an individual level while comparing and identifying patterns. Two investigators (MHK and NC) coded the interviews using NVivo V.12 Plus (QSR International, Doncaster, UK). MHK is a female who has a master’s degree in sports and musculoskeletal physiotherapy, 20 years of clinical physiotherapy experience with 4 years of involvement with water polo. MHK is also a former elite rower, having competed at senior world championship and Olympic level and served on her sports athlete’s commission. MHK has received training in qualitative analysis. NC is female who has a PhD in physiotherapy and is an experienced qualitative researcher. The analysis was iterative and involved six steps: (1) both investigators repeatedly read the transcripts then discussed initial ideas emerging from the data; (2) MHK and NC coded one transcript together then each coded the remaining transcripts independently with MHK coding 11 transcripts and NC coding 8 transcripts; (3) during the coding process, MHK and NC had five meetings to discuss coding refinement and emerging

preliminary themes addressing the research question; (4) MHK and NC collated and revised theme names and descriptions; (5) MHK and NC presented the themes to BV, AL and KW, who contributed by further theme refinement and wording alterations; (6) an experienced qualitative researcher (KM) uninvolved in the study was asked to confirm the appropriateness of the themes, codes and quotes in regards to the research question.

RESULTS

We interviewed 10 athletes, 5 coaches and 5 support staff for this study with interviews that ranged in duration from 27 to 53 min. The participant group characteristics are outlined below (table 1). Support staff professions included sports medicine, physiotherapy, strength and conditioning and physiology. Only one participant dropped out of the study prior to the interview due to competing priorities.

Athletes, coaches and support staff provided their views on opportunities for improvement of managing upper limb injury and monitoring training load—which on thematic analysis appeared interrelated. In brief, they highlighted the need for better rehabilitation strategies, including the acknowledgement of the mental and emotional health impacts of upper limb injury. Participants stressed that prevention and rehabilitation should be aligned with veracious monitoring of training loads—optimally using objective measurements of training load. Participants suggested that collaboration between all stakeholders with the athlete at the centre of the process was essential with open communication channels also vital for optimal management. The themes are described in greater detail herein and represented visually in figure 1.

Upper limb injury management is adequate - but prevention, communication and knowledge need improving

Reflecting on current upper limb injury management, most participants contrasted their past and current experiences and seemed to believe that the management of upper limb injuries has improved over time (table 2). Such improvement was discussed as a consequence of greater communication between current support staff, having staff members who collaborated effectively and who had extensive knowledge and/or experience in the field. Although the management of upper limb injury was perceived as generally adequate, some participants highlighted aspects of injury management that deserve further attention. Athletes highlighted a lack of strategies

Table 1 Demographic characteristics of participants expressed as mean (SD) unless otherwise specified

Category	N	Age years	Sex: female N (%)	Water polo experience years	Upper limb injury experience years
Athletes	10	25.8 (5.73)	10 (100)	13.4 (5.19)	4.3 (2.16)
Coaches	5	50.2 (8.76)	2 (40)	19.2 (9.44)	13.4 (4.5)
Support Staff	5	37.6 (9.71)	2 (40)	6.8 (3.56)	7 (3.31)

