Physical Therapy in Sport 53 (2022) 143–150

Contents lists available at ScienceDirect

Physical Therapy in Sport

journal homepage: www.elsevier.com/ptsp

How injury prevention programs are being structured and implemented worldwide: An international survey of sports physical therapists

Luciana D. Mendonça [a, b, c, *], Christophe Ley [d], Joke Schuermans [b], Evi Wezenbeek [b], IFSPT [e], Erik Witvrouw [f]

[a] Graduate Program in Rehabilitation and Functional Performance, Universidade Federal dos Vales do Jequitinhonha e Mucuri (UFVJM), Diamantina, Minas Gerais, Brazil
[b] Postdoctoral Researcher at Department of Physical Therapy and Motor Rehabilitation, Faculty of Medicine and Health Sciences, Ghent University, Ghent, Belgium
[c] CAPES Foundation, Ministry of Education of Brazil, Brasília, Distrito Federal, Brazil
[d] Department of Applied Mathematics, Computer Science and Statistics, Ghent University, Ghent, Belgium
[e] Kristian Thorborg, Ummukulthoum Bakare, Luciana D Mendonça - Research Committee – the International Federation of Sports Physical Therapy, the Netherlands
[f] Department of Physical Therapy and Motor Rehabilitation, Faculty of Medicine and Health Sciences, Ghent University, Ghent, Belgium

ARTICLE INFO

Article history:
Received 13 April 2021
Received in revised form
4 June 2021
Accepted 8 June 2021

Keywords:
Athlete
Prevention
Injury
Exercise
Implementation

ABSTRACT

Objective: To identify the role of sports physical therapists (PT) in the injury prevention process and to compare the structure of preventive programs and associated (organization) policies applied in athletic organizations and sports teams of varying gender and level world-wide.
Design: cross-sectional study.
Setting: LimeSurvey platform.
Participants: Sports PT working with athletes invited through the International Federation of Sports Physical Therapy.
Main outcome measures: Sports injury prevention program (IPP) structure and implementation.
Results: 414 participants fully participate in this survey study. Athlete's injury history (68.84%), the most common injuries within the sport modality (67.87%) and athlete's preseason screening results (64.01%) were most frequently used to customize IPPs. Warm-up (70.04%) and individually PT-guided exercise-therapy (70.04%) were the preferred methods to organize the prevention routine. The main barrier for IPP implementation was lack of time within the athlete's weekly training schedule (66.66%). The majority of the participants (72.84%) reported to evaluate the perception of IPP's effect by comparing current and preceding seasons' injury occurrences.
Conclusion: These survey results are the first identifying contemporary sports injury prevention organization and implementation policies on an international level. This information might support the sports PT community in improving and standardizing IPP (implementation) strategies worldwide.

1. Introduction[1]

Sport-related injuries are a significant public health problem requiring a systematic approach consisting of the standardized and systematic implementation of evidence-based prevention strategies (Emery & Tyreman, 2009; Finch & Cassell, 2006; Pickett et al., 2005; Soomro et al., 2016). For example, existing studies already established that regular sports participation can be considered as a major cause of pain and injury in children and adolescents, as it has been demonstrated that about 30% of all injuries in this population across many countries concern sports injuries (Finch & Cassell, 2006; Pickett et al., 2005; Wiggins et al., 2016). Foss and

* Corresponding author. Universidade Federal dos Vales do Jequitinhonha e Mucuri, Department of Physical Therapy, Diamantina, Minas Gerais, Brazil.
E-mail address: lucianademichelis@yahoo.com.br (L.D. Mendonça).
[1] Please note that this paper is the 2nd part of the study. The 1st part of the study is currently under editorial review.

https://doi.org/10.1016/j.ptsp.2021.06.002
1466-853X/

colleagues (Foss et al., 2018) demonstrated that participation in a neuromuscular training program reduce injury incidence compared to a sham intervention in high school and middle school levels. Moreover, young athletes who return to sport after an ACL reconstruction showed a 30 to 40 times greater risk of an ACL re-injury compared with uninjured adolescents (Wiggins et al., 2016). Such injuries have numerous individual, social and economic consequences (DiFiori et al., 2014; Lund & Aaro, 2004; Slimani et al., 2018). Injury prevention programs (IPPs) targeting sport injuries should be applied early in a sport career to maximize its effectiveness (Huang et al., 2020; Wiggins et al., 2016). For example, Huang et al. identified that IPPs targeting ACL injuries could reduce these injury rates by 53% (Huang et al., 2020). However, it should be noted that the way these IPPs are constructed and implemented plays a significant role in its effectiveness (Plummer et al., 2019; Webster & Hewett, 2018; Wiggins et al., 2016).

