2021 consensus statement for preventing and managing low back pain in elite and subelite adult rowers

Fiona Wilson [1], Jane S Thornton [2,3], Kellie Wilkie,[4] Jan Hartvigsen,[5] Anders Vinther,[6] Kathryn E Ackerman [7], J P Caneiro,[8] Larissa Trease [9], Frank Nugent,[10] Conor Gissane,[1] Sarah-Jane McDonnell,[11] Alison McGregor,[12] Craig Newlands,[13] Clare L Ardern [14,15]

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For numbered affiliations see end of article.

Correspondence to
Fiona Wilson, Discipline Of Physiotherapy, Trinity College Dublin School of Medicine, Dublin 2, Ireland;
wilsonf@tcd.ie

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ABSTRACT

Purpose To synthesise evidence on low back pain (LBP) in adult rowers and to create a consensus statement to inform clinical practice.

Methods There were four synthesis steps that informed the consensus statement. In step one, seven expert clinicians and researchers established the scope of the consensus statement and conducted a survey of experienced and expert clinicians to explore current practice. In step two, working groups examined current evidence relating to key scope questions and summarised key issues. In step three, we synthesised evidence for each group and used a modified Delphi process to aid in the creation of the overall consensus statements. Finally, in step four, we combined information from step three with the findings of the clinician survey (and with athlete and coach input) to produce recommendations for clinical practice.

Results The scope of the consensus statement included epidemiology; biomechanics; management; the athlete's voice and clinical expertise. Prevention and management of LBP in rowers should include education on risk factors, rowing biomechanics and training load. If treatment is needed, non-invasive management, including early unloading from aggravating activities, effective pain control and exercise therapy should be considered. Fitness should be maintained with load management and progression to full training and competition. The role of surgery is unclear. Management should be athlete focused and a culture of openness within the team encouraged.

Conclusion Recommendations are based on current evidence and consensus and aligned with international LBP guidelines in non-athletic populations, but with advice aimed specifically at rowers. We recommend that research in relation to all aspects of prevention and management of LBP in rowers be intensified.

INTRODUCTION

Low back pain (LBP) is the most frequently reported musculoskeletal disorder in the community, and can result in long-term pain and disability.[1 2] Rowing is a sport associated with large volumes of training and high cumulative loading of the lumbar spine. The most frequently reported site of pain for rowers, as a result of rowing, is also the low back.[3 4] The most recently published prospective study reported that 21% of all reported illness and injuries over eight seasons in a national rowing team were to the lumbar spine.[5] Recent research has focused on epidemiology and biomechanical analyses to understand mechanisms that contribute to LBP onset. There has been a limited focus on management or prevention strategies.

There are currently no guidelines for managing LBP in rowers (hereby defined as 'rowing-related LBP') or in athletes who participate in other sports. There are guidelines for managing LBP in the general population, however while some principles of management are transferable, there is a need to consider issues that are particular to rowers and athletes.

The overall aim of this project was to inform clinical decisions and standards of care in order to reduce the long-term effects of LBP on rowers, and to influence outcome by reducing personal burden and healthcare costs.

Specifically, we aim to (1) synthesise and present the current evidence on LBP in adult rowers and (2) develop practical recommendations for prevention and management to facilitate translating evidence into practice.

METHODS

The AGREE II reporting checklist[6] (www.agreetrust.org) guided development and reporting of this consensus statement.

Figure 1 summarises the consensus statement methods.

Contributors

A core expert group comprising seven individuals (FW, JST, KW, AV, AMcG, CG and CN) who had published research in rowing-related LBP and who had broad experience of managing rowers with LBP, convened at British Rowing Headquarters, Hammersmith, London, in February 2018. The group defined the objectives of the consensus statement and outlined the personnel required. Two methods experts (JH and CLA) were invited and consulted throughout the process of developing the consensus statement and recommendations. The Medical Commission of the international rowing body 'World Rowing' oversaw and supported the process. World Rowing did not provide any financial support, nor did they have any editorial input, but they have endorsed this document.

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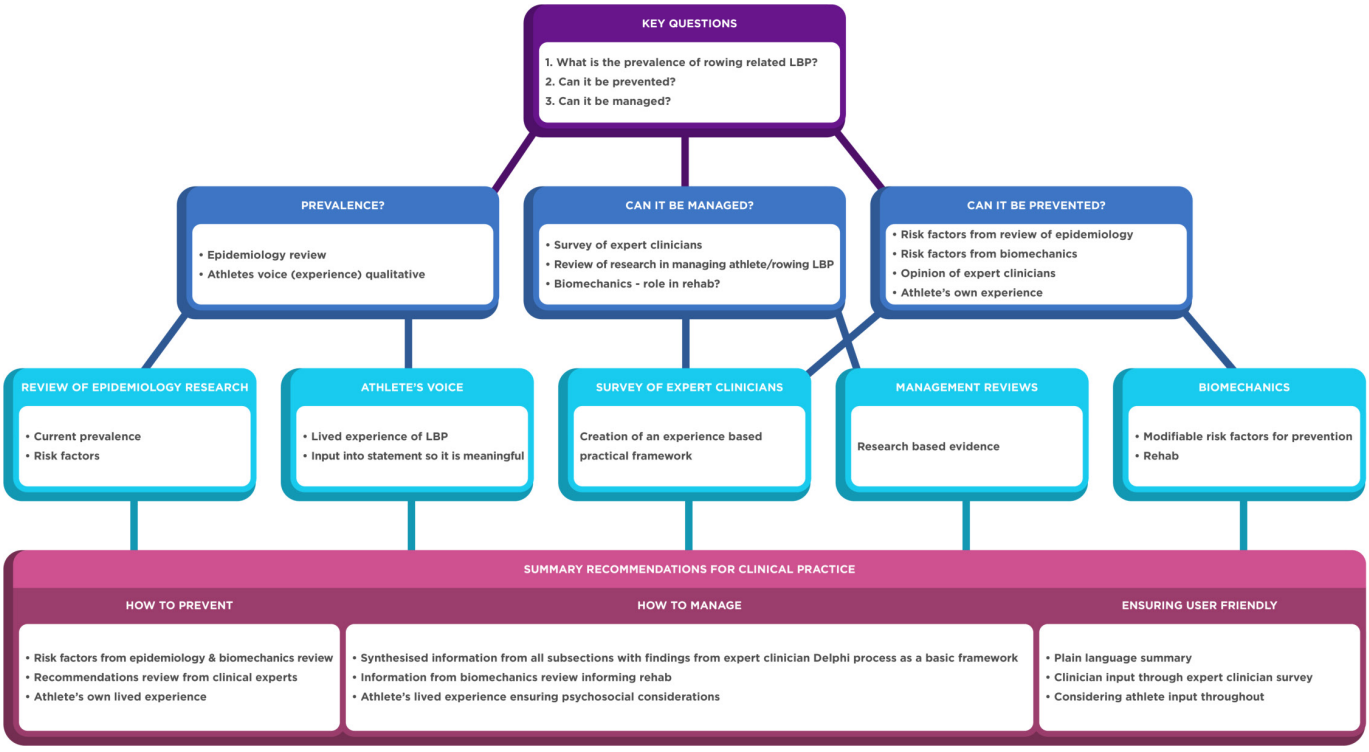

Figure 1 Summary of consensus statement methods.

Following the February 2018 meeting, additional experts were identified for each subsection based on relevant expertise. Experts were required to have (i) been engaged in managing rowing-related LBP, and (ii) conducted research in the area, which they had disseminated. The expert group included physiotherapists, physicians (sports medicine and endocrinology), orthopaedic surgeons, coaches, sport scientists (eg, strength and conditioning experts) and athlete representatives. The group represented all key end users and reflected the composition of the appropriate World Rowing Commissions and the range of key characteristics of the user populations.

Expert group members represented Europe, North America and Australasia, which comprise the greatest number of rowing nations. All rowing nations had the opportunity to contribute to the consensus statement via (i) a clinician survey distributed to every nation registered with World Rowing, and (ii) at an interim presentation of the protocol and preliminary results at the World Rowing Sports Medicine, Science and Coaches Conference in Berlin, November 2018.

Setting the task and defining questions

The keynote presentation from the 2015 World Rowing Championships (WRC) Medical Meeting was used as the reference document when defining the scope of this consensus statement.[7] This presentation had synthesised and summarised the evidence on rowing-related LBP, and was later posted on the World Rowing website in 2016[7] to inform and invite discussion by the world rowing community. The content of the community feedback on the website, input from the World Rowing Sports Medicine Commission members and informal feedback (audience questions and debate) from the WRC meeting were considered and used to inform discussion at the February 2018 meeting in London.

The first task of the February 2018 meeting was to define the questions that would underpin the consensus statement. Three key questions were discussed in a round-table format at the London meeting:

1. What is the extent (prevalence) of rowing-related LBP; how does it compare to other sports and LBP in the general population?
2. Can rowing-related LBP be managed, and how?
3. Can rowing-related LBP be prevented?

Consensus objectives

The core expert group defined project objectives by discussing the key questions; reflecting on how established research could answer these and where new research was required.

We aimed to answer questions 1 and 2 by reviewing epidemiology and management strategies. To understand management, we planned a systematic review to evaluate the evidence for non-pharmacological management of LBP in athletes.[8] We then planned an extensive survey of expert and experienced clinicians to investigate current best clinical assessment and management of an acute episode of LBP in rowers.[9] In addition, we planned qualitative research to investigate the athlete's lived experience.[10]

We agreed that the focus of question 3 would be to explore risk factors reported in epidemiology and to examine the influence of biomechanics as a modifiable and influencing factor in rowing-related LBP. Initial discussions and informal scoping of rowing-related LBP studies identified a considerable research focus on biomechanics, and we agreed to create a subgroup to explore the research on rowing biomechanics.[11] As part of the clinician survey, we also asked clinicians for their opinions on modifiable risk factors.

The following set of objectives were agreed by consensus (box 1).

To accomplish our objectives, we established working groups. Two groups were charged with conducting original research: a qualitative study of the rowers' lived experience of LBP, and a Delphi survey of rowing clinicians' opinions. One group had collected data prior to

Box 1 Objectives of London meeting, February 2018

Objectives

- Perform systematic reviews of epidemiology, biomechanics and management of low back pain.
- To seek information from end users.
  - Rowing athletes to examine their experiences of low back pain.
  - Clinicians to investigate their opinions, experiences and recommendations regarding rowing-related low back pain management.
- Provide a definition of rowing-related low back pain.
- To create a framework for managing rowing-related low back pain with recommendations regarding recognising, triaging and managing pain in the acute, subacute and chronic phases.
- Develop recommendations for rehabilitation and prevention advice

the February 2018 meeting (the qualitative study), so were reconvened for the consensus statement project.

Three groups were established to conduct systematic reviews. The first group was charged with framing a definition of rowing-related LBP and conducting a systematic review of literature on epidemiology of LBP in athletes, with a subgroup analysis of studies that examined rowing-related LBP.[12] The second group examined the biomechanics associated with rowing-related LBP,[11] and the third reviewed the treatment of LBP in athletes with studies examining rowing-related LBP synthesised where possible.[8]

The full methodologies and outputs from each work group are presented as companion papers to this consensus statement.[8–12] The study proposal, interim findings and key questions (from the February 2018 meeting) were presented at the World Rowing Sports Medicine, Science and Coaches Conference in Berlin, November 2018.

Modified Delphi process to decide on the content of the consensus statement

For each of the outputs from the working groups and on completion and analysis of findings, a series of summary statements and recommendations (where possible) were created to reflect the study or review findings. We used a modified two-to-four round Delphi process.

Ahead of round one, we used content analysis to summarise key results using Microsoft Excel (Microsoft Corporation, USA) and Google Docs (www.docs.google.com) for online sharing with each work group. Members of the work groups anonymously rated their level of agreement on a 10-point scale where 1=disagree strongly and 10=agree strongly. Respondents could add statements or suggest modifications to the original statements. Agreement was established when the mean reached a score of seven or above as a representation of combined group opinion.

For round two, the agreed statements, and those that were added in round one, were shared with each working group and the core expert group, along with a completed copy of the study findings. Voting was again conducted anonymously in the Google Doc as described, and the group was invited to add or modify the statements. These invited comments and modifications were also voted on at this stage. In round three, participants rerated their level of agreement for each statement after viewing scoring distribution of group opinion from round two. Consensus for a statement was established when the round three mean score reached seven or above and the SD was two or less. If necessary, a fourth round was conducted. For example, if any authors added modifications of any of the agreed statements at round three.

A separate voting process was conducted by the epidemiology group for the definition of LBP where experts who had published in athlete LBP were also invited to vote in an initial three-round process. A fourth-round vote was conducted and the final statement that was chosen was the one with the highest mean score.

The survey of experienced and expert clinicians was conducted from the outset as a separate Delphi process and methods are detailed in the accompanying paper.[9]

The final summaries and recommendations were based on assessing the quality of evidence, patient values and preferences as well as the experience and insight in the work groups.

Plain language summary

On completion of the consensus statement, three athletes (GO'D, FS and KB) and two coaches (MH and PT) independently provided feedback on content and language. A plain language summary was constructed using their feedback and was guided by methods outlined by the Cochrane Collaboration[13] (online supplemental file 6)

RESULTS

Findings of systematic reviews and summary statements

Findings of systematic reviews and agreed summary statements reached through the Delphi process are summarised in online supplemental appendix A. Accompanying papers report full methods and results.[8 10–12]

Survey of expert and experienced clinicians

Information regarding the study methodology can be accessed in the companion paper.[9] All statements that reached consensus are summarised in online supplemental appendix B and form the basis of recommendations for clinical practice (see below). The findings of this study represent current clinical expertise.

SUMMARY RECOMMENDATIONS FOR CLINICAL PRACTICE

We created recommendations for preventing and managing rowing-related LBP by synthesising the information from research and clinical practice (the assessment and management). The following clinical practice guideline is primarily guided by results from the survey of experienced and expert clinicians as a framework[9] and embeds information from the Delphi outputs of each work group (Epidemiology, Management, Biomechanics and Athlete voice (qualitative)) throughout.

What is rowing-related low back pain and how prevalent is it?

A definition of rowing related LBP is summarised in Box 2. An average of 61% of adult rowers will have experienced an episode of LBP in a 12-month period.[12] This compares with a 12-month prevalence of 51% in athletes overall[12] and 37% in the general population.[1]

What causes rowing-related low back pain, and can it be prevented?

Risk factors contributing to rowing-related LBP are listed in Box 3.

Factors identified in high-quality rowing-specific studies highlight a history of LBP, rapid increases in training/competition load and ergometer training, particularly sessions lasting longer than 30 min. There were no studies that specifically addressed prevention of

Box 2 Definition of rowing-related LBP

Low back pain (LBP) is a symptom that can result from several different known or unknown abnormalities or diseases. It is defined by the location of pain, typically between the lower rib margins and the buttock creases. In some cases, it may be accompanied by pain in one or both legs and some people with LBP have associated neurological symptoms in the lower limbs. Rowing-related LBP is pain that affects a rowing athlete, that is because of or exacerbated by rowing or rowing-related training, resulting in a need to modify or stop scheduled activities.

rowing-related LBP. In their absence, it is pertinent to modify exposure to known risk factors where possible. For example, to monitor response to training load and alter where needed, avoid load spikes and avoid high volumes of ergometer training.

How should rowing-related low back pain be managed?

General recommendations common to each phase

Physical and non-physical factors contribute to both the onset and persistence of pain. A culture of early recognition and management of LBP should be adopted in the training environment. Most episodes of rowing-related LBP are unlikely to be serious and will likely be self-limiting. Rowers with LBP often report feeling isolated during rehabilitation. Coaches and support teams should create an environment where rowers are educated about the nature and presentation of LBP and supported and encouraged to disclose their LBP early to improve outcomes. Clinicians should have a consistent message with a clinical alliance among each other and a therapeutic alliance with the rower. Ongoing education and reassurance should be provided; it is important to include the rower in decision-making from initial triage to return to on-water training.

Psychological stressors such as poor sleep, performance pressure, fear avoidance behaviour and life stressors signal consideration for psychological support. Other levels of appropriate support may be provided by coaching staff, medical staff, family and friends. Rowers should be encouraged to seek mental health support if there is a specific need. Coaches' and athletes' expectations should be managed. In the elite environment, the coach should be involved from the outset (if the athlete consents) and the coach should be encouraged to share ideas about contributing factors to LBP. An athlete-centred approach should be adopted at all stages. Yellow flags should be considered to minimise fear avoidance behaviour and catastrophising. Rowers should avoid developing a fear of specific movement patterns.

The following are general assessment and management recommendations from initial presentation to return to sport (RTS). Recommendations for each phase with specific details are presented in online supplemental table 3.

At the time of initial presentation and during the acute phase of recovery, prioritise:

1. Comprehensive assessment for early identification of red and yellow flags.
2. Effective pain control for activities of everyday life.
3. Keeping the rower active with cross training.
4. Regaining rower-specific movement patterns.
5. Empowering and educating the rower and coach.

