

Systematic development of an injury and illness prevention programme for athletes with a physical impairment: the TIPAS study

Sietske C M Luijten ^{1,2}, Joske Nauta ^{1,2}, Thomas Janssen,^{2,3,4}
Jasmijn Holla,^{2,4,5} Simone C N Jenniskens,^{1,2} Evert Verhagen ^{1,2}

To cite: Luijten SCM, Nauta J, Janssen T, *et al.* Systematic development of an injury and illness prevention programme for athletes with a physical impairment: the TIPAS study. *BMJ Open Sport & Exercise Medicine* 2024;**10**:e001945. doi:10.1136/bmjsem-2024-001945

► Additional supplemental material is published online only. To view, please visit the journal online (<https://doi.org/10.1136/bmjsem-2024-001945>).

Accepted 14 July 2024

ABSTRACT

Background/aim The participation of individuals with physical impairment in sports has numerous benefits, yet there is also the risk of sustaining sport-related injuries or illnesses. Therefore, prevention programmes of these problems are needed to ensure that individuals can maintain a healthy, active lifestyle. Currently, very few prevention interventions are accessible for these athletes. Therefore, the article aims to describe the development process of the Tailored Injury Prevention in Adapted Sports intervention, an online tailored injury and illness prevention intervention for athletes with a physical impairment.

Methods The development was guided by the Knowledge Transfer Scheme (KTS).

Results In the first step, a cohort study and a qualitative study were conducted to define the problem statement. In the second step, a systematic review was performed in order to learn from theory. Steps 3 and 4 involved an iterative process involving collaboration with diverse expert groups. This included defining athletes' needs and creating a health problem blueprint, after which the intervention content was created. To ensure accuracy and completeness, a feedback loop was incorporated. In the final phase of this step, we refined the language used within the intervention together with athletes. Finally, an effect and process evaluation will take place in the last step of the KTS.

Conclusions Through a five-step approach of the KTS, we developed an online injury and illness prevention intervention for athletes with a physical impairment. This intervention provides direct, timely feedback based on their current health status. Furthermore, it takes the sport and the physical impairment of the athletes into account with regard to the given prevention advices.

INTRODUCTION

Multiple studies have identified participation in sports for individuals with a physical impairment to positively impact self-esteem, physical well-being, sense of belonging and freedom and a high quality of life.^{1–6} However, sports participation can also have negative consequences, namely the risk of sustaining sport-related health problems, such as

WHAT IS ALREADY KNOWN ON THIS TOPIC

- ⇒ Participation in sports for individuals with physical impairments have a positive impact on various social, mental and physical variables.
- ⇒ The burden of sport-related injuries and illnesses is notably high in this population, partly due to the existing impairment.
- ⇒ Accessible prevention interventions for these athletes are currently limited.

WHAT THIS STUDY ADDS

- ⇒ Prevention interventions in adapted sports should be tailored to the type of sports and physical impairments of the athletes.
- ⇒ An online health monitoring system could form the foundation for an intervention aiming at providing timely, tailored prevention advices.
- ⇒ Involvement of athletes and healthcare professionals in cocreation bridges the gap between research and practice, facilitating the development of interventions that align with athletes' needs and contextual factors.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

- ⇒ If proven effective, the Tailored Injury Prevention in Adapted Sports tool could be an accessible way to provide athletes with timely, tailored preventive advices to prevent sport-related health problems and enable long-term participation in sports.

injuries and illnesses.^{7 8} These health problems may affect not only their participation in sport, but also in daily life activities. Especially those of athletes with physical impairments, because they add to existing limitations due to their disability.^{9–11} For instance, if an athlete with a spinal cord injury sustains shoulder or respiratory problems, this impacts not only sporting activities but also daily life tasks, social activities, work or school. This could result in a decline in an individual's willingness to participate in sports.^{12 13} Therefore, it is important to prevent sport-related injuries



© Author(s) (or their employer(s)) 2024. Re-use permitted under CC BY-NC. No commercial re-use. See rights and permissions. Published by BMJ.

For numbered affiliations see end of article.

Correspondence to

Sietske C M Luijten;
s.luijten@amsterdamumc.nl

and illnesses to ensure that individuals with physical impairment can maintain a healthy, active lifestyle and continue their long-term involvement in sports.

Due to the heterogeneity of athletes with physical impairment, the ‘one-size-fits-all’ strategy frequently used in sports injury prevention is not suitable. This heterogeneity is visible in, for instance, the classification efforts needed for competition events.^{14 15} This shows the complexity of the adapted sports community, given the participating athletes’ various sports and physical impairments. This is probably a major reason for the scarcity of programmes designed to reduce injuries among these specific athletes, which leads to limited knowledge regarding effective injury prevention strategies.^{7 8} A reported potentially effective strategy is health monitoring in adapted sports, which can improve athletes’ health literacy and prevent sport-related health problems.¹⁶ Providing prevention advice based on the health status report might be an interesting approach for this heterogeneous athlete population to increase the benefits of this health monitoring approach. A key component, however, is that such an approach should consider the unique context and needs of the athletes and, therefore, preferably employ an individualistic approach.^{17–19}

In the Netherlands, the above-mentioned novel individualistic approach has been developed to provide timely, tailored injury prevention advice for athletes with a physical impairment, hereafter referred to as ‘athletes’. The development of this intervention, called the TIPAS intervention (Tailored Injury Prevention in Adapted Sports), was guided by the Knowledge Transfer Scheme (KTS), which serves as a bridge between scientific research and practical application.²⁰ The KTS is a framework developed to ensure that the development of a sports injury prevention programme is systematically built on knowledge from both theory and practice. The current paper aims to describe the systematic development of the TIPAS intervention using the KTS framework.