Indeed, interventions should be (1) developed following research evidence, (2) widely adopted, (3) properly implemented, (4) sustainably and (5) evaluated in terms of effectiveness over time (Donaldson et al., 2016). The occasional existing evidence in sports injury prevention research suggests that injury prevention interventions lack region-, level- and gender-independent widespread dissemination and integration (Bahr et al., 2015; Hanson et al., 2014; Hollis et al., 2012; Norcross et al., 2014; Twomey et al., 2009). The reason behind this could be that clinicians and practitioners are repeatedly confronted with barriers hampering proper organization of IPPs (Donaldson et al., 2017), such as absence of a theoretical background (Donaldson & Finch, 2013), scarce evidence about specific implementation strategies (O'Brien & Finch, 2014) or even cultural and social barriers that could vary between different regions and countries (Donaldson et al., 2019; Pickett et al., 2005; Slimani et al., 2018; Soomro et al., 2016). However, it is striking that hardly any research is available concerning the way sport teams' professionals organize and implement their IPPs. Moreover, it is not always clear which role each associated (health care or technical staff) professional/organization member plays in a team's injury prevention routine and whether or not these sport teams have a proper work environment for injury prevention implementation (e.g. space, materials, technical support, routine organization, etc).

Usually, the sports physical therapist (PT) is responsible for organizing and delivering specific IPP in a sports team (Grant et al., 2014). Nonetheless, no previous study has ever investigated the role of sports PTs in injury prevention processes, let alone how these programs are organized and implemented worldwide. Therefore, the purpose of this international survey was to identify the role of sports PTs in the injury prevention process and to compare the structure of preventive programs and associated (organization) policies applied in athletic organizations and sports teams of varying gender and level world-wide.

2. Methods

This international survey was reported in accordance with "strengthening the reporting of observational studies in epidemiology (STROBE) statement" (von Elm et al., 2014). This study was approved by the Ethics Committee of the Ghent University Hospital (Ghent, Belgium) (report number B6702020000151) which involves an online survey with questions related to sport injury prevention process (injury registration, preseason assessment, prevention program structure, organization and implementation). Considering the massive amount of data and the necessity to properly discuss our findings, we were obligated to write 2 manuscripts (part 1 and part 2). As this paper presents the second part of the results collected in this international survey, the same inclusion and exclusion criteria and methodological procedures were followed [Submission date: March 26th, Journal: Physical Therapy in Sport, YPTSP-D-21-00147].

The survey contained a comprehensive questionnaire consisting of 2 parts: (1) a 'Demographics' section (containing 8 questions of multiple response and 7 short text response) and (2) 'Prevention program structure and implementation' section (containing 9 questions of multiple response, 2 short text response and 1 long text response). This entire questionnaire can be consulted in Appendix 1. The main variables (constructs) collected were: access to sport medicine journals, factors used to customize the IPP, characteristics of the IPP delivered to youth and elite athletes, if another professional help with IPP organization, how the IPP is implemented, difficulties and barriers to IPP implementation, perception of IPP's effect, items related to injury prevention organization and the level of importance (Likert scale) of each item. We also included one final open question (non-obligatory) asking for any additional comment on the previous items.

2.1. Data analysis

All data collected within *LimeSurvey* were exported to Excel for consecutive analysis. Descriptive analysis was performed to define the characteristics of the participants and to estimate the absolute and relative frequency of responses related to IPP implementation. In order to analyse the survey's outcome as regards the implementation and evaluation of the intervention program's (perception of effect) in function of PT demographics, age and working experience, the two latter continuous variables were converted into binary ones using the variables' median as the cut-off point.

Independent Student-t and Pearson chi-square test were used to compare the answers based on respondent's age, gender, amount of experience, and gender composition of their athletic teams. These analyses were performed on the entire selection of continuous and categorical variables collected in the present study. All statistical procedures were performed in the Statical Package of the Social Sciences (SPSS 26) interface. Level of significance was set at $\alpha = 0.05$.