During the subacute phase and through rehabilitation to full RTS, prioritise:

1. Progressively increasing on-water training volume and intensity with concomitant reduction in cross-training.
2. Multidisciplinary involvement in the RTS plan.
3. Ensuring modifiable risk factors for rowing-related LBP are addressed.

Criteria for progressing from one phase to the next are shown in figure 2.

Box 3 Risk factors associated with rowing-related LBP

Risk factors associated with rowing-related low back pain (LBP) (stratified by type of evidence)

Epidemiology research and systematic review

- Previous history of LBP.
- Rapid increase in training or competition load.
- High volume and intensity of training or competition.
- Increased years of exposure to the sport (career length).
- Exposure to ergometer training, specifically sessions >30 min.

Biomechanics research and systematic review

- Fatigue and poor technique lead to increased lumbar spine flexion and decreased hip range of motion during the rowing stroke (exacerbated during ergometer compared with on-water rowing).

Delphi survey of experienced and expert clinicians

- Training load considerations.
  - Steep increase in training load.
  - Reduction in load followed by a sharp increase.
  - Increase in training volume without adequate recovery.
  - Change to training intensity (athlete training outside prescribed or intended training zone).
  - Illness or injury prior to LBP episode causing a reduced training load.
  - Ability to complete high training volume over a longer period of time (3 months is protective for LBP).
  - Young 'training age'.
- On-water rowing considerations.
  - Changes in crew increasing load on rower with LBP episode.
  - Recent change in boat set up.
  - Rough water.
  - Increased lumbar flexion range or getting to end of range during rowing.
- Rower: physical and movement considerations.
  - Hip flexion less than 130 degrees.
  - Reduced hamstring flexibility.
  - Reduced knee flexion range.
  - Reduced posterior chain and abdominal endurance.
  - Motor control of deep squat.
  - Control deficits when lifting weights.
- Rower: psychological considerations.
  - Fear of pain or movement.
  - Worry of having LBP for first time.
  - Worry of having a subsequent episode of LBP.
  - Selection pressure.
  - Increased stress related to being close to a key event.
- Other considerations.
  - Poor nutrition or reduced energy intake.
  - Poor sleep habits

Outcome measures and adjunct clinical assessment tools

Clinically based outcome measures

Useful outcome measures for assessment at triage and through progression by experienced clinicians are as follows: Visual Analogue Scale; Patient-Specific Functional Scale; Orebro Musculoskeletal

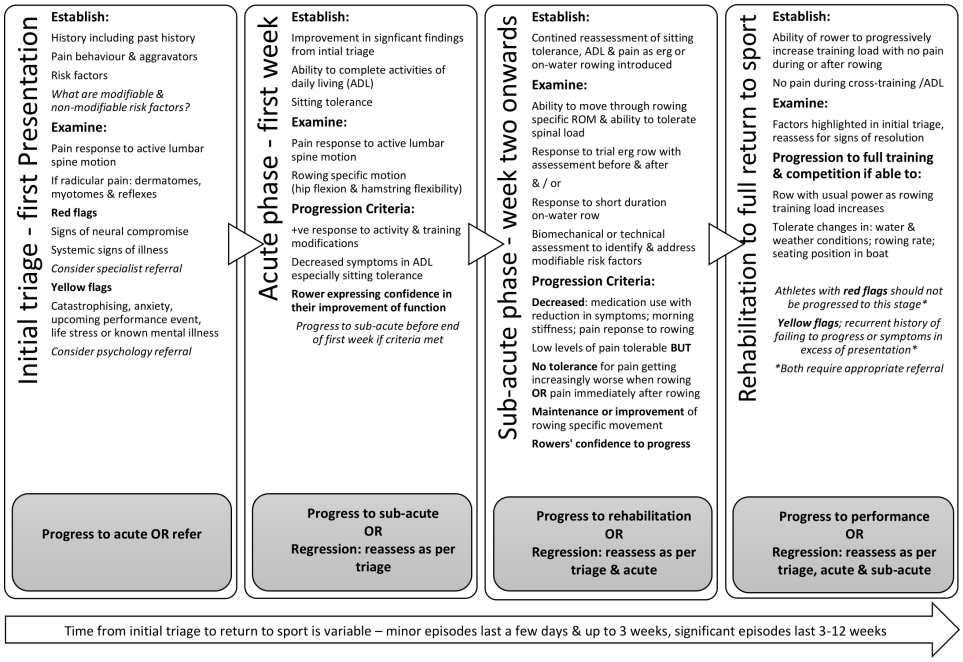

Figure 2 Acute episode of rowing-related low back pain: progression through phases from initial presentation to full return to sport.

Pain Screening Questionnaire and simple, functionally orientated questions, such as the influence of pain on ability to row.

Biomechanics

The relationship of biomechanics to prevention and treatment of rowing-related LBP is unclear. Tools that have been used in research for monitoring rowing-appropriate biomechanics in this population are as follows: electromagnetic motion measuring devices (eg, Flock of Birds system); two or three-dimensional motion analysis systems (eg, video recording or 3-D motion capture system); ROM devices (eg, goniometer or inclinometer); force measurement devices (eg, load cell attached to the rowing ergometer handle or in the foot plate); electromyography and isokinetic or isometric tests (eg, isokinetic dynamometer). Further research exploring clinical application of these tools is required before recommendations for practice can be made.

Imaging

There is no evidence to support routine imaging of the low back in rowers. Anatomical MRI changes are common in the lumbar spine of symptomatic[14] and asymptomatic[15] rowers. Just as in the general population, interpret MRI findings in a rower in the context of the clinical presentation. Limit imaging to investigating trauma or significant neurology, or where the imaging findings would influence the rower's management plan.

Surgery

Surgery may be indicated if there are progressive or distinct neurological signs and symptoms, and a clear surgical target. It is unclear whether return to rowing rates are different after surgical management versus after non-surgical management, and we could not identify any randomised controlled trials. Thus, our findings support recent non-systematic reviews on athlete LBP. Reviews focused on surgical outcomes report that surgery is more effective than non-surgical treatment at reducing pain in the short-term and medium-term, but these effects do not persist.[16 17]

Pharmacology

There were no specific recommendations made for managing rowing-related LBP in any studies. Guidelines for pharmacological management of LBP in the general population and for athletes[18] should be followed according to the World Anti-Doping Agency rules.

Plain language version

The plain language version of this document is included in the online supplemental file along with the plain language version of online supplemental table 3 (labelled as plain language online supplemental table 3A) and progression flow chart (labelled as plain language online supplemental figure 2A).

DISCUSSION

In our original meeting in February 2018, we raised a number of questions regarding rowing-related LBP. We wanted to explore the prevalence of rowing-related LBP and how it compared with other sports and LBP in the general population. While the quality and heterogeneity of published studies examining back pain in sports precludes confident comparisons, rowers may have elevated risk of experiencing LBP when compared with the general population, and rowing appears to be a sport with a higher prevalence of LBP than many other sports.

We explored the management of rowing-related LBP through a review of published research and by consulting experts. In general, there was an absence of good quality research examining interventions for LBP in athletes, and we could not find any specifically tailored to rowers. We synthesised available information from our review with recommendations from clinicians (gathered through a survey) to form the framework of a consensus statement to inform clinical practice. Some of these principles are supported by recommendations for managing LBP in the general population but are expanded with advice tailored to the rowing context, particularly in progression through phases to allow RTS. We sought opinions and feedback from rowers

and coaches and used this feedback to create a plain language summary that was meaningful to end users.

We investigated if rowing-related LBP could be prevented. We identified risk and other factors associated with an episode of rowing-related LBP, but there was no research investigating effectiveness of interventions aimed to prevent LBP in rowers. This suggests that modifying exposures to risk factors where possible may currently be the best approach to preventing LBP in rowers.

Synthesis of evidence from different sources allowed us to create recommendations that were meaningful to rowers and coaches. We highlighted the inadequate research evidence on athlete LBP and call for more quality research. The complexities of LBP were not addressed in athletes; no research has adequately explored the biopsychosocial interactions in rowing-related LBP.

Target populations

The target user population for this statement is healthcare providers who are managing rowing-related LBP at elite and subelite levels. The plain language summary provides information for adult rowers, coaches and support staff. We intend the recommendations to provide education regarding how best to prevent rowing-related LBP and how to reduce the impact of LBP when it does occur, including how best to avoid the recurrence of pain or persistent pain. The consensus statement applies to rowers with and without LBP, so that rowers and clinicians working with rowers may consider the recommendations in the context of primary and secondary LBP prevention.

The target patient population is adult male and female rowers of all boat and weight classes in all rowing settings from club and college to international standard. When applying the information in the consensus statement to masters rowers, the clinician should consider aspects of normal ageing and age-related disease. The information in the consensus statement may not apply to youth (junior) level rowers who are under 18 years, or para rowers.

Expected outcomes

The consensus statement provides a framework to inform best care based on current evidence and clinical expertise. It includes end users by highlighting the lived experience of rowers ('rower's voice') from qualitative research and the rowers' and coaches' input into a plain language summary. This document reflects the current state of knowledge and should be read in conjunction with the accompanying systematic reviews and other companion papers,[8–12] which provide context.

Updating, applicability and dissemination

We aimed to highlight evidence gaps and create a call for action. A further outcome is a call for action to update the consensus statement as new evidence emerges. It is intended that this consensus statement will be formally reviewed and updated at 5-year intervals with the first review before 31 December 2025. Barriers to application of this guideline may be resource availability in some settings, including access to a healthcare provider with adequate experience. The plain language summary provides information that may be helpful for athletes without access to such healthcare. Tools that will be used to promote access to this guideline will be open access publishing in the host journal and on the worldrowing.com website. An infographic will promote key messages. Following publication and after a defined period of time, rowing nations will be surveyed to explore their use of the recommendations. To measure dissemination, the core expert group recommended using download metrics of this paper, and the number of engagements on social media when the recommendations are disseminated through the channels described above.

Research priorities

Prospective studies across diverse rowing populations (age groups, boat/rowing types and ability levels including para rowers) are required to establish incidence of and risk factors for rowing-related LBP. A standard definition of rowing-related LBP should be used and refined as needed. We introduced a definition in our recommendations. High-quality randomised controlled trials are urgently needed to determine the effectiveness of individual interventions and management strategies (particularly surgery) from initial acute care to a full return to training and competition. A care pathway should be created for junior, para and masters rowers.

Limitations

A limitation of the consensus statement methods was that the members of each working group also participated in the Delphi process for their respective topics. Working group members were blinded to responses where possible, but there is a risk of bias.

CONCLUSIONS

We present a consensus statement for best practice in rowing-related LBP. This statement is based on research evidence and clinical practice and aligns with recommendations from international guidelines for managing LBP in the general population, and includes specific recommendations for rowers. Research efforts in relation to all aspects of managing rowing-related and athlete-related LBP should be intensified. It is our hope that the statement will help guide decisions regarding prevention and management of rowers with LBP. Future research should focus on a standardised approach to defining, assessing and managing LBP in rowers, encompassing the biopsychosocial influences on LBP.

Author affiliations
[1]Discipline of Physiotherapy, Trinity College Dublin School of Medicine, Dublin, Ireland
[2]Family Medicine, Schulich School of Medicine & Dentistry, University of Western Ontario, London, Ontario, Canada
[3]Epidemiology & Biostatistics, Schulich School of Medicine & Dentistry, University of Western Ontario, London, Ontario, Canada
[4]Hobart, Tasmania, Australia
[5]Department of Sports Science and Clinical Biomechanics, University of Southern Denmark, Odense, Syddanmark, Denmark
[6]Copenhagen, Denmark
[7]Division of Sports Medicine- Boston Children's Hospital, Neuroendocrine Unit-Massachusetts General Hospital, Harvard Medical School, Boston, Massachusetts, USA
[8]School of Physiotherapy and Exercise Science, Curtin University, Perth, Western Australia, Australia
[9]University of Tasmania School of Medicine, Hobart, Tasmania, Australia
[10]Department of Physical Education and Sports Sciences, University of Limerick, Limerick, Ireland
[11]Sport Ireland Institute, Abbotstown, Dublin, Ireland
[12]Surgery and Cancer/Human Performance Group, Faculty of Medicine, Imperial College London, London, UK
[13]High Performance Sport New Zealand, Auckland, New Zealand
[14]Sport and Exercise Medicine Research Centre, La Trobe University, Melbourne, Victoria, Australia
[15]Division of Physiotherapy, Karolinska Institute, Huddinge, Sweden

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Twitter Fiona Wilson @fionawilsonf, Jane S Thornton @janesthornton, Kathryn E Ackerman @drkateackerman, Larissa Trease @DrLarissaTrease and Clare L Ardern @clare_ardern

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ORCID iDs
Fiona Wilson http://orcid.org/0000-0002-0292-1087
Jane S Thornton http://orcid.org/0000-0002-3519-7101
Kathryn E Ackerman http://orcid.org/0000-0003-2626-7785
Larissa Trease http://orcid.org/0000-0002-8413-2814
Clare L Ardern http://orcid.org/0000-0001-8102-3631

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Epidemiology of low back pain in rowers

A systematic review examined the prevalence of and risk factors for LBP in the general sports population to provide context for rowing.[1] The following question regarding rowing-related LBP was addressed:

"What is the current epidemiological evidence for prevalence of LBP in rowers and what are the associated risk factors?"

In 86 studies in all sports, the mean LBP point prevalence was 33%; lifetime prevalence was 63%; 12-month prevalence was 51%. Comparison across sports was limited by participant numbers, study quality and methodologies, and varying LBP definitions. Risk factors for LBP included history of a previous episode, and statistically significant associations were reported for high training volume, periods of load increase, and years of exposure to the sport.

There were 11 studies (1695 participants) that specifically examined LBP in rowers.[2-12] Six studies (667 participants) were high quality.[2 4 7 8 11 12] The most common LBP prevalence estimate for rowing studies was 12 months. The mean 12-month prevalence of LBP for rowers was 48% (range 32% - 95%). When only high-quality studies were pooled, the 12-month prevalence was **61%** (95% CI: 42-78%, I^2 95%). Data are summarised in Table A1

Author, year of publication	Country	No. of participants (M/F)	Mean participant Age (years) (SD)	Type of participants	Variables of interest	Data collection mode	LBP prevalence	Risk factors
Bahr et al. 2004	Norway	N=199, 131(M), 68(F)	M:21(6) F:22 (5)	Elite rowers	LBP prevalence and time loss (training and competition)	Questionnaire	1) LIFETIME: 63.3%; control 51% 2) 12 MONTH (retro) 55.5% rowers; 47.5% control 3) 7 DAYS (retro) 25.3% rowers; 19.6% control	Periods of increased training or competition load p<0.05
Clay, Mansell and Tierney 2016	USA	N=37(F)	N/R	College Division 1 rowers.	LBP prevalence, history of LBP, LBP associated disability	Clinical examination & questionnaire	1) 12 MONTH (retro): 68%	1) Increased years of rowing, 58% greater years in LBP group, p=0.008 2) Previous history of LBP, p=0.27,
Fett, Trompeter and Platen 2017	USA	N=83	21.1	Elite rowers	LBP prevalence	Questionnaire	1) LIFETIME: 96.4%; 2) 12 MONTH (retro): 95.2%; 3) 7 day (retro): 67.5%	1) Training volume, p<0.05 2) Increased age, p<0.001 3) Rowing participation OR 6.4 (95% CI 1.9-21.5)
Gonzalez et al. 2018	USA	N=31(F)	19.9(1.4)	National Collegiate Athletic Association Division I, open-weight rowers	LBP prevalence, FMS and SEBT performance	Clinical examination	1) One season (pros): 58% 2) 12 MONTH (retro): 54%	1) FMS score of <16 increased risk of LBP; RR=0.0667, 95% CI 0.9-2.11
Hickey, Fricker and McDonald 1997	Australia	N=172 88(M), 84(F)	F:20.1 M:21.3	Elite rowers	All injuries: type, region and prevalence	Retrospective analysis of medical database (10 years)	15.2% female and 25% male had LBP over 10 years	Weight training self-reported as most common 'mechanism of injury' (no data provided)
Maselli et al. 2015	Italy	N=133 107(M) 26(F)	19	National Championship rowers	LBP prevalence duration, severity and frequency of symptoms, time loss from work and training	Questionnaire	1) LIFETIME: 64.7%; 2) 12 MONTH (retro): 40.6%; 3) 1 MONTH (retro):19.5%	1) Type of rowing: a) Sculling + sweep; OR 4.43, p<0.001, 95% CI 1.87-10.48 b) Sweep only; OR= 3.32, p=0.03, 95% CI 1.16-6.27. Both higher risk than sculling only 2) Male sex; OR=2.62, p=0.03, 95% CI 1.16-6.27
Newlands, Reid and Parmar 2015	New Zealand	N=76, 46(M), 30(F)	M:23(4) F:21(4)	International rowers	LBP prevalence, previous history, movement competency screen	Questionnaire	1) 12 MONTH (pros): 52.6 % 2) incidence: 1.67	1) Increasing age;OR=1.08, p=0.02, 95% CI 1.01-1.15 2) Previous LBP history; OR=1.58, 95% CI 0.9-2.65