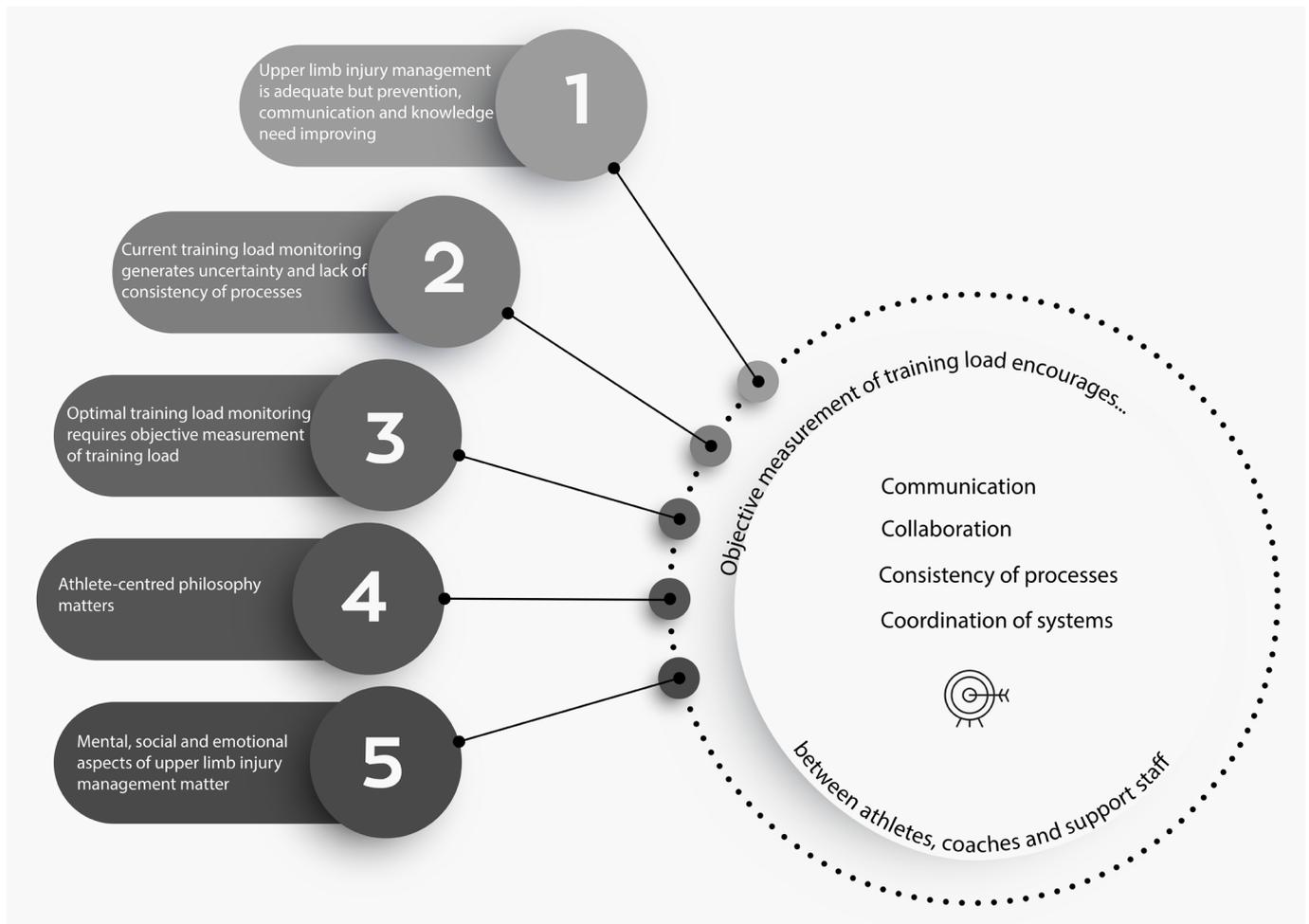


Figure 1 Schematic representation of themes and processes.

to prevent injuries from happening, differing levels of communication and coordination between athletes and support staff, and a need to further develop knowledge regarding water polo and its specific injuries. Likewise, support staff emphasised the importance of enhancing athlete's involvement, the need of having a physiotherapist and/or coach assistants integrated into training programmes (eg, at the pool) and further coach education. Guidelines and diagrams were also highlighted as important tools that had the potential to enhance training planning, communication and coordination across stakeholders.

Current training load monitoring generates uncertainty and lack of consistency of processes

Both support staff and athletes discussed several issues regarding the current athlete self-report of training load on the Australian Institute of Sport Athlete Management System—as a surrogate internal training load.¹⁷ Participants raised concerns regarding athletes being asked, when concluding training, to provide a single numerical rating of perceived exertion during the training session (table 3). They were concerned that a single numerical rating of perceived exertion did not accurately reflect variations in intensity that athletes experience in a

training session—leading to athlete uncertainty on how to rate their perceived exertion in the session. There was also concern about the retrospectivity of the rating—in terms of monitoring within session exertion (internal training load) and planning future training sessions.

Another important issue discussed by athletes was a single rating of perceived exertion for a session may not validly reflect or measure the intensity and volume of upper limb activity—known as external load.¹⁸ The lack of a valid measure of external load often required further contextual interpretation. Athletes believed that this contextualisation required greater communication between them, coaches and support staff. Notably, discussions about shooting volume relative to high-intensity swimming were perceived as important, but they varied depending on time of year and geographical location of the training environment. Participants also discussed potential solutions to monitor upper limb training activities and suggested that internal load measures could be supplemented by external training load measures—specifically using wearable technology.

Most participants thought the lack of external load monitoring impacted on rehabilitation and return to play due to the dearth of valid data on training and

Table 2 Key codes and quotes on the theme—upper limb injury management is adequate—but prevention, communication and knowledge need improving

Codes	Quotes (emphasis added)
Communication, collaboration and coordination between stakeholders are improving	<p>'I think when we've had really good staff on the program, it's been really great. Like at the moment, we've got really great strength and conditioning, really great physio, which means they all work together, and they all streamline and it all sort of builds on one another. Whereas in the past I've had lots of ones that either undermine other people or they don't really care' Athlete 3</p> <p>'Yeah, I think it's adequate. (...) I think we can still do it even better and make sure it's consistent. (...) they [athlete injury data] are discussion points about, "Hey, there's a red flag, we just got to be a little bit aware of that." (...) They are the conversation piece, they're not the black and white, these are the numbers and you're going to hit them and nothing else (...) They just kind of keep us all...on the same page.' Coach 2</p>
Lack of data and knowledge regarding upper limb injury management generates uncertainty	<p>'You know, for rugby and for swimming and for athletics they have all this data on like this injury for this athlete... So we're kind of just making it up. And in terms of loading for my shoulder in Australia...we just don't know. And the way that we train is so different to overseas as well...I don't know...water polo is just so under explored.' Athlete 11</p> <p>'I've obviously been with girls that haven't had their shoulder injuries taken more serious and are no longer playing anymore because they can't because of their shoulders. I think just figuring out what it is first early on instead of just kind of going, "Oh, your shoulder—It's just sore." And then like pushing you away. I think it's more...just like figuring out... what is causing this before you send a player away and continuing them to train at full capacity like...I think it just needs to be sorted out a bit earlier.' Athlete 6</p> <p>'I think too many times in the past they've gone, "Oh, you've got an injury, you can't train at all," so basically we don't see them then they come back and...they're at the bottom level...They can maybe be doing something with their other arm...It's challenging...you get mixed messages sometimes." Coach 4</p>
There are opportunities to improve communication, collaboration and coordination between stakeholders	<p>'When I started to increase my training load, at a younger age...I started to get...just consistent injuries really...It was bursitis in my right shoulder and that is my throwing arm as well...and I just think that, like looking back on that I was just kind of thrown into the deep end with no real, you know, prehab or rehab, what's right and wrong to do before and after a session.' Athlete 7</p> <p>'So, I think it's improving. (...) One barrier is coaches not listening...Coaches not listening to, coaches thinking they know more than a physio or a doctor or a strength coach, I think that's a huge barrier. I think another one is (...) getting athletes to really listen and take ownership and, because sometimes it's hard...for them to be patient enough.' Coach 3</p>
There are opportunities to improve upper limb injury management by better coordination and collaboration with healthcare professionals	<p>'They don't put anything in place to...prevent them. Whether or not a step further to preventing some of those could be improved. I'd say, yes is probably the answer to that... It just seems like you're constantly hitting a brick wall when you're trying to work out who belongs where (...) it just seems that if that is a lot more open and collaborative...It would work a lot better. And there'd be less athletes that actually suffer.' Athlete 3</p> <p>'I think we can do better still (...) I think the more you have a physio integrated into your program, available to your program, to be at the pool, to be at the gym, to be involved in writing these programs...with some of the rehab and return to play (...) So, the more they're involved, I think the better those shoulders are managed because they're seeing them in training as well and understanding the squad better and not just coming and making an assessment purely based on, what they're hearing...I think I've said a number of times just about the having a physio ingrained. (...) I think the consistency of, either our process of planning or at least how we're communicating it between programs, whether it's institutes, clubs right down to...maybe participation.' Coach 2</p>
There are opportunities to improve coach education on upper limb injury management	<p>'And it's really hard...for junior coaches to manage 20 different athletes with different kind of expectations. (...) so maybe education for the coaches about those kinds of things and the impact it has on an athlete to come from doing nothing to coming in that week, you decided to have a week to do five swim sets of 6K (...) So more education on that kind of stuff for the coaches...just that education piece, whether it's a simple (...) spreadsheet, whether it's (laughs) a bit of paper with a diagram that kind of guides you in the right direction, so at the lowest level or at the most under-resourced (laughs) level that the coach has some guidelines and some help of how to navigate an injury so that they're not just winging it again.' Coach 2</p> <p>'Unless you are employed by an institute of sport, or the top national coaches, the positions are mostly voluntary and part-time so there is a lack of skill in understanding what to adjust (...) People either ignore shoulder pain or expect shoulder pain is a normal part of the sport or pull athletes out completely and say 'Well, you can't train if you can't throw' or 'you can't complete the swim set'...So again, I think coaching skill.' Support Staff 4</p>