3. Results

414 sports PTs participated in this study. The participant's recruitment flow and their characteristics were published previously in part 1 of the international survey and can be comprehensively consulted in the first paper [Submission date: March 26th, Journal: Physical Therapy in Sport, YPTSP-D-21-00147]. As stated in Methods, this second part refers to IPP and all data is presented below.

3.1. Injury prevention program organization

Most sports PTs (315 respondents – 76.08%) indicated regularly consulting scientific literature to implement preventive strategies for the most common injuries. The majority reported consulting scientific literature every month (158 respondents - 50.15%), 83 (26.35%) reported to do this on a weekly basis, 47 (14.92%) indicated to consult the evidence only once a year and 27 (8.57%) indicated other options, such as 1 to 3 times each 6-months. 99 PTs (23.91%) did not consult scientific evidence. The reasons behind this were reported to be (1) not having access to scientific journals and/or to research databases (29.29%), (2) experiencing difficulty comprehending scientific papers (language barriers) (25.25%) and (45.45%) did not indicate any reason. No differences were found on the (systematic) exploration of scientific literature based on sports PT's gender, experience, age and gender of their associated athletic teams.

The main factors that sport PTs use to customize the IPP are shown in Fig. 1. No differences were found as regards these factors based on sports PT's gender, experience, age and gender of their associated athletic teams.

Half of the participants (196 respondents; 51.71%) reported performing tailored prevention, specific for each athlete, 20.58% (78 respondents) indicated to give tailored prevention program dividing their athletes in groups according to their risk profile and 10.02% (38 respondents) provide a generic IPP, not taking into account any athlete-specific baseline screening results. 76 sports PTs (17.67%) indicated mixing generic and individually tailored programs, depending on their risk profile and age/category. Only 2 sports PTs (0.52%) reported not applying IPP in adult-athletes.

When asked if they organized the IPP alone, 98 sports PTs (23.67%) indicated being the only one responsible for injury prevention in their organization. The majority (316 respondents, 76.33%) reported collaborating with other professionals for respective organization. For 41.00%, the collaboration with a second PT was most frequent in the prevention organization within their associated sports team/club, followed by collaborations with the strength and conditioning coaches (27.00%), the head coach (18.00%) and the teams' physician (14.00%).

Fig. 2 presents the distribution of the results as regards a question about how important the sports PT considered individual injury prevention exercises performed by the PT, specific injury prevention exercises performed by the strength and conditioning coach, recovery, sleep, nutrition, training control and warm-up in injury prevention.

A description of which injury prevention methods were selected by the sports PTs with Likert scale score for each one and comparisons based on the sports PT's age, gender, work experience and the gender of their athletes is presented in Table 1.

3.2. Injury prevention program implementation

When asked about the team's weekly prevention regimen; 117 participants (28.26%) indicated that their IPP is an exclusive part of the training session organized by the sports PT; 120 participants (28.98%) indicated that it is an exclusive part of the warming-up routine organized by the strength and conditioning coach (83 respondents – 20.04%) or by the head coach (37 respondents - 8.93%) prior to training and (3) 49 sports PTs (11.83%) indicated this as an exclusive part of the physical training sessions organized by the strength and conditioning coach. Mixed injury prevention organization formats were indicated by 99 sports PTs (23.91%). Moreover, 27 sports PTs (6.52%) indicated that the head coach decides when the IPP can take place, whereas 2 sports PTs (0.48%) do not apply IPPs in their athletes.

Fig. 1. Factors used to customize the injury prevention program.

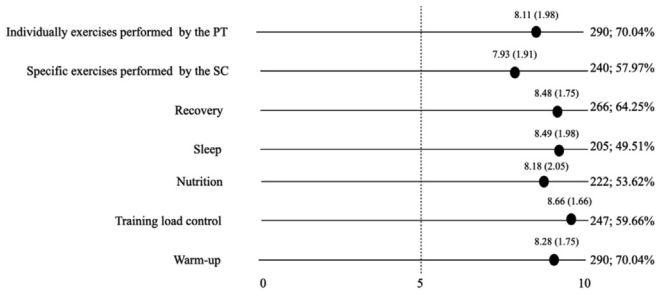

Fig. 2. Frequency of prevention methods and Likert scale score indicating the importance of each one. Abbreviations: PT = physical therapist; SC = strength and conditioning coach.