					(MCS) score,training volume		episodes per 1000 h of rowing exposure.	(logistic regression) 3) Total training hours/month; r=0.83, p<0.01 4) Ergometer hours/month; r=0.8, p<0.01 5) Average training hours/month; r=0.73, p<0.01 6) Average Km rowed/month; r=0.71, p=0.01
Schultz, Lenz and Buttner-Janz 2016b	Germany	N=45 29(M) 16(F)	22	Elite Rowers	1. Prevalence of LBP. 2. Pain intensity (VAS)	Questionnaire	1) 12 MONTH (retro): 31.5%	N/R
Smoljanović et al. 2018	Croatia	N=743, 475(M) 268(F)	50	Masters rowers	All injuries sustained during a 12-month period	Questionnaire	1) 12 MONTH (retro): 32.6%	1) Ergometer training >30 minutes in rowers age 60+years; x^2 4.114, p=0.043 2) Scullers higher risk than sweep rowers; x^2 4.973, p=0.026
Trompeter, Fett and Platen 2019	Germany	N=156 57.1%M, 41.7%F	22.2 (5.1)	Elite and no-elite rowers	Prevalence and severity of LBP.	Questionnaire	1) 12 MONTH (retro): 75% rowers, 58% controls. 2) 7 DAY (retro): 40% rowers, 29% controls. 3) LIFETIME: 84% rowers, 71% controls.	Training volume (12 month LBP); p=0.022, r=0.184
Wilson et al. 2010	Ireland	N=20 12(M) 8(F)	26.3 (4.2)	International rowers	1. Incidence of all injuries 2. training and competition exposure 3. type of injury	Questionnaire	1) 12 MONTH (pros): 31.8%	1) Ergometer training (more than 30 mins); r=0.75, p=0.01 2) Heavy weight training; r=0.66; p=0.02 3) Increased core stability training; r=0.68, p=0.01

Table A1: Studies examining epidemiology of low back pain in rowers

Summary statements from the Delphi process are in Table A2

Summary statements & recommendations: Epidemiology of low back pain in athletes with a rowing subgroup analysis
Exercise caution when comparing results of studies with different definitions of LBP. A standardised definition of athlete LBP is needed.
Prevalence varies widely among studies as a result of different methodologies and definitions of LBP. More research is needed, using gold standard prospective data collection, to estimate more precisely the prevalence of LBP in athletes.
Risk factors for LBP in athletes are: history of LBP; rapid increase in training or competition load; higher volume and intensity of training/competition; Increased years of exposure to the sport (career length)
Rowing-specific risk factors are: all of above + ergometer training greater than 30 minutes/session.
Radiological abnormalities should be considered in relation to symptom presentation and not in isolation. The significance of radiological abnormalities in the absence of symptoms is unclear.
Pre-season screening does not predict within-season onset of LBP in athletes.
Technical issues/biomechanics are likely to be a risk factor for LBP in some sports, but there is insufficient evidence to identify those and more research is needed to confirm this.

Table A2: Summary statements and recommendations from epidemiology of LBP in athletes review.

Definition of rowing-related low back pain

Fourteen experts (FW, KW, JT, KA, CG, JH, LT, AV, SJM, JPC, AMcG, MW, JAH, JS) rated nine initial statements proposed by the experts from standard, widely used LBP definitions and from those contained in the athlete LBP epidemiology studies. A decision was made following a four-round Delphi process. The consensus definition is described in **Box 1** (main document).

Relationship between biomechanics and rowing-related low back pain

A systematic review examined the relationship between rowing-related LBP and rowing biomechanics.[13] The following question regarding rowing-related LBP was raised:

"What are the spine, pelvis and hip biomechanics of rowing and how do they influence the risk of low back pain in rowers?"

Thirteen studies investigated spine kinematics during rowing and nine studies investigated muscle activity. One study compared the ergometer to rowing in a boat and all other studies were conducted on an ergometer. Rowing activity was associated with in an increased

sagittal flexion range in the lumbar spine over time (spinal creep), which increased as rowers fatigued.

Studies that specifically examined LBP reported conflicting results regarding the influence of LBP on kinematics; some demonstrated that rowers with LBP history move more through their lumbar spine than their hips and other studies found no difference between groups.

Muscle activity during rowing is dominated by the extensor group of the trunk with trunk flexor activity focused on the transition from the drive to recovery phase. One study compared fixed and dynamic ergometers and found no difference in trunk muscle activity. One cross sectional, injury surveillance study (not included in the biomechanics review) reported a reduction in LBP prevalence when fixed ergometers were replaced by dynamic ergometers but no biomechanical factors were explored.[14] No studies examined trunk muscle function in a boat. Fatigue altered muscle recruitment. Rowers with LBP history had less efficient erector spinae recruitment compared to those without a history of LBP.

Summary statements from the Delphi process are in Table A3.

Summary statements & recommendations: Relationship of biomechanics to rowing-related LBP
There is insufficient evidence to recommend one ergometer type (fixed vs dynamic) over the other to avoid LBP
Rowing requires a relatively vertical pelvic position at the catch. If limitations in hip flexion do not allow for a vertical pelvis and increased lumbar flexion results, the risk for LBP may increase
Trunk asymmetries do not appear to be associated with LBP
The muscle activity of the trunk is dominated by the extensor group when rowing; the flexor group is relatively silent. The trunk flexors (abdominals) act as a braking force (eccentrically) at the end of the drive and at the change in direction of the trunk to the recovery.
There is insufficient evidence to confidently define which trunk and hip biomechanics increase risk of LBP in rowers. Future studies should evaluate rower biomechanics as part of a longitudinal LBP risk assessment programme

Table A3: Summary statements and recommendations from relationship of biomechanics to rowing-related LBP

Managing low back pain in athletes

A systematic review examined the management strategies for LBP in athletes and aimed to examine rowing specifically (where possible).[15] The following question was raised:

"*What is the evidence for commonly used treatments for managing LBP in athletes?*"

Thirteen randomised controlled trials (505 participants) examined exercise, biomechanical and activity modifications, and manual therapy. These were included in the review. Studies examining surgery and injection therapies were observational in design and were not included. There was a reduction in pain and disability after any treatment. Exercise was the most frequently investigated treatment, although no return to sport (RTS) data were reported for any exercise intervention. Different treatments for LBP in athletes improved pain, function, and RTS, but it was unclear what the most effective treatments were. All exercise approaches reduced pain and improved function in athletes with LBP. There was

insufficient evidence to support activity or biomechanical modifications or manual therapy as stand-alone therapies. There were no studies that specifically examined management strategies in rowers.

Summary statements and recommendations from the Delphi process are shown in Table A4.

Summary statements & recommendations: Managing low back pain in athletes
Until robust evidence is produced for athlete populations, recommendations for LBP management in non-athletic populations should be used to guide management of LBP in athletes, considering the sport-specific circumstances surrounding the athlete while adopting a biopsychosocial approach.
Employ shared decision-making regarding individual treatment goals – consider the athlete's goals, expectations regarding pain, disability, quality of life and return to sport
EXERCISE
Exercise interventions improve pain and function in athletes with LBP.
The effect of exercise interventions on return to sport rates is unknown.
Targeted, dynamic (isotonic rather than isometric), functional (sport-specific) exercise appears to be the most beneficial for athletes with LBP, but there is insufficient evidence to recommend one exercise protocol over another.
BIOMECHANICAL OR ACTIVITY MODIFICATIONS
Biomechanical and activity modifications may result in a reduction of LBP, but there is insufficient evidence to recommend them as stand-alone treatments.
MASSAGE AND MANUAL THERAPY
Massage and manual therapy may improve pain and function in athletes with LBP, but there is insufficient evidence to recommend them as stand-alone treatments.

Table A4: Summary statements and recommendations from managing LBP in athletes.

Rowers' lived experience of rowing-related low back pain

Semi-structured interviews were conducted with 25 rowers in Ireland and Australia.[16] Rowers revealed a culture of openness or concealment that influenced their experience. Rowers' relationships with coaches and peers framed their overall experience, their willingness to reveal their pain, how early they revealed their pain, and the support that they received. The summary recommendations from the Delphi process are shown in Table A5.

Summary recommendations: Rowers' lived experience of rowing-related low back pain
Rowers should be taught about the nature, presentation, and various factors that contribute to LBP.
Rowers should be encouraged to disclose their LBP at an early stage and be informed about the potential negative impacts of concealing their LBP.
Rapid referral pathways to best evidence-based management should be created where possible, so that rowers can access care for LBP.
Rowers should be supported by their coaches, management, and teammates when disclosing LBP.
Rowers feel socially isolated during LBP rehabilitation and supports should be put in place where possible, including peer support (teammates).
There should be a clinical alliance among medical staff to ensure that LBP management strategies and information given to rowers is consistent.
Education regarding best practices should be available to clinicians treating rowing-related LBP.
Medical teams should adopt shared decision-making strategies with the rowers they are treating.
Communication among rowers, coaches and medical staff is important to ensure a uniform narrative with clear and consistent messages around rowing-related LBP.

Table A5: Summary recommendations from the qualitative study of rowing-related LBP

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APPENDIX: Statements gaining consensus from Delphi study of experienced and expert clinicians

Table 1 Assessment & management of rowing-related low back pain – statements gaining consensus for each phase of recovery			***M***		***SD***	
			R2	*R3*	*R2*	*R3*
Initial Triage – first presentation						
	The acute assessment of a rower with low back pain can be performed by a Physiotherapist or Doctor experienced with seeing rowers.		8.9	9.5	1.7	0.8
	The rower should be questioned to establish the type of pain presentation to classify into; non-specific somatic pain with/without somatic referral and/or radicular pain with/without radiculopathy and/or inflammatory pain and/or atypical pain presentation that needs red flag exclusion.		9.3	9.4	1.5	1.6
	The rower should be questioned to determine the history of this episode, past history, pain intensity & quality, pain behaviour & 24 hr picture, aggravating & easing factors, other symptoms such as changes in sensation, motor control and bladder & bowel function.		9.7	10.0	0.9	0.0
	When the athlete first presents it is important to understand their previous low back pain history.		9.5	10.0	0.8	0.0
	At the time of initial triage the therapist must understand how the rower's sleep is disturbed due to their low back pain.		8.3	8.6	1.4	1.4
Assess	Establish the occurrence of pain during activities of everyday living including sitting, standing, walking & night pain.		9.1	9.8	1.8	0.6
Assess	Establish risk factors including previous episode of similar pain, technical issues in boat, change of water conditions or seat position, change in training load, gym load, cross training load, increased rowing training age and time at this level of rowing.		9.0	9.6	1.6	0.9
	Red flags include cauda equina signs, peripheral neurological signs or systemic cancer signs such as weight loss, night pain & sweats.		9.8	10.0	0.6	0.0
	Yellow flags include catastrophising, increased anxiety, significant upcoming performance event, life stressors or known mental health disease.		8.1	9.5	2.2	0.8
	I assess every new presentation of low back pain for neural compromise & seek this clinical sign to assist in early referral.		9.2	8.8	1.2	2.9
	A management aim for the rower presenting with neurological dysfunction is to investigate this thoroughly & treat to restore.		8.5	9.3	2.0	1.3
	Test reflexes, strength & sensation of the lower limb when radicular pain and/or sensory change and/or strength change is reported.		9.0	9.7	2.3	0.6
	How the athlete is moving during activities of everyday life, such as sit to stand & walking, need to be assessed at initial triage.		8.8	9.5	1.3	0.9
	Pain responses to active lumbar spine motion need to be assessed.		9.0	9.8	1.0	0.4
Manage	The primary management focus at initial triage is to gain early & effective pain relief.		8.2	8.1	1.6	1.6
Manage	Manual therapies are an appropriate early intervention in the triage stage of low back pain in rowers.		6.8	7.3	2.1	1.8
Manage	At initial triage a management aim should be to restore function for activities of daily living.		7.8	8.6	1.8	1.3
Manage	A rower that presents on the first occasion with severe low back pain should be removed from on water and ergometer rowing.		7.7	8.4	2.3	1.9
Move	If the rower is able to sit without pain, they can start stationary bike riding. If unable to sit, the rower should to remain active e.g. walking.		7.2	7.6	1.9	0.9
Move	The rower should be encouraged to walk. The duration & whether to include hills & steps will be dictated by the severity of symptoms.		7.1	7.7	2.5	1.4
Move	If a rower is able to row on water and/or on the ergometer without pain or muscle guarding, they should be allowed to do so.		7.6	8.3	2.2	1.7
Educate	The rower should be educated & re-assured about their presenting low back condition, it is especially relevant to alleviate fears.		8.2	8.9	1.7	1.0
Educate	Medical staff should begin conversations about identified 'yellow flags' including stress & its effect on pain.		7.3	8.1	1.9	1.4
Educate	In the initial triage the rower should be educated about the injury & included in the decision making of the initial plan.		9.2	10.0	1.0	0.0
Educate	A rower should be encouraged to see a psychologist if they have a regular person they interact with or if there is a specific need.		6.8	7.5	2.4	1.3
Educate	It is important to manage a coach and athlete's expectations at the initial triage.		9.3	9.9	1.0	0.3
Educate	It is important to involve the coach from the outset & allow them to contribute their ideas about why the injury may have occurred.		8.3	8.2	1.6	1.2
Acute Phase – first week of pain						
	The response to rest and activity modification are important indicators of prognosis over the first week.		8.5	9.1	1.4	1.0
	Improvement of symptoms experienced in everyday life are considered good indicators for prognosis in the first week.		7.8	9.1	1.2	0.7
	A good sign of recovery is a rower expressing confidence in the improvement of their low back pain & function in the first week.		8.3	8.5	1.1	1.1
Assess	Over the first week of presentation the therapist should continue to monitor the rowers sitting tolerance.		8.3	7.5	1.5	1.7
Assess	Over the first week of presentation, monitoring pain response to lumbar range of motion is an important indicator of progress.		7.8	7.7	1.2	1.1
Assess	The therapist should continue to monitor the rower's ability to complete their usual activities of daily living.		8.8	9.5	1.2	0.7
Assess	Rowing specific ranges must be assessed, specifically hip flexion & hamstring range that can affect how the pelvis & low back moves in the boat. Improvement towards rowing specific range of motion is desirable.		8.1	8.4	1.9	1.9
	In the initial week of management control of pain continues to be a management focus.		8.6	9.2	1.1	1.0
Manage	The use of manual therapies, such as Physiotherapy or soft tissue treatment in the region is appropriate.		8.5	8.6	1.5	1.6
Manage	Focus on re-establishing normative movement, rowing specific range of motion & progression towards spinal load requirements for rowing.		7.8	8.3	1.7	1.6
Manage	The acute phase is the time to commence a functional exercise rehabilitation program.		7.0	7.9	2.3	1.6
Manage	In the initial week, management focus should be on what the rower can do to maintain fitness but not exacerbate low back pain.		8.7	9.5	1.1	0.8
Exercise	Continuation or graduation of cardiovascular training program within limits of injury.		8.9	9.9	1.1	0.3
Exercise	During the first week, as the rower can tolerate sitting, stationary bike training can commence.		8.6	9.1	1.1	0.9
Exercise	During the first week the rower can be encouraged to swim or perform exercises in the water.		8.0	8.5	1.3	1.1
Exercise	During the first week the rower can use walking as a form of training & add hills & stairs to increase the training intensity.		7.8	8.8	1.3	0.6
Exercise	A cross-training alternative is elliptical training, especially if sitting is not being tolerated. As sitting is tolerated, stationary bike can commence.		7.1	8.1	1.3	0.5
Exercise	If a successful rowing ergometer trial is conducted, the rower can progress to a short duration on water row of less than 10km.		7.1	7.5	1.3	1.0
Educate	Rower should be involved in treatment planning, they should be empowered to assist in guided decision making & educated about their injury.		7.8	9.1	2.6	1.0
Educate	Yellow flags include; stressors in life or sport, poor sleep, fear avoidance, pressure from coach / selection / upcoming performance.		8.1	9.0	1.3	0.9
Educate	Yellow flags include a stress response to injury which may manifest as poor sleep, lowered mood or fear avoidance behaviours.		8.0	8.5	1.2	0.9
Educate	Strategies for controlling stress include; use of psychology services, coach support, using mindfulness techniques or family & friends support.		7.3	8.5	1.5	0.5
Sub-Acute Phase – return to rowing						
	No pain during activities of daily living & no pain with other cross training modalities are good signs of progression.		8.3	9.5	1.4	0.7
	A reduction in morning stiffness is a good sign of progression.		7.3	8.1	1.1	0.9
	A reduction in medication along with reducing symptoms is a good sign of progression.		8.4	8.9	1.1	1.1
	Red flags should continue to be monitored for in this phase & should raise the concern for non-musculoskeletal diagnoses.		8.6	8.8	2.0	1.8
	Low levels of pain during rowing, pain that is not getting worse when rowing & no pain after rowing are good indicators of progression.		8.7	9.0	1.2	0.9
	A good sign is a rower who rates themselves as being confident to progress & heading progressively towards 100% recovery.		7.1	8.6	2.7	0.9
Assess	Continued re-assessment of significant objective findings should occur throughout the sub-acute phase.		8.4	9.2	1.7	1.2
Assess	When considering return to rowing, the motion of the hamstrings & hip & the ability to sit & load the lumbar spine should be assessed.		8.2	9.5	1.5	0.7
Assess	Trailing an ergometer row & assessing the response should be completed before returning the rower to training.		7.6	8.2	1.6	1.3