DEVELOPMENT OF THE TIPAS INTERVENTION

The five steps of the KTS²⁰ have been defined as follows: (1) describing the problem as encountered in practice; (2) gathering all available evidence relevant to the problem; (3) engaging with representatives from practice, often practitioners or experts in the area, to discuss the completeness of the evidence; (4) developing the intervention and (5) evaluating the effectiveness and (development) process of the intervention.²⁰ This evaluation aims to understand the impact of the intervention and any areas for improvement. A schematic overview of the KTS steps taken in developing TIPAS is presented in [figure 1](#). Patients or the public, namely athletes, healthcare professionals and researchers, were involved in the design and conduct of our research.

Step 1: problem statement

To assess the sport-related health problem in our athletes, we conducted a prospective cohort and qualitative study

in the Netherlands.^{21 22} First, we conducted a prospective cohort study during one sporting season period (40 weeks) to describe the injury and illness problems of athletes with physical impairment in the Netherlands. Our main aim was to describe the prevalence, magnitude, severity and burden of sport-related health problems in athletes with a physical impairment.²¹ The results demonstrate a high weekly prevalence of health problems and differences in injury severity among different impairment categories and sports levels. This study yielded a few key take home messages, as is presented in [table 1](#).

Second, we conducted a qualitative study with athletes and healthcare professionals to better understand the ‘injury and illness problem’ in context. The main aim was to understand the perspectives of athletes and healthcare professionals regarding injuries, risk factors, preventive strategies and treatment of sport-related health problems ([table 1](#)—online supplemental appendix 3).²²

Step 2: evidence synthesis and description

In the second step of the project, we aimed to describe all available evidence on injury prevention in athletes with a physical impairment. We conducted a systematic review to provide a comprehensive overview of the literature on sports-related health problems, their aetiology, preventive measures and their efficacy in reducing injury prevalence in para sports ([table 1](#)).^{8 17 23} This overview complements the overview of sports-related health problems in adapted sports in the Netherlands of step 1, which forms the base of the ‘problem statement’ required for this approach.

Steps 3 and 4: knowledge transfer group and intervention development

The third step of the KTS is to translate the theoretical and descriptive information gathered in the first two steps into practice by establishing knowledge transfer groups (KTGs).²⁰ The fourth step of the KTS focusses on the development of the intervention and aims to describe the goal of the intervention, the target groups and the context surrounding the intervention based on all the knowledge gathered in the first three steps. Due to the iterative process of multiple KTGs during the development of the TIPAS intervention, we will describe steps 3 and 4 together through phases, ending with a description of the intervention.

Phase 1: what are the needs of the athletes?

Following the first two steps of the KTS, a concept for the TIPAS intervention was developed based on a previously proven effective intervention for athletes without impairments.¹⁹ Hespanhol *et al* showed that providing direct feedback based on runners’ health status, measured by the Oslo Sports Trauma Research Centre (OSTRC) questionnaire on health problems,²⁴ was an easy and effective way to reduce injuries.¹⁹ The TIPAS intervention will follow this concept of providing direct feedback based on self-reported health status tracking and adding personalisation based on individual