Significant differences were observed concerning the strategies used to implement IPPs based on sports PT's gender ($p = 0.02$) and years of experience ($p = 0.02$). Male sports PTs indicated that their IPP is organized as a part of the warm-up with the head coach and strength and conditioning coach or based on the head coach decision significantly more frequently than female sports PTs ($p = 0.02$), who reported the prevention routines are organized by means of sports PT guided and strength conditioning sessions most frequently. More experienced sports PTs indicated significantly more that their prevention session is organized as a part of the warm-up, governed by the head coach, compared to their colleagues with less working experience ($p = 0.02$) who reported that injury prevention in their organization was mostly organized and governed by the sports PT him-/herself.

More than half of the sports PTs (216 respondents; 52.17%) indicated experiencing difficulties with implementing the preventive program in their team's weekly training schedule. Table 2 indicates the main barriers sports PT's are confronted with when wanting to organize and implement injury prevention strategies and training sessions in their organizations. No differences were found on barriers to implement IPPs based on sports PT's gender, experience, age and gender of their associated athletic teams. Only sports PTs who work with female teams did not indicate a lack of support from the physician or strength and conditioning coach as barriers in organizing injury prevention within their organizations.

3.3. Perception of an IPP effect

The majority of the participants (372 sports PTs, 89.85%) indicated regularly analysing the perception of effect of the implemented IPPs. Fig. 3 shows the methods used to assess the perception of a preventive effect. Only 42 sports PTs (10.15%) reported not verifying the perception of effect of the implemented IPPs. No differences were found on the item of 'perception of effect of the implemented IPPs' based on sports PT's gender, experience, age and gender of their associated athletic teams.

Interestingly, 295 sports PTs (71.25%) considered their IPP to be effective, 59 (14.25%) did not consider it to be effective and 60 (14.49%) did not have an opinion as regards this item. The participants used a Likert scale to rate their perception of success in injury prevention (being 0 no success and 10 successful). We found significant differences between sports PTs working with female or male athletes in their perception of IPP successes ($p = 0.01$). Specifically, sports PTs working with female teams perceived their IPP less effective compared to their colleagues working with male teams (Table 3).

Table 1
Frequency and Likert scale score of prevention methods used per sub-group.

Methods (mean (SD))							
	Exercises with PT	Exercises with SC	Recovery	Sleep	Nutrition	Load Control	Warm-up
Younger PT	8.14 (1.89)	8.05 (1.82)	8.46 (1.74)	8.44 (2.08)	8.19 (2.17)	8.54 (1.72)	8.23 (1.76)
Older PT	8.08 (2.06)	7.82 (1.98)	8.50 (1.76)	8.53 (1.89)	8.16 (1.85)	8.76 (1.59)	8.33 (1.73)
p-value	0.74	0.25	0.84	0.65	0.89	0.21	0.60
Female PT	8.19 (2.06)	7.96 (2.13)	8.70 (1.73)	8.62 (2.04)	8.37 (1.90)	8.75 (1.77)	8.42 (1.75)
Male PT	8.09 (1.96)	7.92 (1.84)	8.42 (1.75)	8.45 (1.97)	8.12 (2.04)	8.63 (1.62)	8.24 (1.75)
p-value	0.68	0.87	0.21	0.50	0.34	0.58	0.42
Female team	7.82 (2.22)	7.39 (2.61)	8.29 (1.96)	8.50 (1.66)	8.18 (1.65)	9.04 (1.13)	8.21 (1.45)
Male team	8.39 (1.75)	8.14 (1.73)	8.59 (1.65)	8.47 (2.02)	8.30 (2.08)	8.56 (1.74)	8.36 (1.71)
p-value	0.13	0.05	0.38	0.95	0.76	0.16	0.67
Less experience	8.28 (1.73)	7.91 (1.92)	8.33 (1.83)	8.31 (2.15)	8.15 (2.06)	8.53 (1.78)	8.28 (1.64)
More experience	7.96 (2.17)	7.95 (1.89)	8.61 (1.66)	8.64 (1.82)	8.20 (1.97)	8.76 (1.54)	8.28 (1.84)
p-value	0.12	0.83	0.13	0.11	0.82	0.18	0.97

Abbreviations: SD = standard deviation; PT = physical therapist; SC = strength and conditioning coach.