APPENDIX: Statements gaining consensus from Delphi study of experienced and expert clinicians

Manage	A trial on water row should be completed before scheduling a return to rowing training.	7.8	8.9	1.5	0.9
	When the rower begins to return to the boat, tolerance to sitting should continue to be monitored.	8.4	8.8	1.7	1.4
	When the rower returns to the boat, pain in activities of daily living should continue to be monitored.	8.5	8.7	1.2	0.9
	When the rower returns to the boat, pain when rowing should be well understood and continually monitored.	8.9	9.5	1.0	1.0
	As soon as athlete is able to row without pain & with their normal movement patterns they should be returned to on water rowing.	7.2	8.5	2.6	0.7
	Biomechanical assessment & technical coaching is an important part of the return to rowing phase for an athlete with low back pain.	7.7	8.7	1.6	1.3
	In the initial return to rowing phase, technical issues that are likely contributing risk factors for low back pain should be addressed.	8.5	9.5	1.6	0.8
	When considering a return to on water training, the management aims need to include restoration of rowing specific range of motion.	8.6	9.4	1.2	1.0
	When considering a return to on water training, the management aims need to consider the ability of the spine to be loaded.	9.0	9.7	1.2	0.6
	Maintenance or improvement of mobility is a key component of the return to rowing phase.	7.8	8.6	1.5	1.2
Training	Management must focus on a return to rowing protocol with a gradual re-loading program agreed on by the rower, medical and coaching staff.	9.3	9.7	1.1	0.6
	When prescribing return to row consider: 8-10km in single ≠ 8-10km in eight, stability of boat returning to & weather. Set athlete up for success.	8.6	9.7	3.2	0.5
	In the initial return to rowing phase, medical staff should work closely with coaches to plan load progressions and monitor actual load.	7.9	10.0	0.9	0.0
	A Medical Practitioner's involvement is often necessary in the return to rowing phase of rehabilitation from low back pain.	7.7	7.0	1.7	1.7
	On water & rowing ergometer should progressively increase in intensity & time as pain allows. Prioritise building on water rowing first.	7.7	8.1	1.7	1.5
	The rowing ergometer should be used when the water is rough or the weather is not conducive to on water rowing.	7.1	7.0	2.5	0.6
	As sitting tolerance increases, as can time on a stationary or road bike. The bike can be used to 'top up' training load at the end of a rowing session.	8.5	9.3	1.2	0.8
	If pain with sitting persists, the use of upright exercise for training can be considered; elliptical training, running, hill walking and/or ski ergometer.	7.2	7.8	2.6	1.3
	Swimming can be used as a form of increasing training load. Care to not increase shoulder load quickly as this may contribute to shoulder injury.	8.1	8.1	1.1	0.5
	Involvement of a strength & conditioning coach in the rehabilitation phase of the rower with low back pain is important.	7.3	7.5	1.7	1.4
	Tolerance of land based training is important in this phase.	7.8	8.0	1.0	0.8
	Strength, gym & core muscular training are essential parts of the sub-acute management of the rower with low back pain.	7.1	8.3	1.8	1.8
Educate	Exercises should be prescribed to ensure appropriate movement control, stability and strength is gained for performance of the rowing stroke.	8.7	9.1	1.8	1.0
	Medical staff & strength & conditioning staff shoulder work together to construct an appropriate program of exercises individual to the rower.	9.1	9.7	1.1	0.6
	Yellow flags are important to recognise & monitor e.g. fear avoidance behaviour & catastrophising - they may be heightened at competition time.	8.3	9.4	1.4	0.8
	It is important for the rower to avoid developing a fear of specific movement patterns. A cognitive functional therapy approach or a confidence with movement approach can be helpful. Splinting or overprotective movements should be discouraged.	7.8	8.2	2.0	1.8
	If a rowers has access psychological services, this should be continued through the sub-acute phase.	7.0	7.2	1.3	1.1
	If a rower is finding it difficult to cope or their progression is not as expected, psychological consultation may be considered.	7.9	8.5	1.4	1.1
	The return to rowing phase must include self-management advice & self-empowerment for the rower with low back pain.	8.3	9.3	1.2	0.8
Rehabilitation Phase – return to normal training load					
Assess	It is important to continue to re-assess significant findings throughout the return to rowing period.	8.9	9.1	1.1	1.2
	When the rower has returned to rowing, their everyday life pain should also be monitored, especially pain immediately after rowing.	8.7	9.1	1.4	0.9
	When the rower is increasing their rowing load it is important to review them & ensure their main objective findings are continuing to improve.	8.6	9.2	1.2	1.0
	Being able to row with no pain or no increase in symptoms is essential for progressing training load.	7.7	8.3	2.6	2.0
	Rowing with quality movement patterns, achieving usual power & tolerating different stroke pressures and rates are very good signs of recovery.	8.7	9.8	1.3	0.4
	Tolerating changing water conditions, changes in rowing rate & change in seating in the boat are all good indications of recovery.	8.8	9.4	1.2	0.8
	The response to progressively increasing rowing & ergometer work load should be continually monitored.	8.8	9.5	1.0	0.7
	Athletes with red flags should not be progressed to this stage.	9.1	9.9	1.4	0.3
	Yellow flags may also be a recurrent history of failing to progress & having symptoms in excess of the clinical presentation.	7.0	8.6	1.3	0.9
Manage	Medical staff should communicate with the coach about management expectations & address risk factors for low back pain the rower.	9.4	9.5	0.7	0.5
	Coaches' observations should be integrated in the rehabilitation stage.	9.1	9.1	1.0	0.8
	Ensuring the athlete & coach are working on causative factors for the specific incidence of low back pain is imperative at this stage.	8.8	9.1	1.4	1.4
	Emphasis should be placed on restoring the rower's usual biomechanics & addressing risk factors identified to prevent re-occurrence.	8.8	9.7	1.3	0.5
	In the final phase I always ensure the rower has corrected any identified movement or strength deficiencies.	8.1	8.5	1.8	1.5
	A key component of the rehabilitation of a rower is the graduation of an individualised strength & mobility program.	8.4	9.1	1.4	0.9
	The creation of a maintenance exercise & mobility program is essential for rowers in the final phase of rehabilitation.	7.8	8.6	1.6	1.2
	Work with coaching staff to ensure the rehabilitation program translates into on water and gym changes to protect from further injury.	8.6	8.6	1.0	0.7
	A strength & conditioning coach is an important contributor to the final rehabilitation phase of low back pain in rowers.	7.5	7.8	1.3	1.0
Training load	A return to full training should include a planned program of increasing distance & intensity on the water as well as progressive increases in ergometer rowing, cross training & strength & conditioning work.	8.8	9.5	1.5	1.2
	Gradually build on water volume & intensity, based on pain response, up to full training load. Time to do this is individual & based on the severity of the initial injury & the improvement in the individual's condition over time.	9.1	10.0	1.3	0.0
	The priority in a return to rowing program should always be on water training. The ergometer may need to be used due to weather conditions.	8.5	8.9	1.4	0.9
	The return to rowing program should be agreed upon by both medical & coaching staff. A clear schedule should be set out that can be adjusted as the response to increasing on water and/or ergometer time is assessed.	8.8	9.8	1.3	0.4
	During a return to full training, less cross training is performed as more on water & rowing ergometer training is completed.	8.4	9.0	2.2	0.6
	The stationary bike or road bike can be used to 'top up' training load as on water and ergometer rowing are increasing.	8.8	8.8	1.3	0.9
	Converse with the coach or observe on water training to ensure the rower is returning to normal movement patterns & force production.	8.9	8.8	0.9	0.9
	Strength & conditioning training can be introduced but high loads should be avoided until a full on-water training load has been achieved.	7.4	8.8	2.4	1.3
	Strength & conditioning sessions should progressively introduce more loaded exercises & progress towards a rower's usual program.	8.2	9.5	2.7	0.7
	The medical and strength & conditioning staff should work together to return the rower to their usual strength &conditioning program.	8.5	9.2	2.7	0.6
Educate	Ensure an athlete centred & coach supported approach. It is important that the athlete does not become dependent on medical staff for specific	8.2	9.5	2.8	1.2
	Continue use of a sports psychologist if the rower believes this in beneficial or the medical staff believe this could provide ongoing support.	7.7	8.1	1.2	0.9
	Encourage discussion regarding athlete self-management during the rehabilitation phase.	9.2	10.0	0.8	0.0
	Continual education, re-assurance & explanation should occur throughout the return to rowing phase.	8.2	8.8	1.5	0.9

R = round, M = Mean, SD = Standard Deviation, Mo = Mode

APPENDIX: Statements gaining consensus from Delphi study of experienced and expert clinicians

Box 1 Important considerations – novel response statements gaining consensus

Creating a culture of early recognition and management of low back pain in the training environment optimises management and improves learning and performance. (M: R2 8.8, R3 9.5, SD: R2 2.5, R3 1.9)

Identifying radicular pain early (with or without sensory and/or motor change) is essential and management must involve medical assessment as soon as possible. (M: R2 9.0, R2 9.5, SD: R2 1.9, R3 1.3)

There are gender differences in the causal factors for low back pain in rowers - males are at risk due to reduced hip flexion, females are at risk due to reduced trunk strength. (M: R2 6.1, R3 7.2, SD: R2 2.5, R3 1.9)

M = Mean, R = round, SD = Standard Deviation

Table 2 Assessment of rowing-related low back pain – statements gaining consensus relating to all phases of recovery			***M***		***SD***	
			R 2	*R* 3	*R* 2	*R* 3
Imaging						
Imaging is not required nor recommended as a routine part of the rehabilitation process.			6.6	9.2	3.1	1.0
Risk Factors						
Training load is a key factor to understand to determine if it contributed to the development of low back pain in the rower. A steep increase in training load or a reduction in load followed by an increase in load are specific risk factors that should be understood.			9.0	9.7	1.1	0.6
Psychological stress is a key factor to understand early in the assessment process, this may include; fear of movement, selection pressure, worry about having low back pain for first time, worry about a subsequent episode of low back pain & increased stress related to being close to a key event.			6.9	7.6	1.6	1.2
Technique (e.g. posture) or technical (e.g. boat set-up) issues are key factors to address during rehabilitation.			8.0	9.1	1.8	0.7
Of the following specific risk factors, rate your agreeance with each as a risk factor for rowing-related low back pain;						
Training	change to training intensity (e.g. increase in power strokes or athlete training outside prescribed or intended training zone)		8.2	8.5	1.2	1.2
	illness or another injury prior to this injury causing a reduced training load		7.9	8.5	1.3	0.5
	ability to complete high level of training volume over a longer period of time (3months is protective for injury)		7.9	8.1	1.2	0.9
	having a young training age		6.8	7.4	1.1	1.4
On-water	changes in crew increasing load on injured rower		6.8	7.1	1.3	1.7
	recent change in boat set up		7.0	7.0	1.8	1.2
	rough water		7.2	7.5	1.7	1.0
Physical & movement	increased lumbar flexion range during rowing		7.5	7.3	1.6	1.6
	getting to end of range lumbar flexion during rowing		7.5	7.1	2.0	1.8
	reduced hip flexibility <130degrees		7.1	8.7	2.1	0.9
	reduced hamstring flexibility		7.2	7.6	1.9	1.8
	hip motion & hamstring flexibility once pain reduced (may not be accurate indication in the presence of pain)		7.3	7.1	1.5	1.1
	reduced knee flexion range		6.4	7.2	2.0	1.5
	reduced posterior chain endurance (erector spinae thoracic and lumbar)		7.7	8.5	1.4	0.8
	reduced abdominal endurance		7.5	7.2	1.7	2.0
	muscular control of deep squat		7.2	7.3	1.5	1.4
	control deficits when lifting weights		7.7	7.4	1.2	0.8
Other	previous history of low back pain		9.5	10.0	0.8	0.0
	>30min on ergometer during one session		6.6	7.0	2.7	2.0
	poor nutrition or reduced energy intake		7.3	7.4	1.7	1.1
	poor sleep habits		7.1	7.5	1.7	1.6
Outcome Measures						
Using outcome measures or scales is important for analysing the severity of a rower's pain and/or disability & being able to monitor this over time.			6.5	7.5	2.2	1.4
Consider specific outcome measure, rate how useful when managing a rower with low back pain (1=useful, 2=undecided, 3=not useful)			***R2 Mo***		***R3 Mo***	
Visual / verbal analogue scale /10			1		1	
Patient Specific Functional Scale			1		1	
Orebro Musculoskeletal Pain Screening Questionnaire			2		1	
A simple function specific question - e.g. is the pain great enough to stop you rowing?			1		1	

R = round, M = Mean, SD = Standard Deviation, Mo = Mode

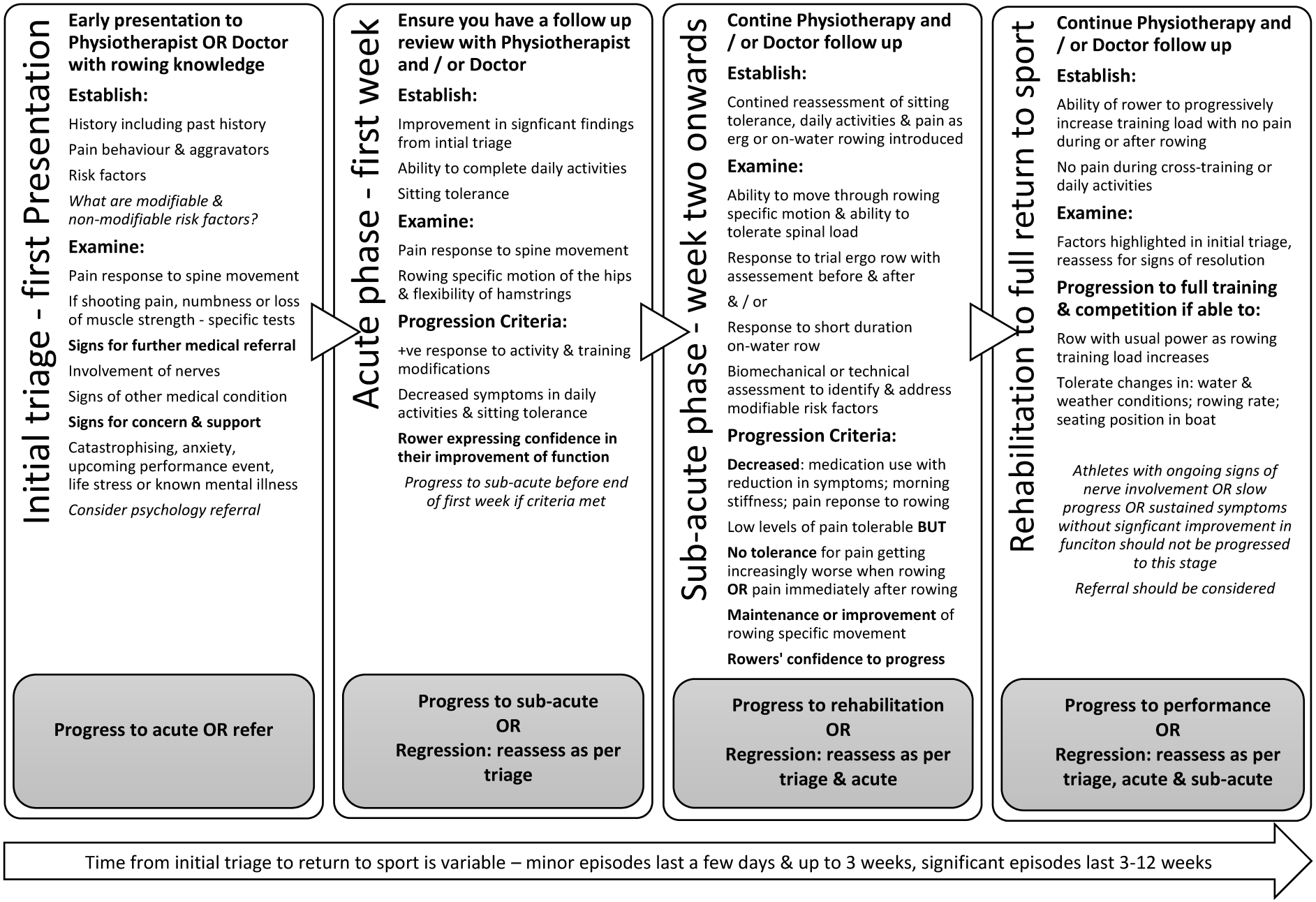
Table 3 Specific rowing-related low back pain considerations for developing and masters rowers – statements gaining consensus	***M***		***SD***	
	R 2	*R* 3	*R* 2	*R* 3
Developing Rowers				
A priority in the management of the developing rower with low back pain is the engagement of their parents & coach.	9.2	9.5	0.8	0.5
A priority in the management of the developing rower in the subacute phase is education about their injury.	9.1	9.6	0.8	0.5
A key for understanding for successful management is understanding the rower's rate of growth & flexibility as contributing factors.	8.5	9.2	1.4	1.3
I have a more conservative rehabilitation plan for developing rower than elite rowers throughout their management and rehabilitation.	8.2	8.5	1.3	1.4
Masters Rowers				
I prioritise the assessment of medical co-morbidities in a masters rower when compared to an elite.	6.9	8.3	2.7	1.0
Some biomechanical & movement restrictions may not be amenable to change due to underlying degenerative processes & should be assessed & accommodated as part of the rehabilitation program.	7.9	8.8	2.2	1.3