performance prior to injury. The lack of longitudinal data was also highlighted by support staff as a barrier for effective planning regarding training progressions across multiple stakeholders and sites.

Optimal training load monitoring requires objective measurement of training load

When questioned about improving current upper limb injury management and training load monitoring, participants highlighted the need for concrete data to quantify number, intensity and speed of shots, passes, drills, strokes, blocks and swimming. Participants believed such information could have several benefits,

such as: foster stakeholder discussions, assist training prescription, create opportunities for readjustments, track movement mechanism and progression, enhance use of internal load monitoring and improve understanding of water polo demands (table 4). Some athletes, coaches and support staff who had experience with wearable sensors discussed the value of objective information as an evaluation mechanism for collaborative training load planning. Some coaches reflected on the objective measurements as assisting in establishing a well-balanced weekly training activity structure and providing a feedback loop for future planning collaboration and communication.

Table 3 Key codes and quotes on the theme—current training load monitoring generates uncertainty and lack of consistency of processes

Codes	Quotes (emphasis added)
Current load monitoring generates uncertainty	<p>'Some of it is lost in translation in terms of...what is high load...and what's not. I remember we went into the camp and it was...supposed to be an easy week. And we got to the end of the week and everyone was like, "Good God, that was awful, that was not easy."...and so that kind of disconnect between what the coaches are perceiving as easy and what the players are perceiving as easy...' Athlete 13</p> <p>'Yeah, I think it's adequate. And then, I think like anything, I think we can still do it even better and make sure it's consistent. And I think there's even room to, to still move on what, what fits into which category. (...) So, for me, they're just about the conversation piece, they're not the black and white, these are the numbers and you're going to hit them and nothing else. It's the risk around them. They just kind of keep us all I guess on the same page.' Coach 2</p>
Load monitoring—athlete rating of perceived exertion does not accurately capture what actually occurred within the session	<p>'I think some loads might be quite low in terms of like RPE, but the shoulder load is extreme. So you might go from... 20 minutes of shooting at a training session and it's an RPE 3, and then (...) go 50 minutes the next session and it's still an RPE 3 but...that acute load on the shoulder is huge and you wouldn't be able to see the difference. (...) they're completely different sessions and the load is completely different in terms of body parts.' Athlete 11</p> <p>'It relies a lot upon the individual's perception, which is fair enough but...we did a swim yesterday morning (...) and sometimes they [the athletes] ask me after it, " ...What am I meant to rate that?" "Well...what did you think?"...so they're sort of asking me...what they're meant to rate it. (...) So that's...a bit hit and miss. Look really, the best way of monitoring...it's got to be done scientifically' Coach 3</p>
Load monitoring—Australian Institute of Sport Athlete Management System is perceived by athletes as being unidirectional from athlete to coach/staff—a platform for staff that athletes lack connection with and do not get specific training information from	<p>'The AMS system...it's supposed to see how you're traveling and...risk awareness of shoulder, anything that plays up. But...no one's ever predicted a shoulder injury, a shoulder flare-up for me. (...) The AMS... I feel like is more of a communication tool between the support staff...like medical staff, to keep everyone up to date. But as an athlete, I don't even look at the loading because...it just seems to change. They tell us what to do and then it's like...no actually, we're doing this, even though the athletes feel like this.' Athlete 12</p> <p>'I think AMS is a complete waste of time unless people are actually willing to look at the data in the current moment. I think we use it as a 'hindsight tool' more than a 'in the moment' tool. So I think a lot of injuries, potentially upper limb injuries have become present based on loads. So I don't think it's well utilised at all.' Athlete 11</p> <p>'AMS is very dependent on the athlete's buy-in. the athlete's compliance. And in the past we've had and still do have varying levels of athlete compliance. It's improved a lot but is still a bit hit and miss to be honest with you.' Coach 3</p>
Absence of communication and collaboration with athletes on injury recovery and training load monitoring	<p>'Communication has to be transparent across all parties that are dealing with the injured athlete. Choices being made around me is not so helpful (...) I think everyone wants to feel like they're being heard and they have an opinion, but I think there's a lot of conversations that get spoken about behind the athlete's back. I think the athlete should be part of the process on the decision made, whether it's in favour of the athlete or not.' Athlete 11</p> <p>'I find that...in the handover of athlete care, I tend to find...that things are missed and things aren't as nice as...they are when you have a full rehab at home with the same people, day in and day out, for 6 months...There are differing goals of the people involved...differing KPIs...as much as we like to talk about athlete first and athlete care.' Support Staff 2</p>