Table 2
Barriers to implement preventive programs and methods used to analyse the perception of a preventive effect.

Barriers to implementation		
	Respondents (n = 216)	Frequency
lack of time on athlete's routine	144	66.66%
lack of support from the athletes	91	42.13%
lack of support from the head coach	84	38.88%
lack of infrastructure (space and materials)	81	37.50%
overload of the physical therapy service	70	32.40%
lack of support from the manager	36	16.66%
lack of support from the strength and conditioning coach	32	14.81%
lack of support from another PTs	26	12.03%
lack of support from the physician	20	9.26%
Methods to analyse the perceived effect		
	Respondents (n=372)	**Frequency**
number of injuries	271	72.84%
amount of time loss	184	49.46%
uses athlete's perception	93	25.00%
uses coach's opinion	61	16.39%
uses manager's opinion	20	5.37%

Abbreviations: PT = physical therapist.

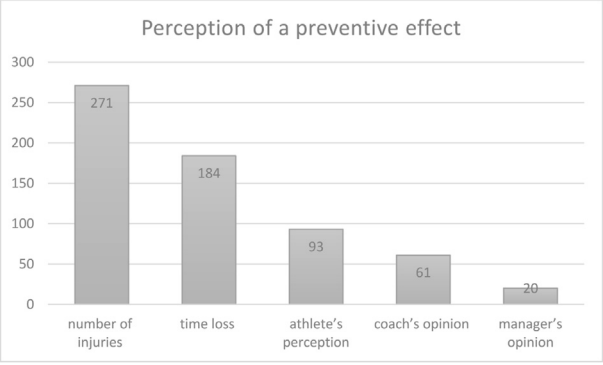

Fig. 3. Most frequent methods used to assess the perception of IPP's effect.

4. Discussion

The purpose of this study was to identify the role of the sports PT in the injury prevention process world-wide and to compare the associated organization/implementation policies and strategies, as well as the exact structure of preventive programs currently applied in sports teams of different gender and level.

The content of the IPPs was mainly determined by the athlete's injury history, the most common injuries within the sport modality and the results of the preseason assessment. This is in accordance with numerous studies who identified injury history as one of the most important risk factors for sustaining a new injury (Green et al., 2020; Hill et al., 2015; Toohey et al., 2017; van der Worp et al., 2015). For example, Green and colleagues (Green et al., 2020) recently published a meta-analysis on the risk of hamstring strain injury. They found that any history of hamstring strain injury (risk ratio (RR) of 2.7) and recent hamstring strain injury (RR of 4.8) were the most common significant risk factors for hamstring strain injury. Moreover, Wiggins et al. indicated in their systematic review and metanalysis that athletes younger than 25 years who return to sport have a secondary ACL injury rate of 23% (Wiggins et al., 2016). Therefore, systematic injury registration is an absolute key factor in evidence-based IPPs content composition and should be mandatory in an athletic organization. The existing evidence indicates that keeping track of the athlete's individual injury history is necessary to customize an optimal preventive approach.

This survey indicated that the second most common criterion used to compose a IPP is the evidence-based injury epidemiology figures in the sports domain/athletic field the physiotherapist's team engages in. With regard to injury prevention in football (soccer), the generic FIFA 11+ prevention program is recognized as the most disseminated one and it was developed based on football injury epidemiological research and research as regards risk factor identification for those most frequently occurring injuries in football (Sadigursky et al., 2017). Two systematic reviews and meta-analyses indicated that including Nordic hamstring exercises in IPPs, significantly reduces the risk of hamstring injuries among

Table 3
Frequency of perception about injury prevention success.