R = round, M = Mean, SD = Standard Deviation

	Coaches & medical staff should encourage rowers to seek assessment of Low Back Pain (LBP) early. Delaying this can prolong recovery.	Assessment & management by a Medical Doctor & Physiotherapist experienced in managing rowing-related LBP is ideal.	Episodes of rowing-related LBP are most often not serious, they are self-limiting & early management will educate the rower about severity & recovery.	Many factors contribute to a presentation of rowing-related LBP, these include; physical, biological, social & psychological –they all need to be managed.
	INITIAL TRIAGE – first presentation	ACUTE- first week	SUB-ACUTE – return to rowing	REHABILITATION – return to full training
EXAMINATION	Establish type of presentation; Non-specific LBP with / without somatic referral Radicular pain with / without radiculopathy Inflammatory component to pain Atypical pain requiring red flag exclusion Psycho-social screening for; mental health issues, catastrophizing, anxiety, upcoming competition & / or life stressors.	Re-assess findings from initial triage including; sitting tolerance, lumbar range of motion & ability to complete activities of daily living (ADL). Assess rowing specific ranges; specifically hip flexion & hamstring length, as they affect how the pelvis & lumbar spine move in the boat. Improvement in the motion of the pelvis & hips is desirable.	Assess rower's ability to move through rowing specific movement & ability to tolerate spinal load. If have not yet rowed, trial erg row &/or short duration on-water row with assessment before & after. Response to on-water training should be continually assessed. Coach or medical staff should ensure rower's stroke pattern consists of appropriate pelvic motion & limits excessive low back motion.	Ensure the rower is confident in their ability to progress. Objective markers in initial triage assessed for signs of resolution; pain should be absent during ADL & cross training. Rowers should be able to row with usual power & tolerate changes in; water conditions, rowing rate & seating in boat. Rowing stroke pattern should be monitored during water or erg sessions that induce high levels of fatigue.
MANAGEMENT	Restore function in ADL with early & effective pain relief. Manual therapies may assist. Avoid aggravating activities. Red flags include changes in; sensation or motor control, bladder or bowel function OR systemic signs of illness such as weight loss, night pain & sweats. Referral to medical specialist required. Refer to Psychologists if there is a regular person the rower sees / specific need identified.	Control of pain with activity modification +/- medication (prescribed under International Olympic Committee & World Anti-Doping Agency guidelines) +/- manual therapies. Restore movement via rowing specific exercises & progress towards spinal load requirements. Poor sleep, performance pressure, fear avoidance behaviour & life stressors signal consideration for support on an individual basis.	Rowers should be active participants in their recovery. It is important for the rower to avoid developing a fear of specific movement patterns, a cognitive functional therapy approach or a confidence with movement approach can be helpful. Splinting or overprotective movements should be discouraged. If a rower is finding it difficult to cope or if they have already accessed psychological services, this should be encouraged & continued.	Emphasis placed on restoring usual rowing biomechanics & addressing modifiable risk factors that can prevent reoccurrence. Continue to support self-management, the rower should be seen less for specific interventions such as manual therapies or ongoing use of medication. Do not progress to this stage if red flags identified. Yellow flags include recurrent history of failing to progress or symptoms in excess of presentation; progress slowly & with care.
EXERCISE & TRAINING	Avoid complete rest. If rowing aggravates; stop on-water & rowing ergometer (erg) training. If can sit without pain; start short duration stationary bike. If sitting is painful prescribe walking; duration & including hills or steps is dependent on symptoms. If rower is able to row on-water or erg without pain or muscles guarding, they should be encouraged to do so.	Focus on what the rower CAN DO to maintain fitness but not exacerbate LBP. Continuation or graduation of a cardiovascular cross-training program within limits of the pain. If the rower tolerates sitting, stationary bike used. As sitting tolerance increases, a trial erg row can commence & then progression to a short duration on-water row of less than 10km. If sitting is not tolerated, use of an elliptical trainer, swimming or walking should be encouraged.	If not able to row; continue cross-training with increasing duration & intensity. Can use; stationary bike, elliptical trainer, ski erg & walking including up hills & stairs. Consider swimming but gradually increase to avoid shoulder pain. Modality is dependent on symptoms & access. Return to rowing program should be agreed on by medical staff, rower & coach. Intensity & volume increase, building on-water rowing before erg unless rough water prevents this. Consider boat type when prescribing training: 8-10km x1 ≠ 8+. Rower can continue to use cross-training to 'top-up' training load. The planned & completed training load should be monitored. Clinicians & strength & conditioning (S&C) coaches should work together to formulate exercises individual to the rower that address rowing specific ROM, trunk strengthening & movement deficits.	Return to full training should planned with increasing on-water distance & intensity as well as progressive increase in erg +/- S&C & cross-training. This should be individually tailored. As rower approaches return to full on-water training a reduction in cross-training occurs as part of overall load management. A strength & mobility program that addresses modifiable risk factors for LBP should continue to ensure change is made & may be prescribed for long term maintenance. Medical and coaching staff should work together to ensure the rehabilitation program translates into technical changes to protect from further injury. S&C training should initially avoid high loads, progressive increases towards usual training can occur, monitoring response. Medical & coaching staff should continue to work with the rower to achieve this.
EDUCATION	Provide injury education, alleviate fears & include the rower in initial planning. Manage coach & the rower's expectations. Involve coach from outset & allow them to contribute ideas about injury occurred.	Involve the rower in planning & educate about the multi-dimensional nature of LBP including contributors to onset & persistence of pain. Support may come from coaching staff, medical staff, family & friends or psychology.	The rower & coach should have a thorough understanding of what symptoms can be tolerated when returning to training. A rower should have; no / low levels of pain during rowing, pain not getting increasingly worse when rowing & no pain immediately after rowing. Continue to reassure & educate the rower & coach.	An athlete centred & coach supported approach should be encouraged. Empower the rower to self-manage, have input into the plan & follow the plan with the support of the medical staff & coaching team around them.

	Coaches & medical staff should encourage rowers to seek assessment of Low Back Pain (LBP) early. Delaying this can prolong recovery.	Assessment & management by a Medical Doctor & Physiotherapist experienced in managing rowing-related LBP is ideal.	Episodes of rowing-related LBP are most often not serious, they are self-limiting & early management will educate the rower about severity & recovery.	Many factors contribute to a presentation of rowing-related LBP, these include; physical, biological, social & psychological –they all need to be managed.
	First presentation to medical staff	First week of presentation	SUB-ACUTE – return to rowing	REHABILITATION – return to full training
EXAMINATION	Establish type of LBP presentation; Typical for rowers Nerve involvement Inflammatory component Pain requiring further examination for diagnosis Screening for; mental health issues, catastrophizing, anxiety, upcoming competition & / or life stressors.	Re-assess findings from first presentation including; sitting tolerance, low back range of motion & ability to complete activities of daily living (ADL). Assess rowing specific ranges; specifically hip flexion & hamstring length, as they affect how the pelvis & low back moves in the boat. Improvement in the motion of the pelvis & hips is desirable.	Assess rower's ability to move through rowing specific movement & ability to tolerate spinal load. If they have not yet rowed, trial erg row &/or short duration on-water row with assessment before & after. Response to on-water training should be continually assessed. The coach or medical staff should ensure the rower's stroke pattern consists of suitable pelvic motion & limits excessive low back motion.	Ensure the rower is confident in their ability to progress. Objective markers in initial triage assessed for signs of resolution; pain should be absent during ADL & cross training. Rowers should be able to row with usual power & tolerate changes in; water conditions, rowing rate & seating in boat. Rowing stroke pattern should be monitored during water or erg sessions that induce high levels of fatigue.
MANAGEMENT	Restore function in ADL with early & effective pain relief. Manual therapies may assist. Avoid aggravating activities. Be aware of changes to; sensation or muscle power, bladder or bowel function OR signs of illness such as weight loss, night pain & sweats. Referral to medical specialist required. Refer to Psychologists if there is a regular person the rower sees / specific need identified.	Control of pain with activity modification +/- medication (prescribed under International Olympic Committee & World Anti-Doping Agency guidelines) +/- manual therapies. Restore movement via rowing specific exercises & progress towards spinal load requirements. Poor sleep, performance pressure, fear avoidance behaviour & life stressors signal consideration for support on an individual basis.	Rowers should be active participants in their recovery. It is important for the rower to avoid developing a fear of specific movement patterns, a functional movement approach with awareness or a confidence with movement approach can be helpful. Splinting or overprotective movements should be discouraged. If a rower is finding it difficult to cope or if they have already accessed psychological services, this should be encouraged & continued.	Emphasis placed on restoring usual rowing biomechanics & addressing modifiable risk factors that can prevent reoccurrence. Continue to support self-management, the rower should be seen less for specific interventions such as manual therapies or ongoing use of medication. Do not progress to this stage if red flags identified. Yellow flags include recurrent history of failing to progress or symptoms in excess of presentation; progress slowly & with care.
EXERCISE & TRAINING	Avoid complete rest. If rowing aggravates; stop on-water & rowing ergometer (erg) training. If the rower can sit without pain; start short duration stationary bike. If sitting is painful prescribe walking; duration & including hills or steps is dependent on symptoms. If the rower is able to row on-water or erg without pain or muscles guarding, they should be encouraged to do so.	Focus on what the rower CAN DO to maintain fitness but not exacerbate LBP. Continuation or graduation of a cardiovascular cross-training program within limits of the pain. If the rower tolerates sitting, stationary bike used. As sitting tolerance increases, a trial erg row can commence & then progression to a short duration on-water row of less than 10km. If sitting is not tolerated, use of an elliptical trainer, swimming or walking should be encouraged.	If not able to row; continue cross-training with increasing duration & intensity. The rower can use; the stationary bike, elliptical trainer, ski erg & walking including up hills & stairs. Consider swimming but gradually increase to avoid shoulder pain. Modality used is dependent on symptoms & access. Return to rowing program should be agreed on by medical staff, rower & coach. Intensity & volume increase, building on-water rowing before erg unless rough water prevents this. Consider boat type when prescribing training: 8-10km x1 ≠ 8+. Rower can continue to use cross-training to 'top-up' training load. The planned & completed training load should be monitored. Clinicians & strength & conditioning (S&C) coaches should work together to formulate exercises individual to the rower that address rowing specific ROM, trunk strengthening & movement deficits.	Return to full training should planned with increasing on-water distance & intensity as well as progressive increase in erg +/- S&C & cross-training. This should be individually tailored. As rower approaches return to full on-water training a reduction in cross-training occurs as part of overall load management. A strength & mobility program that addresses modifiable risk factors for LBP should continue to ensure change is made & may be prescribed for long term maintenance. Medical and coaching staff should work together to ensure the rehabilitation program translates into technical changes to protect from further injury. S&C training should initially avoid high loads, progressive increases towards usual training can occur, monitoring response. Medical & coaching staff should continue to work with the rower to achieve this.
EDUCATION	Provide injury education, alleviate fears & include the rower in initial planning. Manage coach & the rower's expectations. Involve coach from outset & allow them to contribute ideas about how injury occurred.	Involve the rower in planning & educate about the multi-dimensional nature of LBP including contributors to onset & persistence of pain. Support may come from coaching staff, medical staff, family & friends or psychology.	The rower & coach should have a thorough understanding of what symptoms can be tolerated when returning to training. A rower should have; no / low levels of pain during rowing, pain not getting increasingly worse when rowing & no pain immediately after rowing. Continue to reassure & educate the rower & coach.	An athlete centred & coach supported approach should be encouraged. Empower the rower to self-manage, have input into the plan & follow the plan with the support of the medical staff & coaching team around them.

Figure 1 Acute episode of rowing-related low back pain: progression through phases from initial presentation to full return to sport



Epidemiology of low back pain in rowers

A systematic review examined the prevalence of and risk factors for LBP in the general sports population to provide context for rowing.[1] The following question regarding rowing-related LBP was addressed:

"What is the current epidemiological evidence for prevalence of LBP in rowers and what are the associated risk factors?"

In 86 studies in all sports, the mean LBP point prevalence was 33%; lifetime prevalence was 63%; 12-month prevalence was 51%. Comparison across sports was limited by participant numbers, study quality and methodologies, and varying LBP definitions. Risk factors for LBP included history of a previous episode, and statistically significant associations were reported for high training volume, periods of load increase, and years of exposure to the sport.

There were 11 studies (1695 participants) that specifically examined LBP in rowers.[2-12] Six studies (667 participants) were high quality.[2 4 7 8 11 12] The most common LBP prevalence estimate for rowing studies was 12 months. The mean 12-month prevalence of LBP for rowers was 48% (range 32% - 95%). When only high-quality studies were pooled, the 12-month prevalence was **61%** (95% CI: 42-78%, I^2 95%). Data are summarised in Table A1

Author, year of publication	Country	No. of participants (M/F)	Mean participant Age (years) (SD)	Type of participants	Variables of interest	Data collection mode	LBP prevalence	Risk factors
Bahr et al. 2004	Norway	N=199, 131(M), 68(F)	M:21(6) F:22 (5)	Elite rowers	LBP prevalence and time loss (training and competition)	Questionnaire	1) LIFETIME: 63.3%; control 51% 2) 12 MONTH (retro) 55.5% rowers; 47.5% control 3) 7 DAYS (retro) 25.3% rowers; 19.6% control	Periods of increased training or competition load p<0.05
Clay, Mansell and Tierney 2016	USA	N=37(F)	N/R	College Division 1 rowers.	LBP prevalence, history of LBP, LBP associated disability	Clinical examination & questionnaire	1) 12 MONTH (retro): 68%	1) Increased years of rowing, 58% greater years in LBP group, p=0.008 2) Previous history of LBP, p=0.27,
Fett, Trompeter and Platen 2017	USA	N=83	21.1	Elite rowers	LBP prevalence	Questionnaire	1) LIFETIME: 96.4%; 2) 12 MONTH (retro): 95.2%; 3) 7 day (retro): 67.5%	1) Training volume, p<0.05 2) Increased age, p<0.001 3) Rowing participation OR 6.4 (95% CI 1.9-21.5)
Gonzalez et al. 2018	USA	N=31(F)	19.9(1.4)	National Collegiate Athletic Association Division I, open-weight rowers	LBP prevalence, FMS and SEBT performance	Clinical examination	1) One season (pros): 58% 2) 12 MONTH (retro): 54%	1) FMS score of <16 increased risk of LBP; RR=0.0667, 95% CI 0.9-2.11
Hickey, Fricker and McDonald 1997	Australia	N=172 88(M), 84(F)	F:20.1 M:21.3	Elite rowers	All injuries: type, region and prevalence	Retrospective analysis of medical database (10 years)	15.2% female and 25% male had LBP over 10 years	Weight training self-reported as most common 'mechanism of injury' (no data provided)
Maselli et al. 2015	Italy	N=133 107(M) 26(F)	19	National Championship rowers	LBP prevalence duration, severity and frequency of symptoms, time loss from work and training	Questionnaire	1) LIFETIME: 64.7%; 2) 12 MONTH (retro): 40.6%; 3) 1 MONTH (retro):19.5%	1) Type of rowing: a) Sculling + sweep; OR 4.43, p<0.001, 95% CI 1.87-10.48 b) Sweep only; OR= 3.32, p=0.03, 95% CI 1.16-6.27. Both higher risk than sculling only 2) Male sex; OR=2.62, p=0.03, 95% CI 1.16-6.27
Newlands, Reid and Parmar 2015	New Zealand	N=76, 46(M), 30(F)	M:23(4) F:21(4)	International rowers	LBP prevalence, previous history, movement competency screen	Questionnaire	1) 12 MONTH (pros): 52.6 % 2) incidence: 1.67	1) Increasing age;OR=1.08, p=0.02, 95% CI 1.01-1.15 2) Previous LBP history; OR=1.58, 95% CI 0.9-2.65