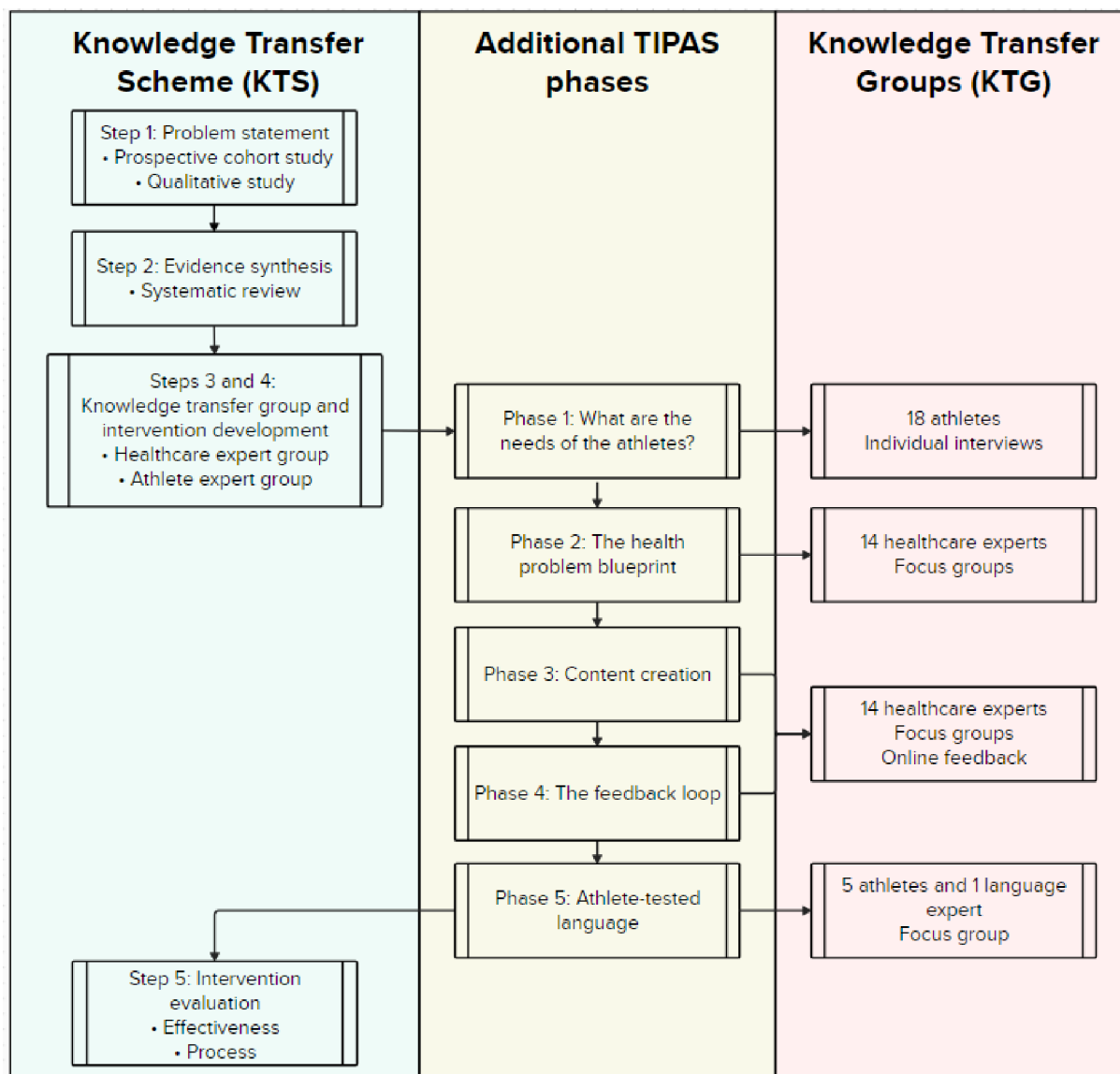


Figure 1 Flow chart of the development process of the TIPAS intervention following the five steps of the Knowledge Transfer Scheme with the additional TIPAS phases. TIPAS, Tailored Injury Prevention in Adapted Sports.

differences between athletes. The first KTG, involving athletes, was established to evaluate this intervention's feasibility, attractiveness, facilitators and barriers. During this phase, we interviewed athletes individually to gather their perspectives on direct, timely, tailored online preventive advices. To reduce the burden on the athletes, these questions were incorporated into the interviews performed in step 1 (online supplemental appendix 3).²² The interviewers explained the TIPAS concept shortly, emphasising how the athletes would gain automatic feedback based on self-reported sport-related health problems measured by a weekly survey. No examples were initially given to ensure that the athletes could express their ideas and thoughts on the TIPAS concept without being guided in a specific direction by the interviewer. If the concepts were unclear, the interviewer would provide an example. The example contained a story about an athlete whom reported a

blister. Based on that report, the athlete would receive direct information about how to treat the blister, prevent it from getting worse and prevent it from happening again. Generally, athletes were interested in the concept of an online injury prevention tool and highlighted the accessibility, support and information it could provide them. Most athletes were interested in more information regarding specific sports and daily life-specific advices to prevent sport-related health problems. However, we also identified some barriers, such as the concern that the injury prevention tool could not be sufficiently personalised to individual needs, making it unappealing to some. The athletes emphasised their unique contexts (due to different physical impairments, sports and daily living characteristics), which would make it challenging to tailor the intervention to each athlete. Furthermore, the athletes mentioned that an online tool would probably be most beneficial for recreational level athletes

Table 1 Key take home messages from the prospective cohort study, qualitative study and systematic review of steps 1 and 2 with regard to the development of an injury and illness prevention intervention for athletes with physical impairments.

Cohort study (step 1)	The differences between the physical impairment categories underline the need for impairment-specific prevention strategies.
	Although physical impairments have been broadly classified into five categories, recognising the differences between these groups provides an initial possibility to tailor injury prevention strategies to specific subgroups. This precedes further exploration and refinement within each category.
	The differences between the levels of sports, namely, recreational, nationally competitive and internationally competitive, show that the level and experience of the athletes should be taken into account when developing injury and illness prevention strategies.
Qualitative study (step 1)	Medical professionals frequently referred to pain as an indication of an injury, but not all athletes agreed. Athletes report that pain is not an injury, but if you have an injury, you could experience pain.
	Athletes often mention sports and daily life restrictions as identifiers of an injury.
	When developing or implementing future prevention and rehabilitation programmes, it is crucial to take into account the similarities and discrepancies in perspectives between athletes with physical impairment and healthcare professionals to enhance understanding and therefore adherence to programmes.
Systematic review (step 2)	The overview shows a wide spectrum of reported sport-related health problems in para sports, partly due to the variety of health problem definitions.
	There is conflicting information concerning the reported risk factors.
	Little research has been conducted on developing and evaluating prevention strategies for para athletes.

since most elite level athletes already have access to medical support teams.