Athlete-centred philosophy matters

All participants discussed athlete-centred practices as enhancing upper limb injury management and training load monitoring (table 5). Participants emphasised the importance of individually targeted approaches as opposed to blanket rules. Athletes perceived regular screenings as a valuable strategy to monitor both improvement and setbacks, with some highlighting the value of having their bodies assessed and treated as a whole rather than just the injured area. Likewise, coaches discussed the importance of tailoring return to play to the context of each athlete, accounting for training background and previous injuries. Both athletes and coaches emphasised having exercise programmes tailored to athletes' needs and adjusting them over time. Individual athlete training statistics were also discussed as a rehabilitation programme tool which could align with the specificities and needs of each athlete. Some athletes who had experience using wearable sensors mentioned how individual sensor information helped their understanding of their physical assessment results, increasing confidence in their recovery process.

Participants discussed needing experts involved whom they could develop trust with and who sought out collaboration with other staff and athletes. Athletes mentioned qualities such as listening, addressing and validating their concerns and assisting their understanding of situations were important for establishing trust and care. Coaches and support staff discussed the development of trust through effective, regular communication and approaching collaboration with a sense of humility and acceptance of others' ideas and potential for contribution. Developing trust and collaboration was reflected on as a key component of athlete-centred philosophy within high-performance environments.

Mental, social and emotional aspects of upper limb injury management matter

Going beyond dealing with physical aspects, all participants discussed the need to manage significant mental and emotional impacts of upper limb injury (table 6). Athletes highlighted the impact these injuries have on their feelings of team inclusion, making them feel frustrated for having to refrain from training and

Table 4 Key codes and quotes on the theme—optimal training load monitoring requires objective measurement of training load

Codes	Quotes (emphasis added)
Objective measurement of training load can complement existing training load monitoring in AMS	<p>‘The study that we did...with the sensors...it was really interesting to know that we could see the increase in load because sometimes when we do AMS (...) <i>I didn’t know how to rate it but it was really good knowing...how many strokes we’re doing.</i> This is the rate it was whereas at this time, it was this and that.’ Athlete 1</p> <p>‘Having some kind of device that we can wear in the pool that can give coaches...<i>numbers of how much load we’re specifically doing, which can match our self-report data and can match the number of minutes that they set aside.</i> Having something like that, I think would be really interesting in terms of loading. It just gives another kind of dimension to that.’ Athlete 15</p>
Objective measurement of training load can assist with consistency of information and communication	<p>‘So if we go AFL...<i>you have things that can measure both the internal load and the external load that the players go through. I think in water polo there’s currently no real external load measure...it is very hard for us to know exactly how much they’ve swum or thrown the ball...</i>...that’s just another piece of the puzzle that actually helps that whole process of <i>everyone talking together, your communication with the athlete, with staff and then having some numbers to back up your decision or to check and tick your progression or your plan...</i>’ Support Staff 1</p> <p>‘I think that, you know the psychological support, the monitoring through the sensors, there’s the physical support from the physio perspective and strength and conditioning perspective...<i>sitting around a table and having the time to actually plan it and map that recovery out with the athlete at the table...</i>...just constantly monitoring it and...reflecting and evaluating how it’s going and...involving the athlete every step of the way and providing them...100% support at all levels’ Coach 3</p>
An ideal scenario of training load monitoring is monitoring training activity in the water	<p>‘I see it being done better. Do arbitrary units have a place in load management? Absolutely. Has water polo as a sport, hung their hat wholly and solely on arbitrary units for a long time, which I disagree with. Absolutely...<i>but it very much now comes down to, for me, what’s the type of training and what do the coaches want to do, and actually tapping into those expertise of what the best training program looks like...and there’s some other [aquatic] playing tracking technology we’ve played around with, which again is just giving us more understanding of what the game demands of the sport</i> are, to therefore help us do better planning of training prescription.’ Support Staff 2</p> <p>‘I know that (physio—deidentified) here has developed a sensor...to monitor the load on shoulders. So, <i>I’d love for us to be able to put those sensors on the athlete every session and monitor, well, firstly, plan it and monitor it and then that will give us an opportunity to readjust it if we need to as we go, because that’ll give us some really good data.</i>’ Coach 3</p>
The training reporting tool should contain/ currently does not contain volume and intensity of passing, shooting and blocking	<p>‘In terms of <i>how they do the loading at the moment, how they categorize everything, like passing and shooting, water polo movements, water polo drills.</i> (...) <i>So, I’d be curious to see, okay, well, they say passing is, by itself, it’s like 20 minutes or whatever and then water polo drills is like 120. Okay, how much of that 120 is then another additional passing or shooting?</i>’ Athlete 12</p> <p>‘So can we show that a shot is getting faster or are they using more rotation through their thoracic? Like, how can we kind of better track it ourselves rather than just looking at it and going, “Oh, yeah, that looks better, that looks faster,”...having some data behind that and showing progression (...) <i>that’s one side of it is as a kind of player tracking type...movement progression tracking mechanism...it just gives us more concrete information to base some of our intuitions off.</i>’ Support Staff 1</p>

competition. Some participants disclosed that the fear of missing certain opportunities, such as being selected for national and international competitions, often led them to put up with significant symptoms. Likewise, coaches and support staff acknowledged the emotional labour involved in supporting athletes through these injuries. Some coaches believed they had let some athletes down, due to lack of time to engage in conversations and give them the necessary attention.