Perceived prevention success (score)						
	1-2 points	3-5 points	6-8 points	9-10 points	Mean (SD)	p-value
Sample	15 (3.62%)	75 (18.11%)	277 (66.90%)	47 (11.35%)	6.75 (1.66)	–
Younger PT	12	37	131	18	6.66 (1.66)	0.37
Older PT	13	37	137	30	6.82 (1.66)	–
Female PT	9	19	64	14	6.78 (1.70)	0.81
Male PT	13	56	205	32	6.73 (1.65)	–
Female team	5	12	25	0	5.89 (1.73)	0.01*
Male team	7	32	115	19	6.76 (1.65)	–
Less experience	14	38	138	25	6.81 (1.56)	0.51
More experience	18	45	107	31	6.69 (1.74)	–

* Indicates significant statistical difference. Abbreviations: SD = standard deviation; PT = physical therapist.

soccer players (Al Attar et al., 2017; van Dyk et al., 2019), which again exemplifies how injury aetiology influences prevention program structure. In our study, almost 75% of the sports PTs indicated to utilise preseason assessment results to customize IPPs. This is supported by Dallinga et al. (Dallinga et al., 2012) who indicated that screening test (such star excursion balance test, hamstrings:quadriceps ratio and decreased hip abduction ROM) could be recommended to the team's medical staff since the (limited) evidence suggests that these might be helpful in predicting knee, hamstring, groin and ankle injury risk in athletes (Bonazza et al., 2017; Sprague et al., 2018; Whittaker et al., 2015). Therefore, literature supports our participants' answers, since they indicate that sport-specific injury epidemiology, clinical reasoning and sport biomechanics were factors that sports PTs considered to set up IPPs. However, more high-quality research is needed to investigate the role of preseason assessment results to build preventive programs (Whittaker et al., 2017).

Interestingly, the majority of sports PTs (75.40%) indicated that they have collaborations with other professionals (i.e. other PT, strength and conditioning coach, head coach and physician) to organize the IPP, which is in accordance with some evidence which especially considers this collaboration to increase athlete's adherence (Breslin et al., 2017). It is positive to see that the majority of IPPs was built by different health care providers since physical therapy, medicine, strength and conditioning, physiology, psychology, etc, seem to be important in injury management and therefore should be included in prevention programs.

Regarding the issue of IPPs implementation, the strategies/prevention approaches most frequently used were individually selected exercises performed by the athlete under strict guidance of the sports PT at the beginning of the training session. Petushek and colleagues (Petushek et al., 2019) found that the most effective ACL IPPs targeting younger athletes were the ones instructed by trained or informed personnel (e.g. coaches, trainers) and provided to the athletes throughout the sport season (as a part of the weekly training routine). Therefore, the results of this survey suggest that the sports PT prevention approach is expected to be very effective.

When asked about the level of importance, the sports PTs gave a higher score to training load control (Jones et al., 2017), recovery and sleep (Bonnar et al., 2018) compared to an individual exercise program performed by the athlete under strict guidance of the sports PT. Unfortunately, this survey did not ask whether the sports PT's are systematically using these elements in their injury prevention approach so further discussion as regards the role and importance of load, recovery and sleep in contemporary, PT guided, sports injury prevention is beyond the scope of this survey paper. Since sports injuries emerge from complex interactions of multiple underlying (risk) factors, injury prevention requires a global approach, including more than just physical training (Bittencourt et al., 2016; Saragiotto et al., 2014). The exact importance of the different aspects and their respective share in the athlete's injury risk, is still to be identified. In the present study, more experienced sports PTs consider sleep to be more important to prevent injuries than the less experienced sports PTs (Bonnar et al., 2018). There is no strong evidence about sleep being an important sport injury preventive measure, however, we have indirect evidence (Gupta et al., 2017). Sleep deprivation affects significantly sport specific skills, reaction time, decision making, mood stability, subjective physical recovery (Fullagar et al., 2015; Mah et al., 2011, 2018; Reilly & Edwards, 2007; Robey et al., 2013) and these factors also play an important role in the development of injuries. Furthermore, sleep quality is related to general well-being (Fullagar et al., 2015) and it is possible that the effects of sleep deprivation in athletes become more apparent after some time which could explain why more experienced sports PTs perceive sleep as an important element of injury prevention compared to less experienced sports PTs.