Phase 2: the health problem blueprint

After SCML and SCNJ combined the information gathered in steps one and two, and the interviews at the beginning of step 3, a comprehensive overview was created encompassing the target population, sport-related health problems, potential risk factors and the intervention's

conceptual framework. The second KTG was established, consisting of 14 medical healthcare experts with different fields of expertise (eg, physical therapists, sports physicians and rehabilitation physicians). The healthcare experts were recruited using snowball sampling facilitated by the research team through email, face-to-face interactions or phone calls. Eligible professionals were those aged 18 or older with self-reported experience in sports injury prevention and treatment.

Workshops were organised with these healthcare experts to discuss the thoroughness and completeness of the overview. These discussions ensured that all aspects of sport-related health problems faced by athletes were represented. Through these discussions and the subsequent incorporation of additional information, a consensus was reached that the overview of sport-related health problems of athletes was complete at this stage of intervention development.

Phase 3: content creation

The focus of the discussion moved on to the specifics of the intervention content. Based on the results of the cohort study, the systematic review and the experience and knowledge of the KTG of phase 2, it was evident that the intervention should be tailored to the physical impairment of the athlete. Due to the type of physical impairments of the athletes participating in the prospective cohort study and based on the para sport translation of the International Olympic Committee (IOC) consensus statement on reporting and recording epidemiological data,²⁵ five categories were deemed sufficient at this stage. The five physical impairment categories are as follows: spinal cord-related disorder, brain disorder, neuromuscular disorder, limb deficiency and impaired passive range of motion.

Furthermore, the established KTGs of phase 2 discussed the importance of tailoring the intervention to the type of sports the athlete plays. A fundamental distinction was made between seated and non-seated sports as this distinction significantly influences the load on the athlete's body during sports and daily life activities, necessitating different prevention strategies.

Finally, the level of sports was discussed with this expert KTG and deemed not urgently important to consider at this stage. They based their conclusion on feedback from athletes and healthcare experts, who suggested that recreational athletes would likely benefit more from an online intervention. Furthermore, the medical experts in the KTG argued that athletes at all levels could use the intervention, provided they found it relevant and useful. This advice was based on the finding that the type of health problems did not differ between recreational-level and competitive-level athletes, only the prevalence and severity of these health problems differed.

Phase 4: the feedback loop

Following the workshop discussions in phase 3, the gathered and discussed information was integrated into the

first concept version of the intervention. For this concept, a decision tree was developed based on the potential answers of athletes on the OSTRC questionnaire (see 'summary TIPAS intervention').^{24 26} The draft was emailed to all medical stakeholders from the different fields of expertise to ensure accuracy and relevance and to check if the information provided during the workshops was interpreted correctly. Feedback was provided by 14 healthcare experts via email. This collaborative and iterative process of receiving and incorporating feedback refined the intervention. All feedback was carefully considered and incorporated, leading to the TIPAS intervention's final version, described below.

Phase 5: athlete-tested language

Finally, a third KTG, consisting of athletes, was established, and an online workshop was organised to discuss how to structure the intervention and phrase the preventive advice it would offer. Nineteen athletes, selected based on representing the various sports and physical impairments participating in the prospective cohort study of step 1, were invited through email to participate in the session. A 'quiz' was made to stimulate an engaging discussion, presenting multiple options for phrasing each preventive advice. After choosing their favourite phrasing option, athletes were invited to engage in a discussion about their choices. This method encouraged athletes to articulate their preferences and reasons, providing insights into how the intervention's content should be communicated. The discussion was audio recorded and informally analysed to determine the key messages from the athletes. The main take-home message from these athletes was that the preventive advice should be formulated in a clear, direct and understandable way without unnecessary text. The main take-home message, the answers to the quiz (a questionnaire with ten questions, each with two or three response options) and the open discussion were used as input. The input was used to draft a final version of the intervention. This version was sent to a language expert to ensure all information provided was phrased correctly.