Financial considerations were also an important factor for injury management. Some athletes reported feeling conflicted due to the need to financially support themselves through work while simultaneously, being expected to take time off work to access healthcare. Social factors such as time, financial and work pressures were discussed as barriers for rehabilitation. This was also emphasised by a few coaches, who believed athletes could perform better if they had financial support to play water polo.

DISCUSSION

Our investigation found five inter-related themes. In brief, our themes indicate that optimisation of upper limb injury management is an ongoing process which can be assisted by emerging objective measurement of training load, but also by recognising and addressing the emotional and mental impacts of injury. With regards to training load monitoring, all participants acknowledged the limitations of the current training load monitoring structure and the need for further advancements in objective measurements and processes. Further to this, we identified four key processes which underpinned the themes—communication and collaboration which were further influenced by consistency of processes and stakeholder coordination of systems. These processes were perceived by participants as: enabling the optimisation of upper limb injury management; improving training load monitoring; and facilitating care and trust—all essential

**Table 5** Key codes and quotes on the theme—athlete-centred philosophy matters

Codes	Quotes (emphasis added)
Specific individual exercises and experts who care	<p>'So I was seeing a physio that I trust, I was well listened to, we took a more holistic approach, not just treating the shoulder. So taking the load off the thoracic element, the neck element, making sure that my hips were working really well to take the load off. So it was that real holistic approach and not just focusing on the acute kind of injury.' Athlete 11</p> <p>'(Strength and conditioning coach—deidentified) is brilliant and he's very much on top of managing that kind of thing. So, having a gym program that's tailored to you and what you're capable of, I think is incredibly useful...I think having that day-to-day stuff is just so invaluable.' Athlete 13</p> <p>'I guess the athletes that are injured, I regularly...adapt the swimming sessions by getting them to swim with a pool buoy or training aid to deload the particular area that's injured. I also work on their technique...which will hopefully help the injury. It's part of my job.' Support Staff 5</p>
Objective measures can aid tailored approaches	<p>'I guess we don't know the cumulative result of that load has on development of injuries...so in the first part it would be about data collection and how that load might correlate with specific injuries (...) It could potentially be beneficial' Support Staff 3</p> <p>'I think (...) having baseline measurements that every athlete as on an individual basis, I think is really important... I think individual statistics on athletes is the best way to go. So if time and money wasn't a factor I would screen every athlete and make their rehab or their prehab designed for them.' Athlete 11</p>
Coordination of systems, guidelines and communication enhance trust and collaboration	<p>'If patient trust, a system that everyone's followed and we know that works, a return to play kind of guideline or return to sport guideline. I guess I would consider it as similar to a concussion. I know each concussion is different. Therefore, each shoulder injury is different, but if you have means tests on that individual athlete, I think that would be really good. Then you have guidelines and new targets that you can hit and you know your progression.' Athlete 11</p> <p>'I think transparency and communication. So, the athletes (...) knowing what some of those milestones are and why they're important 'cause if they don't know, they're probably gonna get frustrated if they're not hitting them or if the milestones keep moving for some reason and they're not aware. So, I think that's a big one and for me that links back to the confidence piece.' Support Staff 1</p>

features to optimise high-performance environments. This is consistent with and builds on previous injury prevention research which found open communication and shared responsibility as vital attributes of high-performance environments.^{19 20}

Upper limb injury guidelines and knowledge need further development

Our first theme emphasises the need for ongoing development of stakeholder communication, injury prevention education and guideline development in water polo. In injury prevention research, contextual, environmental and equipment interventions have been proposed to have a greater impact on injury prevention efficacy than attempting to change individual athlete behaviours.²¹ Athlete viewpoints must be sought to develop contextual tools and resources which maximise impact of injury prevention strategies.²² Similar to the findings of *Ekstrand et al*,²³ our participants perceived a deficit of consistent communication and collaboration between staff or organisations as factors that hindered injury prevention and return to play optimisation. In agreement with our first theme, others have argued that successful shared decision-making on return to play processes relies on effective communication within teams in order to build trust.²⁴

According to coaches, educational programmes and tools such as guidelines could improve their knowledge and enable them to better support athletes. Findings from previous qualitative research in other sports such as gymnastics and handball also emphasised the potential

benefits of further coach education and training to optimise athlete support.^{25 26} Currently, no water polo injury guidelines exist in Australia. Acknowledging a lack of guidelines, athletes and support staff contrasted water polo with other sports that have return to play guidelines and injury prevention educational programmes such as rugby²⁷ and Australian Rules Football.²⁸

Current training load monitoring relies on subjective internal training load monitoring and does not currently use objective external training load monitoring

The findings of our second theme were linked to a perception that current subjective internal training load monitoring practises do not fully describe intrasession changes in perceived intensity. Athletes expressed uncertainty in processes associated with giving a single numerical rate of perceived exertion and subsequently felt disconnected from the current training load monitoring platforms. Athletes acknowledged the differing perception of session rate of perceived exertion compared with the perception of the coach. Other studies have highlighted communication, feedback to the athlete from staff about injury surveillance and training load monitoring data as vital for athlete engagement and continual use of monitoring systems.²⁹ Additionally, other research has recognised that context plays a profound role in influencing the athlete's reporting of rate of perceived exertion.³⁰ For these reasons, it has been recommended that both subjective internal measurements as well as objective external measurements of training load to be adopted.¹⁸