					(MCS) score,training volume		episodes per 1000 h of rowing exposure.	(logistic regression) 3) Total training hours/month; r=0.83, p<0.01 4) Ergometer hours/month; r=0.8, p<0.01 5) Average training hours/month; r=0.73, p<0.01 6) Average Km rowed/month; r=0.71, p=0.01
Schultz, Lenz and Buttner-Janz 2016b	Germany	N=45 29(M) 16(F)	22	Elite Rowers	1. Prevalence of LBP. 2. Pain intensity (VAS)	Questionnaire	1) 12 MONTH (retro): 31.5%	N/R
Smoljanović et al. 2018	Croatia	N=743, 475(M) 268(F)	50	Masters rowers	All injuries sustained during a 12-month period	Questionnaire	1) 12 MONTH (retro): 32.6%	1) Ergometer training >30 minutes in rowers age 60+years; x^2 4.114, p=0.043 2) Scullers higher risk than sweep rowers; x^2 4.973, p=0.026
Trompeter, Fett and Platen 2019	Germany	N=156 57.1%M, 41.7%F	22.2 (5.1)	Elite and no-elite rowers	Prevalence and severity of LBP.	Questionnaire	1) 12 MONTH (retro): 75% rowers, 58% controls. 2) 7 DAY (retro): 40% rowers, 29% controls. 3) LIFETIME: 84% rowers, 71% controls.	Training volume (12 month LBP); p=0.022, r=0.184
Wilson et al. 2010	Ireland	N=20 12(M) 8(F)	26.3 (4.2)	International rowers	1. Incidence of all injuries 2. training and competition exposure 3. type of injury	Questionnaire	1) 12 MONTH (pros): 31.8%	1) Ergometer training (more than 30 mins); r=0.75, p=0.01 2) Heavy weight training; r=0.66; p=0.02 3) Increased core stability training; r=0.68, p=0.01

Table A1: Studies examining epidemiology of low back pain in rowers

Summary statements from the Delphi process are in Table A2

Summary statements & recommendations: Epidemiology of low back pain in athletes with a rowing subgroup analysis
Exercise caution when comparing results of studies with different definitions of LBP. A standardised definition of athlete LBP is needed.
Prevalence varies widely among studies as a result of different methodologies and definitions of LBP. More research is needed, using gold standard prospective data collection, to estimate more precisely the prevalence of LBP in athletes.
Risk factors for LBP in athletes are: history of LBP; rapid increase in training or competition load; higher volume and intensity of training/competition; Increased years of exposure to the sport (career length)
Rowing-specific risk factors are: all of above + ergometer training greater than 30 minutes/session.
Radiological abnormalities should be considered in relation to symptom presentation and not in isolation. The significance of radiological abnormalities in the absence of symptoms is unclear.
Pre-season screening does not predict within-season onset of LBP in athletes.
Technical issues/biomechanics are likely to be a risk factor for LBP in some sports, but there is insufficient evidence to identify those and more research is needed to confirm this.

Table A2: Summary statements and recommendations from epidemiology of LBP in athletes review.

Definition of rowing-related low back pain

Fourteen experts (FW, KW, JT, KA, CG, JH, LT, AV, SJM, JPC, AMcG, MW, JAH, JS) rated nine initial statements proposed by the experts from standard, widely used LBP definitions and from those contained in the athlete LBP epidemiology studies. A decision was made following a four-round Delphi process. The consensus definition is described in **Box 1** (main document).

Relationship between biomechanics and rowing-related low back pain

A systematic review examined the relationship between rowing-related LBP and rowing biomechanics.[13] The following question regarding rowing-related LBP was raised:

"What are the spine, pelvis and hip biomechanics of rowing and how do they influence the risk of low back pain in rowers?"

Thirteen studies investigated spine kinematics during rowing and nine studies investigated muscle activity. One study compared the ergometer to rowing in a boat and all other studies were conducted on an ergometer. Rowing activity was associated with in an increased

sagittal flexion range in the lumbar spine over time (spinal creep), which increased as rowers fatigued.

Studies that specifically examined LBP reported conflicting results regarding the influence of LBP on kinematics; some demonstrated that rowers with LBP history move more through their lumbar spine than their hips and other studies found no difference between groups.

Muscle activity during rowing is dominated by the extensor group of the trunk with trunk flexor activity focused on the transition from the drive to recovery phase. One study compared fixed and dynamic ergometers and found no difference in trunk muscle activity. One cross sectional, injury surveillance study (not included in the biomechanics review) reported a reduction in LBP prevalence when fixed ergometers were replaced by dynamic ergometers but no biomechanical factors were explored.[14] No studies examined trunk muscle function in a boat. Fatigue altered muscle recruitment. Rowers with LBP history had less efficient erector spinae recruitment compared to those without a history of LBP.

Summary statements from the Delphi process are in Table A3.

Summary statements & recommendations: Relationship of biomechanics to rowing-related LBP
There is insufficient evidence to recommend one ergometer type (fixed vs dynamic) over the other to avoid LBP
Rowing requires a relatively vertical pelvic position at the catch. If limitations in hip flexion do not allow for a vertical pelvis and increased lumbar flexion results, the risk for LBP may increase
Trunk asymmetries do not appear to be associated with LBP
The muscle activity of the trunk is dominated by the extensor group when rowing; the flexor group is relatively silent. The trunk flexors (abdominals) act as a braking force (eccentrically) at the end of the drive and at the change in direction of the trunk to the recovery.
There is insufficient evidence to confidently define which trunk and hip biomechanics increase risk of LBP in rowers. Future studies should evaluate rower biomechanics as part of a longitudinal LBP risk assessment programme

Table A3: Summary statements and recommendations from relationship of biomechanics to rowing-related LBP

Managing low back pain in athletes

A systematic review examined the management strategies for LBP in athletes and aimed to examine rowing specifically (where possible).[15] The following question was raised:

"*What is the evidence for commonly used treatments for managing LBP in athletes?*"

Thirteen randomised controlled trials (505 participants) examined exercise, biomechanical and activity modifications, and manual therapy. These were included in the review. Studies examining surgery and injection therapies were observational in design and were not included. There was a reduction in pain and disability after any treatment. Exercise was the most frequently investigated treatment, although no return to sport (RTS) data were reported for any exercise intervention. Different treatments for LBP in athletes improved pain, function, and RTS, but it was unclear what the most effective treatments were. All exercise approaches reduced pain and improved function in athletes with LBP. There was

insufficient evidence to support activity or biomechanical modifications or manual therapy as stand-alone therapies. There were no studies that specifically examined management strategies in rowers.

Summary statements and recommendations from the Delphi process are shown in Table A4.

Summary statements & recommendations: Managing low back pain in athletes
Until robust evidence is produced for athlete populations, recommendations for LBP management in non-athletic populations should be used to guide management of LBP in athletes, considering the sport-specific circumstances surrounding the athlete while adopting a biopsychosocial approach.
Employ shared decision-making regarding individual treatment goals – consider the athlete's goals, expectations regarding pain, disability, quality of life and return to sport
EXERCISE
Exercise interventions improve pain and function in athletes with LBP.
The effect of exercise interventions on return to sport rates is unknown.
Targeted, dynamic (isotonic rather than isometric), functional (sport-specific) exercise appears to be the most beneficial for athletes with LBP, but there is insufficient evidence to recommend one exercise protocol over another.
BIOMECHANICAL OR ACTIVITY MODIFICATIONS
Biomechanical and activity modifications may result in a reduction of LBP, but there is insufficient evidence to recommend them as stand-alone treatments.
MASSAGE AND MANUAL THERAPY
Massage and manual therapy may improve pain and function in athletes with LBP, but there is insufficient evidence to recommend them as stand-alone treatments.

Table A4: Summary statements and recommendations from managing LBP in athletes.

Rowers' lived experience of rowing-related low back pain

Semi-structured interviews were conducted with 25 rowers in Ireland and Australia.[16] Rowers revealed a culture of openness or concealment that influenced their experience. Rowers' relationships with coaches and peers framed their overall experience, their willingness to reveal their pain, how early they revealed their pain, and the support that they received. The summary recommendations from the Delphi process are shown in Table A5.

Summary recommendations: Rowers' lived experience of rowing-related low back pain
Rowers should be taught about the nature, presentation, and various factors that contribute to LBP.
Rowers should be encouraged to disclose their LBP at an early stage and be informed about the potential negative impacts of concealing their LBP.
Rapid referral pathways to best evidence-based management should be created where possible, so that rowers can access care for LBP.
Rowers should be supported by their coaches, management, and teammates when disclosing LBP.
Rowers feel socially isolated during LBP rehabilitation and supports should be put in place where possible, including peer support (teammates).
There should be a clinical alliance among medical staff to ensure that LBP management strategies and information given to rowers is consistent.
Education regarding best practices should be available to clinicians treating rowing-related LBP.
Medical teams should adopt shared decision-making strategies with the rowers they are treating.
Communication among rowers, coaches and medical staff is important to ensure a uniform narrative with clear and consistent messages around rowing-related LBP.

Table A5: Summary recommendations from the qualitative study of rowing-related LBP

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APPENDIX: Statements gaining consensus from Delphi study of experienced and expert clinicians

Table 1 Assessment & management of rowing-related low back pain – statements gaining consensus for each phase of recovery			***M***		***SD***	
			R2	*R3*	*R2*	*R3*
Initial Triage – first presentation						
	The acute assessment of a rower with low back pain can be performed by a Physiotherapist or Doctor experienced with seeing rowers.		8.9	9.5	1.7	0.8
	The rower should be questioned to establish the type of pain presentation to classify into; non-specific somatic pain with/without somatic referral and/or radicular pain with/without radiculopathy and/or inflammatory pain and/or atypical pain presentation that needs red flag exclusion.		9.3	9.4	1.5	1.6
	The rower should be questioned to determine the history of this episode, past history, pain intensity & quality, pain behaviour & 24 hr picture, aggravating & easing factors, other symptoms such as changes in sensation, motor control and bladder & bowel function.		9.7	10.0	0.9	0.0
	When the athlete first presents it is important to understand their previous low back pain history.		9.5	10.0	0.8	0.0
	At the time of initial triage the therapist must understand how the rower's sleep is disturbed due to their low back pain.		8.3	8.6	1.4	1.4
Assess	Establish the occurrence of pain during activities of everyday living including sitting, standing, walking & night pain.		9.1	9.8	1.8	0.6
Assess	Establish risk factors including previous episode of similar pain, technical issues in boat, change of water conditions or seat position, change in training load, gym load, cross training load, increased rowing training age and time at this level of rowing.		9.0	9.6	1.6	0.9
	Red flags include cauda equina signs, peripheral neurological signs or systemic cancer signs such as weight loss, night pain & sweats.		9.8	10.0	0.6	0.0
	Yellow flags include catastrophising, increased anxiety, significant upcoming performance event, life stressors or known mental health disease.		8.1	9.5	2.2	0.8
	I assess every new presentation of low back pain for neural compromise & seek this clinical sign to assist in early referral.		9.2	8.8	1.2	2.9
	A management aim for the rower presenting with neurological dysfunction is to investigate this thoroughly & treat to restore.		8.5	9.3	2.0	1.3
	Test reflexes, strength & sensation of the lower limb when radicular pain and/or sensory change and/or strength change is reported.		9.0	9.7	2.3	0.6
	How the athlete is moving during activities of everyday life, such as sit to stand & walking, need to be assessed at initial triage.		8.8	9.5	1.3	0.9
	Pain responses to active lumbar spine motion need to be assessed.		9.0	9.8	1.0	0.4
Manage	The primary management focus at initial triage is to gain early & effective pain relief.		8.2	8.1	1.6	1.6
Manage	Manual therapies are an appropriate early intervention in the triage stage of low back pain in rowers.		6.8	7.3	2.1	1.8
Manage	At initial triage a management aim should be to restore function for activities of daily living.		7.8	8.6	1.8	1.3
Manage	A rower that presents on the first occasion with severe low back pain should be removed from on water and ergometer rowing.		7.7	8.4	2.3	1.9
Move	If the rower is able to sit without pain, they can start stationary bike riding. If unable to sit, the rower should to remain active e.g. walking.		7.2	7.6	1.9	0.9
Move	The rower should be encouraged to walk. The duration & whether to include hills & steps will be dictated by the severity of symptoms.		7.1	7.7	2.5	1.4
Move	If a rower is able to row on water and/or on the ergometer without pain or muscle guarding, they should be allowed to do so.		7.6	8.3	2.2	1.7
Educate	The rower should be educated & re-assured about their presenting low back condition, it is especially relevant to alleviate fears.		8.2	8.9	1.7	1.0
Educate	Medical staff should begin conversations about identified 'yellow flags' including stress & its effect on pain.		7.3	8.1	1.9	1.4
Educate	In the initial triage the rower should be educated about the injury & included in the decision making of the initial plan.		9.2	10.0	1.0	0.0
Educate	A rower should be encouraged to see a psychologist if they have a regular person they interact with or if there is a specific need.		6.8	7.5	2.4	1.3
Educate	It is important to manage a coach and athlete's expectations at the initial triage.		9.3	9.9	1.0	0.3
Educate	It is important to involve the coach from the outset & allow them to contribute their ideas about why the injury may have occurred.		8.3	8.2	1.6	1.2
Acute Phase – first week of pain						
	The response to rest and activity modification are important indicators of prognosis over the first week.		8.5	9.1	1.4	1.0
	Improvement of symptoms experienced in everyday life are considered good indicators for prognosis in the first week.		7.8	9.1	1.2	0.7
	A good sign of recovery is a rower expressing confidence in the improvement of their low back pain & function in the first week.		8.3	8.5	1.1	1.1
Assess	Over the first week of presentation the therapist should continue to monitor the rowers sitting tolerance.		8.3	7.5	1.5	1.7
Assess	Over the first week of presentation, monitoring pain response to lumbar range of motion is an important indicator of progress.		7.8	7.7	1.2	1.1
Assess	The therapist should continue to monitor the rower's ability to complete their usual activities of daily living.		8.8	9.5	1.2	0.7
Assess	Rowing specific ranges must be assessed, specifically hip flexion & hamstring range that can affect how the pelvis & low back moves in the boat. Improvement towards rowing specific range of motion is desirable.		8.1	8.4	1.9	1.9
	In the initial week of management control of pain continues to be a management focus.		8.6	9.2	1.1	1.0
Manage	The use of manual therapies, such as Physiotherapy or soft tissue treatment in the region is appropriate.		8.5	8.6	1.5	1.6
Manage	Focus on re-establishing normative movement, rowing specific range of motion & progression towards spinal load requirements for rowing.		7.8	8.3	1.7	1.6
Manage	The acute phase is the time to commence a functional exercise rehabilitation program.		7.0	7.9	2.3	1.6
Manage	In the initial week, management focus should be on what the rower can do to maintain fitness but not exacerbate low back pain.		8.7	9.5	1.1	0.8
Exercise	Continuation or graduation of cardiovascular training program within limits of injury.		8.9	9.9	1.1	0.3
Exercise	During the first week, as the rower can tolerate sitting, stationary bike training can commence.		8.6	9.1	1.1	0.9
Exercise	During the first week the rower can be encouraged to swim or perform exercises in the water.		8.0	8.5	1.3	1.1
Exercise	During the first week the rower can use walking as a form of training & add hills & stairs to increase the training intensity.		7.8	8.8	1.3	0.6
Exercise	A cross-training alternative is elliptical training, especially if sitting is not being tolerated. As sitting is tolerated, stationary bike can commence.		7.1	8.1	1.3	0.5
Exercise	If a successful rowing ergometer trial is conducted, the rower can progress to a short duration on water row of less than 10km.		7.1	7.5	1.3	1.0
Educate	Rower should be involved in treatment planning, they should be empowered to assist in guided decision making & educated about their injury.		7.8	9.1	2.6	1.0
Educate	Yellow flags include; stressors in life or sport, poor sleep, fear avoidance, pressure from coach / selection / upcoming performance.		8.1	9.0	1.3	0.9
Educate	Yellow flags include a stress response to injury which may manifest as poor sleep, lowered mood or fear avoidance behaviours.		8.0	8.5	1.2	0.9
Educate	Strategies for controlling stress include; use of psychology services, coach support, using mindfulness techniques or family & friends support.		7.3	8.5	1.5	0.5
Sub-Acute Phase – return to rowing						
	No pain during activities of daily living & no pain with other cross training modalities are good signs of progression.		8.3	9.5	1.4	0.7
	A reduction in morning stiffness is a good sign of progression.		7.3	8.1	1.1	0.9
	A reduction in medication along with reducing symptoms is a good sign of progression.		8.4	8.9	1.1	1.1
	Red flags should continue to be monitored for in this phase & should raise the concern for non-musculoskeletal diagnoses.		8.6	8.8	2.0	1.8
	Low levels of pain during rowing, pain that is not getting worse when rowing & no pain after rowing are good indicators of progression.		8.7	9.0	1.2	0.9
	A good sign is a rower who rates themselves as being confident to progress & heading progressively towards 100% recovery.		7.1	8.6	2.7	0.9
Assess	Continued re-assessment of significant objective findings should occur throughout the sub-acute phase.		8.4	9.2	1.7	1.2
Assess	When considering return to rowing, the motion of the hamstrings & hip & the ability to sit & load the lumbar spine should be assessed.		8.2	9.5	1.5	0.7
Assess	Trailing an ergometer row & assessing the response should be completed before returning the rower to training.		7.6	8.2	1.6	1.3