Summary TIPAS intervention

The TIPAS intervention provides online tailored sport-related health problem prevention advice to athletes with a physical impairment (figure 2). The TIPAS intervention targets adult athletes of all levels who participate in (non-)regulated sports at least once a week. The TIPAS intervention is focused on recreational athletes, but is available by athletes across all levels. The TIPAS intervention provides insight into the self-reported health status of the athlete and translates this into personalised prevention advice (online supplemental appendix 1).^{19 24 26 27} Each week, the athlete completes the Dutch translation of the OSTRC questionnaire, which was previously used and adapted for this target population.^{21 26 27} The TIPAS intervention is distributed via the online survey platform Survalyzer.²⁸ After completing the survey, the athlete receives automatically generated tailored prevention advice in the same online environment after the last question. This prevention advice is based on the type of physical impairment and the nature of the athlete's sport. The advice can be grouped into three main categories: (1) If the athlete does not report any health complaint, the TIPAS intervention generates prevention advice to prevent the onset of health problems. (2) If the athlete reports a minor health complaint, the advice generated is focused on preventing the complaint from worsening and the management options. (3) If a severe health problem is reported by the athlete, the TIPAS intervention provides the advice to seek medical attention and information on where to find appropriate medical assistance. The severity of the self-reported health problem is based on the answers to questions 2 and 3 of the OSTRC questionnaire, where a distinction between substantial and non-substantial health problems can be made.²⁷

Step 5: intervention evaluation

The final step of the KTS focuses on the evaluation of the designed measure. Currently, we are conducting a randomised controlled trial (RCT) to evaluate the effectiveness and process of the TIPAS intervention. Originally, the KTS describes that the evaluation could be limited to a process evaluation when an intervention

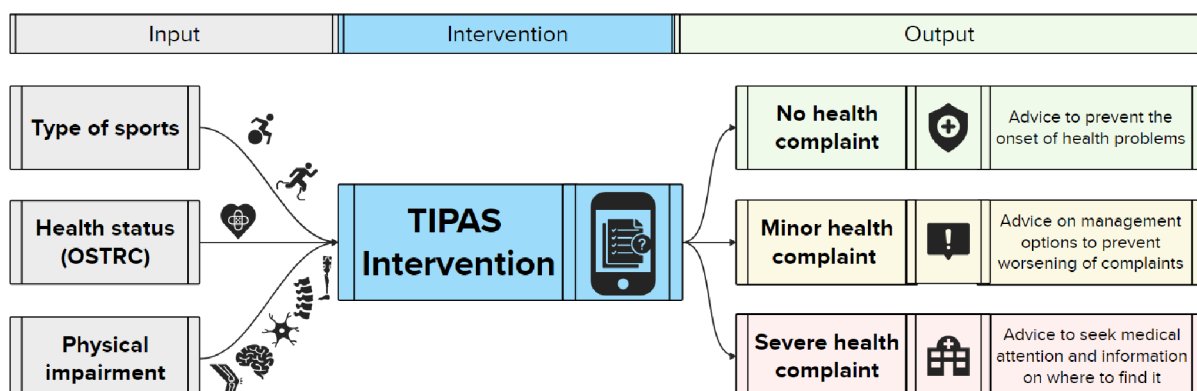


Figure 2 Visualisation of the TIPAS intervention. TIPAS, Tailored Injury Prevention in Adapted Sports.

is based on evidence.²⁰ However, in our case, due to the lack of quality evidence on the effectiveness of our intervention components for our target group, we decided to conduct an effectiveness study and a process evaluation in this final step.^{8 20}

In the RCT, we are collecting information on the health complaints of the users of the TIPAS intervention during one sport season. The effectiveness will be determined based on changes in reported sport-related health problems over time based on the OSTRC questionnaire outcomes.^{21 24 27} Additionally, we will take the severity of the health problems into account.

The process evaluation is based on the Medical Research Council (MRC) framework of process evaluation of complex interventions, focussing on implementation, mechanisms and context throughout the various phases the participant went through during the intervention.²⁹ These phases are an evaluation of the inclusion of participants, the intervention period and the period following the intervention leading to the implementation of the intervention. During the intervention period, data will be gathered on intervention acceptability, fidelity, barriers of use and user experience through semistructured interviews. Furthermore, a change in preventive behaviour will be measured using a baseline questionnaire and a 3 month, 6 month and 9 month follow-up questionnaire regarding preventive behaviour and athletes' perspectives regarding beliefs, knowledge, skills, beliefs about consequences, goals, optimism and social influences regarding injury prevention.¹⁹ A matrix with the components of the process evaluation and the corresponding data sources are provided in online supplemental appendix 2.

DISCUSSION

The TIPAS intervention aims to provide direct, timely and tailored injury and illness prevention advice to athletes with a physical impairment. Guided by the KTS, we developed this intervention using input from a prospective cohort study, a systematic review, interviews, and workshops.

The relative lack of research on sports-related health problems in athletes with physical impairments⁸ and the need for a prevention programme has led to the development of the TIPAS intervention, which is largely based on an established intervention for athletes without impairments.¹⁹ This approach hinges on the fundamental concept of health monitoring, which has demonstrated effectiveness in adapted sports contexts.^{16 19} Given the lack of interventions in adapted sports, the primary objective of the TIPAS project is to determine the effectiveness of that concept within this specific population.