Table 6 Key codes and quotes regarding the theme—mental, social and emotional aspects of upper limb injury management matter

Codes	Quotes (emphasis added)
Mental and emotional aspects play a role in the athlete experience and require support	<p><i>'I think I was pretty intuitive with my body and I knew something wasn't super correct...yeah, it's pretty fatiguing...I would say, I think injuries really do play on the athlete's mind a lot. And it was an injury that I think I was a little bit negative on because I was mismanaged at the start, but once we got the diagnosis, once we got the scans, once we got the doctors on board, I felt quite safe back in the hands of the [deidentified] water polo staff.'</i> Athlete 11</p> <p><i>'It was really, really frustrating...When I had the injury, it was like pretty devastating because this is a period where I really was trying to make teams, trying to always be in front of the head coach of the Australian team (...) it was quite exhausting staying through this process mentally...it was a pretty frustrating experience.'</i> Athlete 9</p> <p><i>'One part is mental...it's really important to have a sports psychologist around...because athletes are passing through not a great period. And then we can decide if they really need support of wellbeing and everything.'</i> Coach 1</p>
Dealing with injuries can be frustrating and impact on sense of team belonging	<p><i>'I think the thing that really helped me during that rehab stuff was having...the medical staff, just always checking in with you during that time, because I think that sometimes when you're injured and you're not able to fully participate, you can sometimes feel quite isolated (...) I think it's actually really important because it just can get a little bit lonely sometimes when you're injured and you're isolated from the team.'</i> Athlete 15</p> <p><i>'It felt like I, as a coach...I was maybe either letting them down or letting the team down if I was pulling them out of things, because I didn't understand the full extent of everything, which is not just me as a coach, but just...the amount of information we had or didn't have. So, I found it very overwhelming, but also frustrating...really frustrating...And so it's very different to now...there's a lot more communication and a lot more notice about what we're doing. So...anyone that's returning, we've got a plan in place.'</i> Coach 2</p>
Experiencing upper limb injury can involve putting up with it	<p><i>'With my finger, because it was on my left hand, I didn't have any time off training...Going back into training, just having to deal with the pain was the only thing. I think what hindered it was, well we were in the middle of a season, so it was quite hard for me to stop playing games at the time...but, looking back on it, I don't think there was another alternative for me.'</i> Athlete 7</p> <p><i>'They know that it's a long road to recovery and they are scared that they will miss out on so much improvement in that time that they'll be modifying training. Which I get, because that was my worst...the first time it started to hurt, I didn't want to say anything because I didn't want to stop training. I didn't want to modify training because I was like, I'm going to miss out on all this time which is really important but there's always more time down the track.'</i> Athlete 1</p> <p><i>'If they understand the consequences, they are a bit better at being honest. If they don't understand the consequences, they go "I'm fine, I can play this weekend," whereas really, they are in a fair bit of pain...All of that comes down to the communication, them having trust in you and you having trust in them that they are going to tell the truth.'</i> Coach 4</p>
Mental & Emotional aspects play a role in the coach experience and require support	<p><i>'There was an athlete that, a few years ago (...) I could sense that she was, they all go through waves of emotions, but hers was the end of her career and that's partly her as a person. But I think then I didn't feel like I could give her the support that she needed so I felt like I was letting an athlete down and I probably felt like I wasn't giving her the best that she could have gotten, but I was doing the best I could in that situation.'</i> Coach 2</p> <p><i>'I've got lived experience through the same (injury) they're going through or they're about to go through (...) I can understand it much better because I've actually gone through it, whereas I'm not sure what I would do if I hadn't have (...) Shoulder specifically, I feel there is such a mental component and a confidence component to it, particularly in water polo because you're working at the end ranges of that limb's capacity and you have to produce a lot of power at that end range. So...you then have to have a lot of confidence in that skill and that joint to get back to peak performance.'</i> Support Staff 1</p>
Life outside of water polo impacts on injury recovery (university, work, financial)	<p><i>'In 2017, I was working full-time as a [manual occupation—deidentified] which actually involves lifting buckets, holding [items—deidentified] that tend to get heavy when they're relatively large. (...) So I definitely think...not so much the job itself but the lack of recovery (...) and just using my arms more and more every day, definitely was associated with how it kind of all started. I don't think it's a coincidence that I had the shoulder injury the year that I started working full-time as a [manual occupation—deidentified].'</i> Athlete 14</p> <p><i>'My biggest factor is just time and also finance, like being able to go to physio at...appropriate times if I've done something to my shoulder in that session, and I've got work all day. It's a toss up, whether you call in late to work and go get physio, but then not sure if you can then pay for that and having to balance those sorts of commitments, is the biggest probably area outside of the pool, is just balancing that because we're an amateur sport, everyone works or studies...So, I think that's probably the biggest one outside of the pool is just those pressures that everyone has of being able to finance yourself and weighing up what are your options...'</i> Athlete 3</p> <p><i>'It would be ideal to be like the Europeans where they are professional. That's their earnings. A lot of these girls, some are studying, some are working. What happens in Europe, they'll do four hours in the morning and...four hours in the evening. That's their work.'</i> Coach 6</p>



In water polo, the lack of objective measurements of external training load was perceived by participants as generating uncertainty and possibly be detrimental to the effectiveness of rehabilitation in returning athletes to play, as well as planning training load. Central to this uncertainty is a lack of data on usual shooting and passing volumes in healthy, full training athletes. A previous study of seven water polo players used a cumbersome video analysis method and showed that there was increasing shoulder soreness with increasing shooting volumes and reducing rest times.⁷ It then seems plausible to consider that current practices and systems could benefit from these data.