APPENDIX: Statements gaining consensus from Delphi study of experienced and expert clinicians

Manage	A trial on water row should be completed before scheduling a return to rowing training.	7.8	8.9	1.5	0.9
	When the rower begins to return to the boat, tolerance to sitting should continue to be monitored.	8.4	8.8	1.7	1.4
	When the rower returns to the boat, pain in activities of daily living should continue to be monitored.	8.5	8.7	1.2	0.9
	When the rower returns to the boat, pain when rowing should be well understood and continually monitored.	8.9	9.5	1.0	1.0
	As soon as athlete is able to row without pain & with their normal movement patterns they should be returned to on water rowing.	7.2	8.5	2.6	0.7
	Biomechanical assessment & technical coaching is an important part of the return to rowing phase for an athlete with low back pain.	7.7	8.7	1.6	1.3
	In the initial return to rowing phase, technical issues that are likely contributing risk factors for low back pain should be addressed.	8.5	9.5	1.6	0.8
	When considering a return to on water training, the management aims need to include restoration of rowing specific range of motion.	8.6	9.4	1.2	1.0
	When considering a return to on water training, the management aims need to consider the ability of the spine to be loaded.	9.0	9.7	1.2	0.6
	Maintenance or improvement of mobility is a key component of the return to rowing phase.	7.8	8.6	1.5	1.2
Training	Management must focus on a return to rowing protocol with a gradual re-loading program agreed on by the rower, medical and coaching staff.	9.3	9.7	1.1	0.6
	When prescribing return to row consider: 8-10km in single ≠ 8-10km in eight, stability of boat returning to & weather. Set athlete up for success.	8.6	9.7	3.2	0.5
	In the initial return to rowing phase, medical staff should work closely with coaches to plan load progressions and monitor actual load.	7.9	10.0	0.9	0.0
	A Medical Practitioner's involvement is often necessary in the return to rowing phase of rehabilitation from low back pain.	7.7	7.0	1.7	1.7
	On water & rowing ergometer should progressively increase in intensity & time as pain allows. Prioritise building on water rowing first.	7.7	8.1	1.7	1.5
	The rowing ergometer should be used when the water is rough or the weather is not conducive to on water rowing.	7.1	7.0	2.5	0.6
	As sitting tolerance increases, as can time on a stationary or road bike. The bike can be used to 'top up' training load at the end of a rowing session.	8.5	9.3	1.2	0.8
	If pain with sitting persists, the use of upright exercise for training can be considered; elliptical training, running, hill walking and/or ski ergometer.	7.2	7.8	2.6	1.3
	Swimming can be used as a form of increasing training load. Care to not increase shoulder load quickly as this may contribute to shoulder injury.	8.1	8.1	1.1	0.5
	Involvement of a strength & conditioning coach in the rehabilitation phase of the rower with low back pain is important.	7.3	7.5	1.7	1.4
	Tolerance of land based training is important in this phase.	7.8	8.0	1.0	0.8
	Strength, gym & core muscular training are essential parts of the sub-acute management of the rower with low back pain.	7.1	8.3	1.8	1.8
Educate	Exercises should be prescribed to ensure appropriate movement control, stability and strength is gained for performance of the rowing stroke.	8.7	9.1	1.8	1.0
	Medical staff & strength & conditioning staff shoulder work together to construct an appropriate program of exercises individual to the rower.	9.1	9.7	1.1	0.6
	Yellow flags are important to recognise & monitor e.g. fear avoidance behaviour & catastrophising - they may be heightened at competition time.	8.3	9.4	1.4	0.8
	It is important for the rower to avoid developing a fear of specific movement patterns. A cognitive functional therapy approach or a confidence with movement approach can be helpful. Splinting or overprotective movements should be discouraged.	7.8	8.2	2.0	1.8
	If a rowers has access psychological services, this should be continued through the sub-acute phase.	7.0	7.2	1.3	1.1
	If a rower is finding it difficult to cope or their progression is not as expected, psychological consultation may be considered.	7.9	8.5	1.4	1.1
	The return to rowing phase must include self-management advice & self-empowerment for the rower with low back pain.	8.3	9.3	1.2	0.8
Rehabilitation Phase – return to normal training load					
Assess	It is important to continue to re-assess significant findings throughout the return to rowing period.	8.9	9.1	1.1	1.2
	When the rower has returned to rowing, their everyday life pain should also be monitored, especially pain immediately after rowing.	8.7	9.1	1.4	0.9
	When the rower is increasing their rowing load it is important to review them & ensure their main objective findings are continuing to improve.	8.6	9.2	1.2	1.0
	Being able to row with no pain or no increase in symptoms is essential for progressing training load.	7.7	8.3	2.6	2.0
	Rowing with quality movement patterns, achieving usual power & tolerating different stroke pressures and rates are very good signs of recovery.	8.7	9.8	1.3	0.4
	Tolerating changing water conditions, changes in rowing rate & change in seating in the boat are all good indications of recovery.	8.8	9.4	1.2	0.8
	The response to progressively increasing rowing & ergometer work load should be continually monitored.	8.8	9.5	1.0	0.7
	Athletes with red flags should not be progressed to this stage.	9.1	9.9	1.4	0.3
	Yellow flags may also be a recurrent history of failing to progress & having symptoms in excess of the clinical presentation.	7.0	8.6	1.3	0.9
Manage	Medical staff should communicate with the coach about management expectations & address risk factors for low back pain the rower.	9.4	9.5	0.7	0.5
	Coaches' observations should be integrated in the rehabilitation stage.	9.1	9.1	1.0	0.8
	Ensuring the athlete & coach are working on causative factors for the specific incidence of low back pain is imperative at this stage.	8.8	9.1	1.4	1.4
	Emphasis should be placed on restoring the rower's usual biomechanics & addressing risk factors identified to prevent re-occurrence.	8.8	9.7	1.3	0.5
	In the final phase I always ensure the rower has corrected any identified movement or strength deficiencies.	8.1	8.5	1.8	1.5
	A key component of the rehabilitation of a rower is the graduation of an individualised strength & mobility program.	8.4	9.1	1.4	0.9
	The creation of a maintenance exercise & mobility program is essential for rowers in the final phase of rehabilitation.	7.8	8.6	1.6	1.2
	Work with coaching staff to ensure the rehabilitation program translates into on water and gym changes to protect from further injury.	8.6	8.6	1.0	0.7
	A strength & conditioning coach is an important contributor to the final rehabilitation phase of low back pain in rowers.	7.5	7.8	1.3	1.0
Training load	A return to full training should include a planned program of increasing distance & intensity on the water as well as progressive increases in ergometer rowing, cross training & strength & conditioning work.	8.8	9.5	1.5	1.2
	Gradually build on water volume & intensity, based on pain response, up to full training load. Time to do this is individual & based on the severity of the initial injury & the improvement in the individual's condition over time.	9.1	10.0	1.3	0.0
	The priority in a return to rowing program should always be on water training. The ergometer may need to be used due to weather conditions.	8.5	8.9	1.4	0.9
	The return to rowing program should be agreed upon by both medical & coaching staff. A clear schedule should be set out that can be adjusted as the response to increasing on water and/or ergometer time is assessed.	8.8	9.8	1.3	0.4
	During a return to full training, less cross training is performed as more on water & rowing ergometer training is completed.	8.4	9.0	2.2	0.6
	The stationary bike or road bike can be used to 'top up' training load as on water and ergometer rowing are increasing.	8.8	8.8	1.3	0.9
	Converse with the coach or observe on water training to ensure the rower is returning to normal movement patterns & force production.	8.9	8.8	0.9	0.9
	Strength & conditioning training can be introduced but high loads should be avoided until a full on-water training load has been achieved.	7.4	8.8	2.4	1.3
	Strength & conditioning sessions should progressively introduce more loaded exercises & progress towards a rower's usual program.	8.2	9.5	2.7	0.7
	The medical and strength & conditioning staff should work together to return the rower to their usual strength &conditioning program.	8.5	9.2	2.7	0.6
Educate	Ensure an athlete centred & coach supported approach. It is important that the athlete does not become dependent on medical staff for specific	8.2	9.5	2.8	1.2
	Continue use of a sports psychologist if the rower believes this in beneficial or the medical staff believe this could provide ongoing support.	7.7	8.1	1.2	0.9
	Encourage discussion regarding athlete self-management during the rehabilitation phase.	9.2	10.0	0.8	0.0
	Continual education, re-assurance & explanation should occur throughout the return to rowing phase.	8.2	8.8	1.5	0.9

R = round, M = Mean, SD = Standard Deviation, Mo = Mode

APPENDIX: Statements gaining consensus from Delphi study of experienced and expert clinicians

Box 1 Important considerations – novel response statements gaining consensus

Creating a culture of early recognition and management of low back pain in the training environment optimises management and improves learning and performance. (M: R2 8.8, R3 9.5, SD: R2 2.5, R3 1.9)

Identifying radicular pain early (with or without sensory and/or motor change) is essential and management must involve medical assessment as soon as possible. (M: R2 9.0, R2 9.5, SD: R2 1.9, R3 1.3)

There are gender differences in the causal factors for low back pain in rowers - males are at risk due to reduced hip flexion, females are at risk due to reduced trunk strength. (M: R2 6.1, R3 7.2, SD: R2 2.5, R3 1.9)

M = Mean, R = round, SD = Standard Deviation

Table 2 Assessment of rowing-related low back pain – statements gaining consensus relating to all phases of recovery			***M***		***SD***	
			R 2	*R* 3	*R* 2	*R* 3
Imaging						
Imaging is not required nor recommended as a routine part of the rehabilitation process.			6.6	9.2	3.1	1.0
Risk Factors						
Training load is a key factor to understand to determine if it contributed to the development of low back pain in the rower. A steep increase in training load or a reduction in load followed by an increase in load are specific risk factors that should be understood.			9.0	9.7	1.1	0.6
Psychological stress is a key factor to understand early in the assessment process, this may include; fear of movement, selection pressure, worry about having low back pain for first time, worry about a subsequent episode of low back pain & increased stress related to being close to a key event.			6.9	7.6	1.6	1.2
Technique (e.g. posture) or technical (e.g. boat set-up) issues are key factors to address during rehabilitation.			8.0	9.1	1.8	0.7
Of the following specific risk factors, rate your agreeance with each as a risk factor for rowing-related low back pain;						
Training	change to training intensity (e.g. increase in power strokes or athlete training outside prescribed or intended training zone)		8.2	8.5	1.2	1.2
	illness or another injury prior to this injury causing a reduced training load		7.9	8.5	1.3	0.5
	ability to complete high level of training volume over a longer period of time (3months is protective for injury)		7.9	8.1	1.2	0.9
	having a young training age		6.8	7.4	1.1	1.4
On-water	changes in crew increasing load on injured rower		6.8	7.1	1.3	1.7
	recent change in boat set up		7.0	7.0	1.8	1.2
	rough water		7.2	7.5	1.7	1.0
Physical & movement	increased lumbar flexion range during rowing		7.5	7.3	1.6	1.6
	getting to end of range lumbar flexion during rowing		7.5	7.1	2.0	1.8
	reduced hip flexibility <130degrees		7.1	8.7	2.1	0.9
	reduced hamstring flexibility		7.2	7.6	1.9	1.8
	hip motion & hamstring flexibility once pain reduced (may not be accurate indication in the presence of pain)		7.3	7.1	1.5	1.1
	reduced knee flexion range		6.4	7.2	2.0	1.5
	reduced posterior chain endurance (erector spinae thoracic and lumbar)		7.7	8.5	1.4	0.8
	reduced abdominal endurance		7.5	7.2	1.7	2.0
	muscular control of deep squat		7.2	7.3	1.5	1.4
	control deficits when lifting weights		7.7	7.4	1.2	0.8
Other	previous history of low back pain		9.5	10.0	0.8	0.0
	>30min on ergometer during one session		6.6	7.0	2.7	2.0
	poor nutrition or reduced energy intake		7.3	7.4	1.7	1.1
	poor sleep habits		7.1	7.5	1.7	1.6
Outcome Measures						
Using outcome measures or scales is important for analysing the severity of a rower's pain and/or disability & being able to monitor this over time.			6.5	7.5	2.2	1.4
Consider specific outcome measure, rate how useful when managing a rower with low back pain (1=useful, 2=undecided, 3=not useful)			***R2 Mo***		***R3 Mo***	
Visual / verbal analogue scale /10			1		1	
Patient Specific Functional Scale			1		1	
Orebro Musculoskeletal Pain Screening Questionnaire			2		1	
A simple function specific question - e.g. is the pain great enough to stop you rowing?			1		1	

R = round, M = Mean, SD = Standard Deviation, Mo = Mode

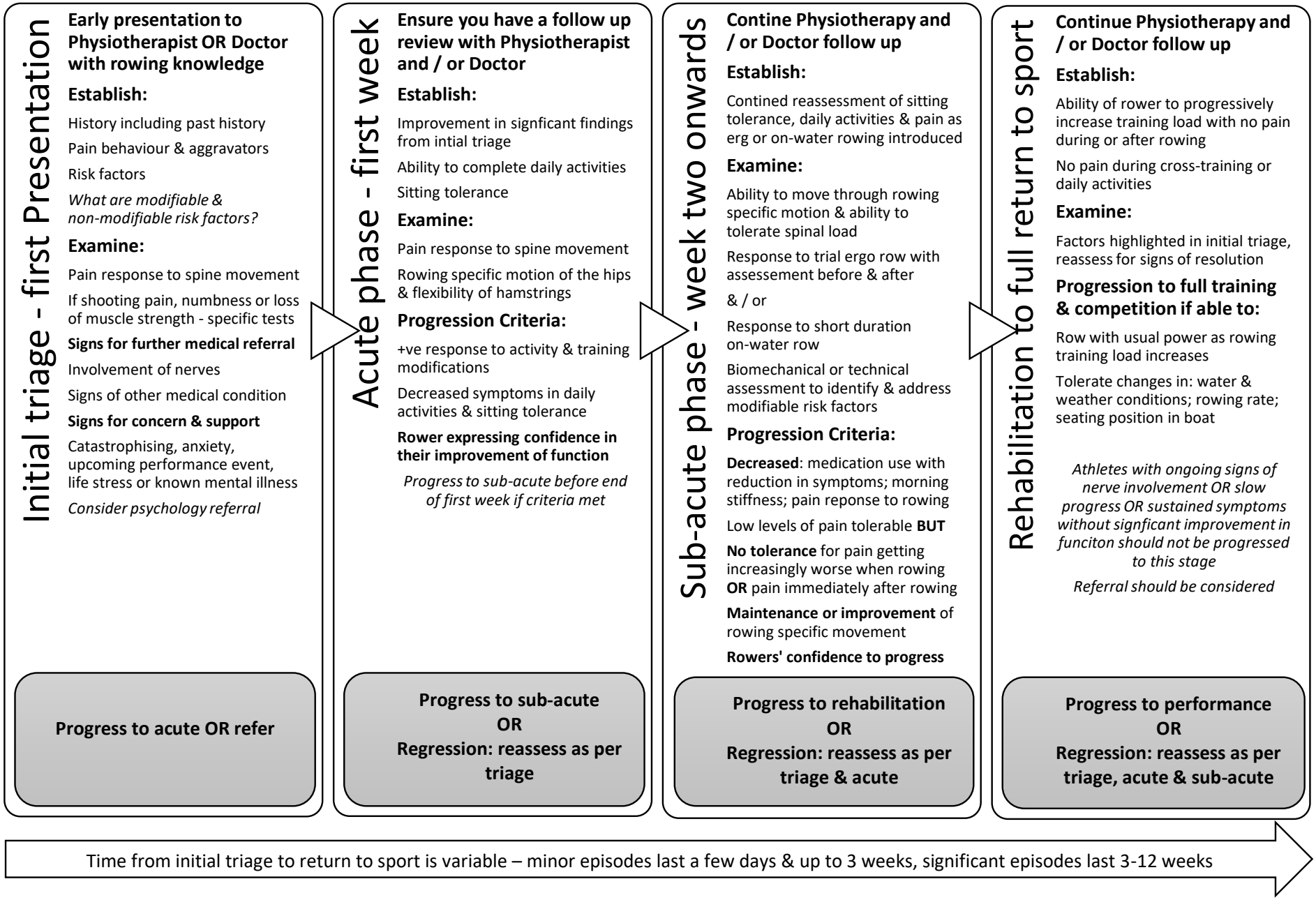
Table 3 Specific rowing-related low back pain considerations for developing and masters rowers – statements gaining consensus	***M***		***SD***	
	R 2	*R* 3	*R* 2	*R* 3
Developing Rowers				
A priority in the management of the developing rower with low back pain is the engagement of their parents & coach.	9.2	9.5	0.8	0.5
A priority in the management of the developing rower in the subacute phase is education about their injury.	9.1	9.6	0.8	0.5
A key for understanding for successful management is understanding the rower's rate of growth & flexibility as contributing factors.	8.5	9.2	1.4	1.3
I have a more conservative rehabilitation plan for developing rower than elite rowers throughout their management and rehabilitation.	8.2	8.5	1.3	1.4
Masters Rowers				
I prioritise the assessment of medical co-morbidities in a masters rower when compared to an elite.	6.9	8.3	2.7	1.0
Some biomechanical & movement restrictions may not be amenable to change due to underlying degenerative processes & should be assessed & accommodated as part of the rehabilitation program.	7.9	8.8	2.2	1.3