With this concept in mind, we developed the TIPAS intervention that considers the current health status, five physical impairment categories and two sports categories. This categorisation was intentionally kept minimalistic in this first stage of development. This decision was influenced by the lack of evidence that further division of the physical impairment or sports categories

would result in a more effective prevention intervention.^{7 8 21 22 30} Furthermore, this decision was influenced by pragmatic reasons, given the complexity of this athlete population. This resulted in a tool that is only minimally tailored to the context of the athlete, making it easier to implement but perhaps also less effective for the athlete. Furthermore, as expressed in steps 3 and 4, during the development of this intervention, we focused mainly on athletes of recreational level, even though the intervention is also usable for athletes of competitive level. Due to the ever-changing and context-dependent environment regarding injury prevention, the focus of the evaluation will, besides an effectiveness evaluation, be on process outcomes to determine which factors contribute to a successful implementation of this new concept and which factors need attention before implementation.³¹⁻³³

Given the unique heterogeneous contexts of the athletes, the intervention can be further developed and tailored to the athletes' needs after evaluating the process and effectiveness of this first round of development.^{8 16-18} For instance, if the tool also needs to consider the sport level, the various adaptive equipment the athletes can use, or if more sports and impairment categories are needed to further tailor the tool to the contexts and needs of the athletes.⁸ After the evaluation, we can determine if it can be used without interaction with professionals, such as coaches or healthcare experts, or if it should be used as a supplementary tool by professionals.

The development process of the TIPAS intervention is strengthened by using the KTS framework, which provided a structured approach for gathering and combining theoretical, scientific and practice-based knowledge.^{31 34} Especially with the heterogeneous target group and the various involved stakeholders, the KTS helped to structure and guide the development process so no voices went unheard. By incorporating the various feedback stages of all stakeholders, we believe that all perspectives are taken into account. By engaging end-users and other stakeholders from the outset, the TIPAS intervention is more likely to align with its target audience's real-world needs and conditions.²⁰

The engagement of end-users across all stages of the systematic development of an injury prevention programme has gained in popularity over the recent years.³⁵⁻³⁷ To the best of our knowledge, the TIPAS intervention is the first intervention focussing on adapted sports. If proven to be effective, this intervention shows the possibilities of directly involving athletes with an impairment in the systematic development of an intervention, ensuring that the intervention meets their needs. Furthermore, if proven effective, this systematic development process could be used to guide further tailoring of the TIPAS intervention for athletes with a physical impairment, or even to broaden the target group to ensure that all athletes, regardless of type of impairment, could participate in sports in a safe and healthy way.

Regarding the process evaluation in step five, the KTS suggests using a framework, such as the RE-AIM (RE-AIM,

Reach, Effectiveness, Adoption, Implementation and Maintenance) framework.²⁰ We decided to use the MRC framework to guide our process evaluation.²⁹ Due to the strong emphasis of the MRC framework regarding the context in which the intervention is implemented and the focus on understanding the intervention's mechanisms, fidelity and contextual factors, we determined this framework will help us understand not just whether the intervention works but how and in what contexts it is most effective. This approach is required for complex interventions, where the interaction between the intervention and this complex environment can significantly influence outcomes.³⁸ The choice of framework thus aligns to ensure that the TIPAS intervention is effective, adaptable and relevant to the specific settings in which it will be implemented.

CONCLUSION

The development of the TIPAS intervention represents a significant step forward in creating tailored injury and illness prevention advice for athletes with physical impairments. The iterative process between key stages of the KTS and the active involvement of a variety of stakeholders has been crucial in aligning the intervention with the real-world needs and contexts of athletes. While the decision to employ a minimalistic categorisation approach and focus mainly on recreational athletes may raise questions about the intervention's broader applicability, these choices also reflect a pragmatic approach to addressing the diverse needs of the adapted sports community. The TIPAS intervention, therefore, stands as a promising model for injury prevention in adapted sports, with its success contingent on ongoing evaluation, refinement and responsiveness to the evolving needs of its target population.

Author affiliations

¹Amsterdam Collaboration on Health & Safety in Sports, Department of Public and Occupational Health, Amsterdam UMC Locatie VUmc, Amsterdam, The Netherlands

²Amsterdam Institute of Sport Science, Amsterdam, The Netherlands

³Department of Human Movement Sciences, Vrije Universiteit Amsterdam, Amsterdam, The Netherlands

⁴Reade, Amsterdam Rehabilitation Research Centre, Amsterdam, The Netherlands

⁵Center of Expertise Prevention in Care and Welfare, Faculty of Health, Sports and Social Work, INHOLLAND University of Applied Sciences location Haarlem, Haarlem, The Netherlands

X Sietske C M Luijten @LuijtenSietske and Evert Verhagen @evertverhagen

Acknowledgements We thank all athletes and healthcare professionals for their time, energy, enthusiasm and input for the development of the Tailored Injury Prevention in Adapted Sports (TIPAS) intervention. Furthermore, we thank Leonie te Loo, Vera van Reuler and Marcella van Diepen for their assistance regarding the data collection for steps 1 and 2. Furthermore, an international advisory board of expert researchers in injury prevention in adapted sports provided their insights during the development of the TIPAS intervention. We thank, Kathrin Steffen, Hilde Moseby Berge, Cheri Blauwet, Kristina Fagher, Jan Lexell and Wayne Derman, for their time and valuable comments over the years.

Contributors All authors contributed to the study's conception and design. All authors contributed to the material preparation. SCML wrote the first draft of the manuscript and all authors commented on previous versions of the manuscript. All authors read and approved the final manuscript. EV is the guarantor.