Objective measurements of training load as a facilitator of consistency of processes, communication and collaboration

Our third theme emphasises that athletes and coaches perceived that objective measurement of training load were required to accurately measure upper limb activity during training. Stakeholders perceived that this information could then increase communication and collaboration regarding training planning. Consistent with the integrated eHealth approach proposed by *Verhagen & Bolling*,³¹ athletes and coaches identified that advancements in objective training load monitoring could be used to facilitate more consistent communication and collaboration between stakeholders, producing greater efficiency in athlete injury recovery. Pilot trials of novel external training load monitoring were mentioned by some participants involved. Consistent with our third theme, other sports have considerable use of both external and internal training load monitoring and support both measures as providing a more complete overview of training completion and adaptation compared with using solely one monitoring process.^{32 33}

Athlete-centred philosophy is perceived as optimising both performance and injury recovery

Our fourth theme highlights the importance of athlete centredness and individualisation in optimising both athlete performance and injury recovery. Similar to the findings on injury prevention practices in Australian Rules Football,³⁴ this theme identified that all stakeholders valued individual approaches to upper limb injury assessment and rehabilitation. Previous literature suggests that coaches with transformational or democratic leadership style had a lower incidence of severe injuries in their teams and actively encouraged, communicated positively and promoted trust with their staff and athletes.³⁵

Within this theme, participants identified that developing caring and trusting relationships between athletes, coaches and support staff can mediate mental and emotional challenges facing athletes recovering from an upper limb injury. Similar to findings in individual sports,³⁶ athletes and staff expressed the need for time with practitioners for developing trusting relationships in training environments. In agreement with *Nodding's* care

ethics and reflected in other team sports,^{37 38} one of the most important factors to optimal rehabilitation was the physical and emotional availability to listen, validate and assist with their injury concerns.

Mental and emotional impacts of injury affect sense of team belonging and can generate frustration

Our fifth theme was linked with the perception that upper limb injury has considerable mental and emotional impacts on both athletes and coaches. A recent consensus statement highlights that injury has significant impacts on athlete's mental and emotional health.³⁹ It is important to acknowledge the contextual and social impacts of injury in terms of athletes lacking a sense of team inclusion or the emotional labour felt by coaches managing an upper limb injury within a team sport.²² Similarly, previous research confirms our finding that athlete's frustration and fear of missing out on selection opportunities or training leads athletes to ignore considerable symptoms.³⁶ In a novel finding, our study found participants acknowledged that athletes often have a conflicted choice between time spent accessing healthcare to optimise injury recovery and supporting themselves financially through employment. Notably, participants perceived this conflict as increasing mental and emotional stress on injured athletes. Further research into this phenomenon is required to begin to understand the impact of this on athletes, coaches and support staff.

Strengths and limitations

There are a number of important factors to consider when interpreting the results of this study. We studied women water polo athletes, coaches and support staff who were part of an Australian elite high performance environment—potentially limiting our findings to this context. Translating our findings to other sports' contexts and/or countries should take this into consideration. The interviews were conducted over a time period that some participants were involved in Olympic selection trials, which may also have influenced the perceptions and views they expressed during the interviews. We also did not include others in the sport who may have administrative, organisational and financial roles to play in implementing our findings—for example, high performance directors and chief executive officers. They may have a different viewpoint on the topics canvassed. Future studies may seek to investigate the role of leadership, governance structures and financial investment in transforming the context in which upper limb injury management and training load monitoring occurs.

A strength of our study is that we studied upper limb injury management and training load monitoring in elite women's water polo—a neglected field of sports injury research.⁴⁰ Our study is also the first qualitative study of the experiences, perceptions and beliefs of women's water polo athletes, coaches and support staff on the topic of upper limb injury management.

CONCLUSION

Upper limb injury management and training load monitoring in elite women's water polo are evolving areas that could be advanced by facilitating sports-specific knowledge, education and the objective measurement of training load. Advancements in the objective measurement of training load would assist in resolving the current uncertainty regarding training load monitoring and their utilisation in managing an athlete. Athletes, coaches and support staff valued intangible qualities of trust and care in their relationships—these values were seen as facilitating athlete physical, mental and emotional recovery following upper limb injuries.

Our findings offer national and international organisations in water polo some direction in optimising upper limb injury management and training load. For example, they are encouraged to (1) develop guidelines to manage injuries and to improve education of coaches in monitoring training and injury rehabilitation; (2) foster trust and care in athlete-coach-support staff relationships; and (3) further develop objective measures as a mechanism for facilitating consistency of processes. Our stakeholder perceptions support this as a means to more open and engaged high performance environments. Overall, participants perceived that encouraging four processes—communication, collaboration, consistency of processes and coordination of systems would facilitate the optimisation of upper limb injury management and training load monitoring.

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Appendix A. Interview Guide

Introduction: We are interested in knowing more about your experiences in having/coaching athletes with an upper limb injury. The aim of this study is to gather information about the current experiences, perceptions and beliefs of athletes, coaches and support staff around how upper limb injuries and training load are managed. Please be aware that there are no right or wrong answers – we are just very keen to hear your thoughts on the topic. Please stop me at any time if you need to take a break or want to end the interview for any reason. Also, remember that you don't have to answer every question – just let me know if you want to move on from something. Before we start, can I please confirm that have your permission to audio-record this interview?

The interviews will contain the following prompting questions:

Questions for athletes

1. (Opening question) So as I mentioned earlier, we are interested in your upper limb injury experience. Can you start by giving me an overview of your upper limb injury experience?