R = round, M = Mean, SD = Standard Deviation

	Coaches & medical staff should encourage rowers to seek assessment of Low Back Pain (LBP) early. Delaying this can prolong recovery.	Assessment & management by a Medical Doctor & Physiotherapist experienced in managing rowing-related LBP is ideal.	Episodes of rowing-related LBP are most often not serious, they are self-limiting & early management will educate the rower about severity & recovery.	Many factors contribute to a presentation of rowing-related LBP, these include; physical, biological, social & psychological –they all need to be managed.
	INITIAL TRIAGE – first presentation	ACUTE- first week	SUB-ACUTE – return to rowing	REHABILITATION – return to full training
EXAMINATION	Establish type of presentation; Non-specific LBP with / without somatic referral Radicular pain with / without radiculopathy Inflammatory component to pain Atypical pain requiring red flag exclusion Psycho-social screening for; mental health issues, catastrophizing, anxiety, upcoming competition & / or life stressors.	Re-assess findings from initial triage including; sitting tolerance, lumbar range of motion & ability to complete activities of daily living (ADL). Assess rowing specific ranges; specifically hip flexion & hamstring length, as they affect how the pelvis & lumbar spine move in the boat. Improvement in the motion of the pelvis & hips is desirable.	Assess rower's ability to move through rowing specific movement & ability to tolerate spinal load. If have not yet rowed, trial erg row &/or short duration on-water row with assessment before & after. Response to on-water training should be continually assessed. Coach or medical staff should ensure rower's stroke pattern consists of appropriate pelvic motion & limits excessive low back motion.	Ensure the rower is confident in their ability to progress. Objective markers in initial triage assessed for signs of resolution; pain should be absent during ADL & cross training. Rowers should be able to row with usual power & tolerate changes in; water conditions, rowing rate & seating in boat. Rowing stroke pattern should be monitored during water or erg sessions that induce high levels of fatigue.
MANAGEMENT	Restore function in ADL with early & effective pain relief. Manual therapies may assist. Avoid aggravating activities. Red flags include changes in; sensation or motor control, bladder or bowel function OR systemic signs of illness such as weight loss, night pain & sweats. Referral to medical specialist required. Refer to Psychologists if there is a regular person the rower sees / specific need identified.	Control of pain with activity modification +/- medication (prescribed under International Olympic Committee & World Anti-Doping Agency guidelines) +/- manual therapies. Restore movement via rowing specific exercises & progress towards spinal load requirements. Poor sleep, performance pressure, fear avoidance behaviour & life stressors signal consideration for support on an individual basis.	Rowers should be active participants in their recovery. It is important for the rower to avoid developing a fear of specific movement patterns, a cognitive functional therapy approach or a confidence with movement approach can be helpful. Splinting or overprotective movements should be discouraged. If a rower is finding it difficult to cope or if they have already accessed psychological services, this should be encouraged & continued.	Emphasis placed on restoring usual rowing biomechanics & addressing modifiable risk factors that can prevent reoccurrence. Continue to support self-management, the rower should be seen less for specific interventions such as manual therapies or ongoing use of medication. Do not progress to this stage if red flags identified. Yellow flags include recurrent history of failing to progress or symptoms in excess of presentation; progress slowly & with care.
EXERCISE & TRAINING	Avoid complete rest. If rowing aggravates; stop on-water & rowing ergometer (erg) training. If can sit without pain; start short duration stationary bike. If sitting is painful prescribe walking; duration & including hills or steps is dependent on symptoms. If rower is able to row on-water or erg without pain or muscles guarding, they should be encouraged to do so.	Focus on what the rower CAN DO to maintain fitness but not exacerbate LBP. Continuation or graduation of a cardiovascular cross-training program within limits of the pain. If the rower tolerates sitting, stationary bike used. As sitting tolerance increases, a trial erg row can commence & then progression to a short duration on-water row of less than 10km. If sitting is not tolerated, use of an elliptical trainer, swimming or walking should be encouraged.	If not able to row; continue cross-training with increasing duration & intensity. Can use; stationary bike, elliptical trainer, ski erg & walking including up hills & stairs. Consider swimming but gradually increase to avoid shoulder pain. Modality is dependent on symptoms & access. Return to rowing program should be agreed on by medical staff, rower & coach. Intensity & volume increase, building on-water rowing before erg unless rough water prevents this. Consider boat type when prescribing training: 8-10km x1 ≠ 8+. Rower can continue to use cross-training to 'top-up' training load. The planned & completed training load should be monitored. Clinicians & strength & conditioning (S&C) coaches should work together to formulate exercises individual to the rower that address rowing specific ROM, trunk strengthening & movement deficits.	Return to full training should planned with increasing on-water distance & intensity as well as progressive increase in erg +/- S&C & cross-training. This should be individually tailored. As rower approaches return to full on-water training a reduction in cross-training occurs as part of overall load management. A strength & mobility program that addresses modifiable risk factors for LBP should continue to ensure change is made & may be prescribed for long term maintenance. Medical and coaching staff should work together to ensure the rehabilitation program translates into technical changes to protect from further injury. S&C training should initially avoid high loads, progressive increases towards usual training can occur, monitoring response. Medical & coaching staff should continue to work with the rower to achieve this.
EDUCATION	Provide injury education, alleviate fears & include the rower in initial planning. Manage coach & the rower's expectations. Involve coach from outset & allow them to contribute ideas about injury occurred.	Involve the rower in planning & educate about the multi-dimensional nature of LBP including contributors to onset & persistence of pain. Support may come from coaching staff, medical staff, family & friends or psychology.	The rower & coach should have a thorough understanding of what symptoms can be tolerated when returning to training. A rower should have; no / low levels of pain during rowing, pain not getting increasingly worse when rowing & no pain immediately after rowing. Continue to reassure & educate the rower & coach.	An athlete centred & coach supported approach should be encouraged. Empower the rower to self-manage, have input into the plan & follow the plan with the support of the medical staff & coaching team around them.

	Coaches & medical staff should encourage rowers to seek assessment of Low Back Pain (LBP) early. Delaying this can prolong recovery.	Assessment & management by a Medical Doctor & Physiotherapist experienced in managing rowing-related LBP is ideal.	Episodes of rowing-related LBP are most often not serious, they are self-limiting & early management will educate the rower about severity & recovery.	Many factors contribute to a presentation of rowing-related LBP, these include; physical, biological, social & psychological –they all need to be managed.
	First presentation to medical staff	First week of presentation	SUB-ACUTE – return to rowing	REHABILITATION – return to full training
EXAMINATION	Establish type of LBP presentation; Typical for rowers Nerve involvement Inflammatory component Pain requiring further examination for diagnosis Screening for; mental health issues, catastrophizing, anxiety, upcoming competition & / or life stressors.	Re-assess findings from first presentation including; sitting tolerance, low back range of motion & ability to complete activities of daily living (ADL). Assess rowing specific ranges; specifically hip flexion & hamstring length, as they affect how the pelvis & low back moves in the boat. Improvement in the motion of the pelvis & hips is desirable.	Assess rower's ability to move through rowing specific movement & ability to tolerate spinal load. If they have not yet rowed, trial erg row &/or short duration on-water row with assessment before & after. Response to on-water training should be continually assessed. The coach or medical staff should ensure the rower's stroke pattern consists of suitable pelvic motion & limits excessive low back motion.	Ensure the rower is confident in their ability to progress. Objective markers in initial triage assessed for signs of resolution; pain should be absent during ADL & cross training. Rowers should be able to row with usual power & tolerate changes in; water conditions, rowing rate & seating in boat. Rowing stroke pattern should be monitored during water or erg sessions that induce high levels of fatigue.
MANAGEMENT	Restore function in ADL with early & effective pain relief. Manual therapies may assist. Avoid aggravating activities. Be aware of changes to; sensation or muscle power, bladder or bowel function OR signs of illness such as weight loss, night pain & sweats. Referral to medical specialist required. Refer to Psychologists if there is a regular person the rower sees / specific need identified.	Control of pain with activity modification +/- medication (prescribed under International Olympic Committee & World Anti-Doping Agency guidelines) +/- manual therapies. Restore movement via rowing specific exercises & progress towards spinal load requirements. Poor sleep, performance pressure, fear avoidance behaviour & life stressors signal consideration for support on an individual basis.	Rowers should be active participants in their recovery. It is important for the rower to avoid developing a fear of specific movement patterns, a functional movement approach with awareness or a confidence with movement approach can be helpful. Splinting or overprotective movements should be discouraged. If a rower is finding it difficult to cope or if they have already accessed psychological services, this should be encouraged & continued.	Emphasis placed on restoring usual rowing biomechanics & addressing modifiable risk factors that can prevent reoccurrence. Continue to support self-management, the rower should be seen less for specific interventions such as manual therapies or ongoing use of medication. Do not progress to this stage if red flags identified. Yellow flags include recurrent history of failing to progress or symptoms in excess of presentation; progress slowly & with care.
EXERCISE & TRAINING	Avoid complete rest. If rowing aggravates; stop on-water & rowing ergometer (erg) training. If the rower can sit without pain; start short duration stationary bike. If sitting is painful prescribe walking; duration & including hills or steps is dependent on symptoms. If the rower is able to row on-water or erg without pain or muscles guarding, they should be encouraged to do so.	Focus on what the rower CAN DO to maintain fitness but not exacerbate LBP. Continuation or graduation of a cardiovascular cross-training program within limits of the pain. If the rower tolerates sitting, stationary bike used. As sitting tolerance increases, a trial erg row can commence & then progression to a short duration on-water row of less than 10km. If sitting is not tolerated, use of an elliptical trainer, swimming or walking should be encouraged.	If not able to row; continue cross-training with increasing duration & intensity. The rower can use; the stationary bike, elliptical trainer, ski erg & walking including up hills & stairs. Consider swimming but gradually increase to avoid shoulder pain. Modality used is dependent on symptoms & access. Return to rowing program should be agreed on by medical staff, rower & coach. Intensity & volume increase, building on-water rowing before erg unless rough water prevents this. Consider boat type when prescribing training: 8-10km x1 ≠ 8+. Rower can continue to use cross-training to 'top-up' training load. The planned & completed training load should be monitored. Clinicians & strength & conditioning (S&C) coaches should work together to formulate exercises individual to the rower that address rowing specific ROM, trunk strengthening & movement deficits.	Return to full training should planned with increasing on-water distance & intensity as well as progressive increase in erg +/- S&C & cross-training. This should be individually tailored. As rower approaches return to full on-water training a reduction in cross-training occurs as part of overall load management. A strength & mobility program that addresses modifiable risk factors for LBP should continue to ensure change is made & may be prescribed for long term maintenance. Medical and coaching staff should work together to ensure the rehabilitation program translates into technical changes to protect from further injury. S&C training should initially avoid high loads, progressive increases towards usual training can occur, monitoring response. Medical & coaching staff should continue to work with the rower to achieve this.
EDUCATION	Provide injury education, alleviate fears & include the rower in initial planning. Manage coach & the rower's expectations. Involve coach from outset & allow them to contribute ideas about how injury occurred.	Involve the rower in planning & educate about the multi-dimensional nature of LBP including contributors to onset & persistence of pain. Support may come from coaching staff, medical staff, family & friends or psychology.	The rower & coach should have a thorough understanding of what symptoms can be tolerated when returning to training. A rower should have; no / low levels of pain during rowing, pain not getting increasingly worse when rowing & no pain immediately after rowing. Continue to reassure & educate the rower & coach.	An athlete centred & coach supported approach should be encouraged. Empower the rower to self-manage, have input into the plan & follow the plan with the support of the medical staff & coaching team around them.

Figure 2A: Acute episode of rowing-related low back pain: progression through phases from initial presentation to full return to sport



Guide for managing low back pain in rowers

What is rowing-related low back pain (LBP) and how common is it?

Pain in your low back (formally defined as the region between the bottom of the rib cage and buttock creases) can arise from several different known or unknown sources, abnormalities or diseases. Some people can have pain in one or both legs, and may also have symptoms such as tingling, weakness or numbness in one or both legs. We can never be sure that LBP was actually caused by rowing, but for the purposes of this document, ***rowing-related low back pain*** is pain that affects a rowing athlete, first started during or is aggravated by rowing or associated training, and results in a need to change or stop scheduled rowing-related activities.

The best research suggests that around 2 out of every 3 adult rowers will have low back pain in a 12-month period, compared with 1 out of every 3 people in the community (non-rowers). Low back pain is common in rowers, and we will call it **'back pain'** through the rest of this document.

What increases the risk of a rower experiencing back pain?

Once a rower has had back pain, they are at an increased risk of getting it again. A rapid increase in training volume or number of competitions, such as a change from head racing to the sprint season, is associated with more reports of back pain. Higher volumes of training overall, and more years of being a rower increase the risk of developing back pain. Doing large volumes of ergometer training, particularly sessions of more than 30 minutes without a break, are associated with an increased risk of back pain. Fatigue and poor technique during rowing contribute to more spine flexion and less hip movement during the rowing stroke. These changes in body position may be exaggerated during ergometer rowing, which may be why ergometer training increases the risk for back pain.

The range of a rower's hip flexion should be at least 130 degrees, knee range of motion should be full, the hamstrings should have good flexibility and the muscles of the trunk should have good endurance, particularly in the back and buttock muscles (posterior chain) to reduce the risk of back pain. We also know that non-physical factors such as psychological stress can contribute to risk.

What you can do to prevent back pain

It is very difficult to completely prevent back pain. Many rowers will experience back pain at some time during their rowing career. We know that for most rowers, their back pain is not serious, and that they will recover well. It is important to prevent a serious episode of pain or

one that causes persistent pain. Preventing back pain can be complex because there can be many reasons, other than rowing, that might increase the risk of developing back pain. Understanding the problem, responding to an episode early by modifying training, and accessing good treatment are likely to help.

There is no one proven way to prevent back pain in rowers. However, some studies have compared rowers with back pain and those without, and found that there was a difference in technique, especially when rowers were fatigued. Rowers who have had back pain before are more likely to flex their lower back (not keeping their pelvis upright, sitting up on their 'sit-bones') as they row, and don't move as well through their hips while keeping a flat and vertical lower back.

Training should focus on dynamic trunk exercises to improve endurance of the posterior chain. Static exercises such as 'planks' are unlikely to help. We don't know if good endurance in trunk muscles will protect you from back pain, but it is likely that good trunk muscle endurance will help maintain good rowing technique.

What you should do if you start to feel back pain from rowing

If you feel pain in your back that is stopping you from completing your normal training, do try not to worry and do share this information with someone you trust such as your physiotherapist or doctor. The good news is that there are effective ways of managing back pain. If you feel that your pain is not likely to settle quickly, involving others such as your team's support staff and coach may be important to make sure you have an appropriate training and management plan in place.

Some rowers might conceal their back pain from teammates or coaches for fear of being regarded as 'weak' or risking exclusion from selection. Coaches can do their part to encourage rowers to be forthcoming about back pain—addressing your back pain early (early management) is likely to result in a better outcome. Training and competing with back pain makes it more difficult to perform well. Coaches must ensure a supportive environment where rowers can be honest about their back pain without fear of judgement.

What you should expect from a good LBP management programme

Once you have informed your coach and either (temporarily) stopped or modified your training, we suggest that you follow the advice given in Table 3A. The flow chart will help you and your coach know when you are ready to progress to each stage of rehabilitation. We recommend you and your coach collaborate with a healthcare provider to progress your rehabilitation because the healthcare provider has specialist skills in rehabilitation, including tests to know when your body is ready to tolerate more load (Fig 2A).

The people helping you manage your back pain (healthcare providers and coaches) should work together with you to create goals that are important to you. Consider focusing your goals on what you need to do to (i) reduce and manage your pain, (ii) improve your function and quality of life, and (iii) returning to full training and competition.

You should expect to modify your training load and be guided to learn the tools you need to manage your back pain and training yourself. Your physical conditioning (your training programme) should be assessed and modified to allow you to keep fit. The way in which you row on the ergometer and on the water should be assessed and modified if needed to address any technique issues that could predispose you to back pain.

You might also like to think about the best way for you to manage your stress levels, sleep quality and social circumstances, as well as general health because these factors can affect your risk of developing back pain and your ability to recover from back pain. A healthcare provider can help you design the best management plan for you and will help direct you to other healthcare providers (e.g. psychologist) as needed for the best support.