Funding This study was funded by the Dutch National Organization for Health Research and Healthcare Innovation (ZonMw; 50-54600-98-236).

Competing interests EV is the editor in chief of *BMJ Open Sports and Exercise Medicine*, and SCML is an associate editor of para sports and epidemiology of *BMJ Open Sports and Exercise Medicine*.

Patient and public involvement Patients and/or the public were involved in the design, or conduct, or reporting or dissemination plans of this research. Refer to the Methods section for further details.

Patient consent for publication Not applicable.

Ethics approval This study involves human participants and was approved by Compliance with Ethical Standards. Ethical approval has been granted for the various design steps and associated substudies of the Tailored Injury Prevention in Adapted Sports (TIPAS) intervention. Step 1—cohort study: trial number VUmc2020.290. Steps 1 and 3—qualitative study and knowledge transfer groups: trial number VUmc.2021.0041. Step 5—evaluation of intervention: trial number VUmc.2021.0581. Participants gave informed consent to participate in the study before taking part.

Provenance and peer review Not commissioned; externally peer reviewed.

Data availability statement Data are available upon reasonable request.

Supplemental material This content has been supplied by the author(s). It has not been vetted by BMJ Publishing Group Limited (BMJ) and may not have been peer-reviewed. Any opinions or recommendations discussed are solely those of the author(s) and are not endorsed by BMJ. BMJ disclaims all liability and responsibility arising from any reliance placed on the content. Where the content includes any translated material, BMJ does not warrant the accuracy and reliability of the translations (including but not limited to local regulations, clinical guidelines, terminology, drug names and drug dosages), and is not responsible for any error and/or omissions arising from translation and adaptation or otherwise.

Open access This is an open access article distributed in accordance with the Creative Commons Attribution Non Commercial (CC BY-NC 4.0) license, which permits others to distribute, remix, adapt, build upon this work non-commercially, and license their derivative works on different terms, provided the original work is properly cited, appropriate credit is given, any changes made indicated, and the use is non-commercial. See: <http://creativecommons.org/licenses/by-nc/4.0/>.

ORCID iDs

Sietske C M Luijten <http://orcid.org/0000-0003-1987-9986>

Joske Nauta <http://orcid.org/0000-0002-4516-1049>

Evert Verhagen <http://orcid.org/0000-0001-9227-8234>

REFERENCES

- Côté-Leclerc F, Boileau Duchesne G, Bolduc P, *et al*. How does playing adapted sports affect quality of life of people with mobility limitations? Results from a mixed-method sequential explanatory study. *Health Qual Life Outcomes* 2017;15:22.
- Aitchison B, Rushton AB, Martin P, *et al*. The experiences and perceived health benefits of individuals with a disability participating in sport: a systematic review and narrative synthesis. *Disabil Health J* 2022;15:101164.
- Reijnen V. Effects of adaptive sports on quality of life in individuals with disability. 2019.
- Hoekstra S, Valent L, Gobets D, *et al*. Effects of four-month handbike training under free-living conditions on physical fitness and health in wheelchair users. *Disabil Rehabil* 2017;39:1581–8.
- Puce L, Okwen PM, Yuh MN, *et al*. Well-being and quality of life in people with disabilities practicing sports, athletes with disabilities, and para-athletes: insights from a critical review of the literature. *Front Psychol* 2023;14:1071656.
- Cheung L, Chan K, Heffernan MG, *et al*. The impact of sport participation for individuals with spinal cord injury: a scoping review. *NeuroRehabilitation* 2022;51:353–95.
- Weiler R, Van Mechelen W, Fuller C, *et al*. Sport injuries sustained by athletes with disability: a systematic review. *Sports Med* 2016;46:1141–53.
- Luijten SCM, Te Loo LM, Nauta J, *et al*. Sports-related health problems in para-sports: a systematic review with quality assessment. *Sports Health* 2024;16:551–64.
- Fagher K, Dahlström Ö, Lexell J. Mental health, sleep, and pain in elite para athletes and the association with injury and illness—A prospective study. *PM&R* 2023;15:1130–9.