Prompting Questions:

- *What did you feel when you first got the injury?*
- *How long have you had/had it for?*
- *How frequently do you have it?*
- *Do you experience fluctuations of symptoms or it is always the same?*
- *What factors outside of waterpolo training/playing do you feel is important for your upper limb injury? Are there any strategies you use to manage your upper limb injury?*

2. What were your experiences of return to playing and rehabilitation?

Prompting questions:

- *Can you give some examples of things that facilitated/helped you in the rehab process?*
- *Can you describe what the treatment feels like?*
- *Can you think of any examples of things which were not so helpful?*
- *Can you please elaborate on what makes you think that (adjust to participant's response) was not so helpful?*
- *What was most important aspect your rehab experience to you?*

3. Overall, how do you perceive upper limb injuries are currently managed in waterpolo?

Prompting Questions:

- *What do you believe to be the facilitators for the management of upper limb injuries in athletes, if any?*
- *What barriers do you believe may hinder the management of athletes with upper limb injuries, if any?*
- *Can you think of anything that could potentially assist the management of upper limb injuries in the future at all?*

4. How do you perceive training load monitoring is currently managed in waterpolo? For instance, frequency of training, duration of training, use of training load units.

Clarifying question:

- Is it fair to say you feel the way training load is monitored is _____ (e.g. potentially problematic, adequate – adjust this according to their response)?

Follow up question:

- Can you tell me more about that?

5. If money or time etc were not a barrier, what tools or resources would you like to see developed to facilitate the management of upper limb injuries?

Follow up questions:

- We are considering developing an upper limb training load monitoring reporting tool. What information do you believe it should contain?
- What information would be useful for you?

6. Let's now consider the opposite scenario – if there were very few resources available but yet, an opportunity to improve how upper limb injuries are managed, what simple changes you would like to see, if any?

7. (Final questions to wrap up) Is there anything else you would like to mention or discuss that we have not covered today?

Follow up question:

- **Could you please summarise to me what we have discussed today?**

Further probing questions will occur if the participant provides innovative and novel information which may better inform the key themes for the participant group.

Questions for Waterpolo **coaches and Strength and conditioning coaches:**

- 1. So as I mentioned earlier, we are interested in your experience coaching athletes who sustained an upper limb injury. Can you start by giving me an overview of your experience coaching these athletes?**

Prompting Questions:

- How did you feel coaching these athletes?
 - What factors outside of waterpolo training do think are important for their upper limb injury?

- 2. What were your experiences of coaching athletes returning to play and undergoing rehab after an upper limb injury?**

Prompting questions:

- Can you give some examples of things that you believe to facilitate the rehab process, if any?
- In your opinion, what was most important aspect the rehab process?

3. Overall, how do you perceive upper limb injuries are currently managed in waterpolo?

- *Prompting Questions:*
- *What do you believe to be the facilitators for the management of upper limb injuries in athletes, if any?*
- *What barriers do you believe may hinder the management of athletes with upper limb injuries, if any?*
- *Can you think of anything that could potentially assist the management of upper limb injuries in the future at all?*

4. How do you perceive training load monitoring is currently managed in waterpolo? For instance, frequency of training, duration of training, use of training load units.

Clarifying question:

- Is it fair to say you feel the way training load is monitored is _____ (e.g. potentially problematic, adequate – adjust this according to their response)?

Follow up question:

- Can you tell me more about that?

5. If money or time etc were not a barrier, what tools or resources would you like to see developed to assist you to coach athletes recovering from an upper limb injury?

Follow up questions:

- We are considering developing an upper limb training load monitoring reporting tool. What information do you believe it should contain?
- What information would be useful for you?

6. Let's now consider the opposite scenario – if there were very few resources available but yet, an opportunity to improve how upper limb injuries are managed, what simple changes you would like to see, if any?**7. (Final questions to wrap up) Is there anything else you would like to mention or discuss that we have not covered today?**

Follow up question:

- **Could you please summarise to me what we have discussed today?**

Further probing questions will occur if the participant provides innovative and novel information which may better inform the key themes for the participant group.

Questions for Other Support Staff (High Performance Managers, Physiotherapy, Medicine, Physiology)

- 1. So as I mentioned earlier, we are interested in your experience supporting athletes who sustained an upper limb injury. Can you start by giving me an overview of your experience supporting these athletes?**

Prompting Questions:

- How did you feel supporting these athletes?
 - What factors outside of waterpolo training do think are important for their upper limb injury?

- 2. What were your experiences of supporting athletes returning to play and undergoing rehab after an upper limb injury?**

Prompting questions:

- Can you give some examples of things that you believe to facilitate the rehab process, if any?
- In your opinion, what was most important aspect the rehab process?

- 3. Overall, how do you perceive upper limb injuries are currently managed in waterpolo?**

- *Prompting Questions: What do you believe to be the facilitators for the management of upper limb injuries in athletes, if any?*
- *What barriers do you believe may hinder the management of athletes with upper limb injuries, if any?*
- *Can you think of anything that could potentially assist the management of upper limb injuries in the future at all?*

- 4. How do you perceive training load monitoring is currently managed in waterpolo? For instance, frequency of training, duration of training, use of training load units.**

Clarifying question:

- Is it fair to say you feel the way training load is monitored is _____ (e.g. potentially problematic, adequate – adjust this according to their response)?

Follow up question:

- Can you tell me more about that?

- 5. If money or time etc were not a barrier, what tools or resources would you like to see developed to assist you to coach athletes recovering from an upper limb injury?**

Follow up questions:

- We are considering developing an upper limb training load monitoring reporting tool. What information do you believe it should contain?
- What information would be useful for you?

- 6. Let's now consider the opposite scenario – if there were very few resources available but yet, an opportunity to improve how upper limb injuries are managed, what simple changes you would like to see, if any?**

7. (Final questions to wrap up) Is there anything else you would like to mention or discuss that we have not covered today?

Follow up question:

- **Could you please summarise to me what we have discussed today?**

Further probing questions will occur if the participant provides innovative and novel information which may better inform the key themes for the participant group.