- 10 Hirschmüller A, *et al.* Injury and illness surveillance in elite para athletes: an urgent need for suitable illness prevention strategies. *Am J Phys Med Rehabil* 2021;100:173–80.
- 11 Ballas J, Buultjens M, Murphy G, *et al.* Elite-level athletes with physical impairments: barriers and facilitators to sport participation. *Disability & Society* 2022;37:1018–37.
- 12 Martin Ginis KA, Ma JK, Latimer-Cheung AE, *et al.* A systematic review of review articles addressing factors related to physical activity participation among children and adults with physical disabilities. *Health Psychol Rev* 2016;10:478–94.
- 13 Diaz R, Miller EK, Kraus E, *et al.* Impact of adaptive sports participation on quality of life. *Sports Med Arthrosc Rev* 2019;27:73–82.
- 14 Mann DL, Tweedy SM, Jackson RC, *et al.* *Classifying the Evidence for Evidence-Based Classification in Paralympic Sport*. Taylor & Francis, 2021:1–6.
- 15 Tweedy SM, Vanlandewijck YC. International paralympic committee position stand—background and scientific principles of classification in paralympic sport. *Br J Sports Med* 2011;45:259–69.
- 16 Fagher K, Badenhorst M, Kunorozva L, *et al.* “It gives me a wake up call”—it is time to implement athlete health monitoring within the para sport context. *Scandinavian Med Sci Sports* 2023;33:776–86.
- 17 Bolling C, van Mechelen W, Pasman HR, *et al.* Context matters: revisiting the first step of the “Sequence of prevention” of sports injuries. *Sports Med* 2018;48:2227–34.
- 18 Bittencourt NFN, Meeuwisse WH, Mendonça LD, *et al.* Complex systems approach for sports injuries: moving from risk factor identification to injury pattern recognition—narrative review and new concept. *Br J Sports Med* 2016;50:1309–14.
- 19 Hespanhol LC Jr, van Mechelen W, Verhagen E. Effectiveness of online tailored advice to prevent running-related injuries and promote preventive behaviour in dutch trail runners: a pragmatic randomised controlled trial. *Br J Sports Med* 2018;52:851–8.
- 20 Verhagen E, Voogt N, Bruinsma A, *et al.* A knowledge transfer scheme to bridge the gap between science and practice: an integration of existing research frameworks into a tool for practice. *Br J Sports Med* 2014;48:698–701.
- 21 Luijten SCM, Nauta J, Janssen TWJ, *et al.* Occurrence of injuries and illnesses in athletes with a physical impairment; a forty-week prospective cohort study. *J Sci Med Sport* 2024;27:160–5.
- 22 Jenniskens SCN, *et al.* Perspectives of athletes with a physical impairment and their healthcare professionals on sports injuries, risk factors and consequences: a qualitative study [in press]. 2024.
- 23 van Mechelen W, Hlobil H, Kemper HC. Incidence, severity, aetiology and prevention of sports injuries. a review of concepts. *Sports Med* 1992;14:82–99.
- 24 Clarsen B, Bahr R, Myklebust G, *et al.* Improved reporting of overuse injuries and health problems in sport: an update of the Oslo sport trauma research center questionnaires. *Br J Sports Med* 2020;54:390–6.
- 25 Derman W, Badenhorst M, Blauwet C, *et al.* Para sport translation of the IOC consensus on recording and reporting of data for injury and illness in sport. *Br J Sports Med* 2021;55:1068–76.
- 26 Pluim BM, Loeffen FGJ, Clarsen B, *et al.* A one-season prospective study of injuries and illness in elite junior tennis. *Scandinavian Med Sci Sports* 2016;26:564–71.
- 27 Clarsen B, Myklebust G, Bahr R. Development and validation of a new method for the registration of overuse injuries in sports injury epidemiology: the Oslo Sports Trauma Research Centre (OSTRC) overuse injury questionnaire. *Br J Sports Med* 2013;47:495–502.
- 28 Survalyzer. Survalyzer next generation. 2020. Available: <https://survalyzer.com/nl/>
- 29 Moore GF, Audrey S, Barker M, *et al.* Process evaluation of complex interventions: medical research council guidance. *BMJ* 2015;350:h1258.
- 30 Pinheiro LSP, Ocarino JM, Madaleno FO, *et al.* Prevalence and incidence of injuries in para athletes: a systematic review with meta-analysis and GRADE recommendations. *Br J Sports Med* 2021;55:1357–65.
- 31 Finch C. A new framework for research leading to sports injury prevention. *J Sci Med Sport* 2006;9:3–9; .
- 32 Tee JC, McLaren SJ, Jones B. Sports injury prevention is complex: we need to invest in better processes, not singular solutions. *Sports Med* 2020;50:689–702.
- 33 van Nassau F, Huis A, van de Glind I, *et al.* Factors influencing the implementation of the eurofit lifestyle change program in professional football clubs in Europe: a qualitative study in four European countries. *Transl Behav Med* 2023;13:212–25.
- 34 Verhagen E. If athletes will not adopt preventive measures, effective measures must adopt athletes. *Curr Sports Med Rep* 2012;11:7–8.
- 35 Gouttebarga V, van Sluis M, Verhagen E, *et al.* The prevention of musculoskeletal injuries in volleyball: the systematic development of an intervention and its feasibility. *Inj Epidemiol* 2017;4:25.
- 36 Pas HIMFL, Bodde S, Kerkhoffs GMMJ, *et al.* Systematic development of a tennis injury prevention programme. *BMJ Open Sport Exerc Med* 2018;4:e000350.
- 37 von Gerhardt AL, Vriend I, Verhagen E, *et al.* Systematic development of an injury prevention programme for judo athletes: the IPPON intervention. *BMJ Open Sport Exerc Med* 2020;6:e000791.
- 38 Fagher K, Kunorozva L, Badenhorst M, *et al.* Safe and healthy para sport project (SHAPE): a study protocol of a complex intervention within para sport. *BMJ Open Sport Exerc Med* 2022;8:e001392.