The most frequent barriers to injury prevention implementation observed in this survey, were related to time-related restrictions of applying injury prevention in the athlete's weekly training routine, athletic adherence and athletes' support. In literature, the head coach is frequently cited as the person who might not support IPPs (Dejonghe et al., 2017). In our study, lack of coach's support was only the fourth barrier indicated, however, this is a recognized barrier (DiStefano et al., 2017). For example, despite the evidence supporting the use of preventive training programs to reduce lower extremity musculoskeletal injuries, programs seem to be adopted by less than 20% of all high school coaches in the United States (DiStefano et al., 2017). Moreover, Richmond et al. (Richmond et al., 2020) recently reported that the most frequently reported barriers to IPP implementation included intervention complexity, planning and readiness for implementation. Our data indicate that athlete's behaviour and weekly training routine (flexibility) should be investigated more thoroughly in future studies. It would also be interesting to identify if the barriers to IPPs implementation would change when in case of acute or overuse injuries, as also longer follow up of injury (factor) related data would be carried out (Ageberg et al., 2019; Donaldson et al., 2019; Emery et al., 2015; Thorborg et al., 2017).

Our data show that the perception of effect of the prevention program is most frequently analysed by the sports PT's by comparing the number of injuries between the current and last season. Interestingly, almost half of the sample also reported considering time-loss comparison between seasons. Existing literature indeed indicates that injury incidence is commonly used to analyse prevention program perceived effect, which is in favour of our results (Ageberg et al., 2019; Al Attar et al., 2016; Kilic et al., 2018; Taylor et al., 2015; Thorborg et al., 2017). However, time-loss, which is a measure of injury severity, is not usually adopted as an epidemiological measure to indicate effectiveness, despite being indicated by Van Mechelen's sequence of prevention

(Andrade et al., 2020; Bleakley et al., 2011; López-Valenciano et al., 2020; van Mechelen et al., 1992). Considering that injury is inherent on sport practice and that it is not always possible to decrease its occurrence significantly (Chalmers, 2002), time-loss should be considered as an essential outcome to access prevention effectiveness in future studies (Benson et al., 2009; Jones et al., 2019).

The majority of our respondents considered their IPP effective and differences were found only between the perception among sports PTs working with female and male teams. Sports PTs who works with female teams generally perceived their prevention approach to be less effective compared to what was reported by sports PTs working with male teams. One hypothesis could be that sports PTs might feel not being able to deliver with full engagement as regards injury prevention because of the lack of financial support and structure that female teams usually face. Despite the participant's perception of a preventive effect, research is not consistent about differences in IPPs effectiveness based on athlete gender (Asker et al., 2018; Smyth et al., 2019). It worth to mention that, historically, IPP was developed and studied first in young female athletes (Collings et al., 2021).

This study has limitations that should be considered. First, the results are susceptible to reporting bias, since the reader must be aware of the fact that each participating sports PT answered the questions based on his/her personal beliefs, perceptions, income and contacts with their colleagues and athletes. The sample size could be larger since it is an international survey involving 34 countries. We suggest that future studies could explore qualitatively the role of STP in injury prevention work. Nevertheless, our results could raise new insights regarding injury prevention research, for example the impact of working with male or female teams, or the importance of the sports PT's occupational status (working half- or fulltime for the athletic/organization). Based on this survey's results and limitations, it would definitely be worthwhile for future research to invest more in the exploration of factors that might be associated with barriers with regard to implementation of injury prevention as well as the analysis of the effectiveness of the IPPs implemented at present. These results could help sports PTs in their decision-making process about injury prevention once they understand the most common practices among their colleagues worldwide.

5. Conclusion

This is the first international large-scale survey on how sports PTs are engaged in injury prevention. Athlete's injury history, the most common injuries within the sport modality and athlete's preseason screening results were most frequently used to customize IPPs. Warm-up and individually PT-guided exercise-therapy were the preferred methods to organize the prevention routine. The main barrier for IPP implementation, was lack of time within the athlete's weekly training schedule and the majority of the participants reported to evaluate the perception of effect of the implemented prevention programs by comparing current and preceding seasons' injury occurrences. This information could help partitioning sports PTs and their colleagues in their decision-making process regarding injury prevention.

Confirmation of ethics compliance

We confirm that the Ethics Committee of the Ghent University approved this study (report number B6702020000151).

Funding information

This work has been partially supported by grants from the *Coordenação de Aperfeiçoamento de Pessoal de Nível Superior* (CAPES - Brazil; finance code 0001). The authors certify that they have no affiliations with or financial involvement in any organization or entity with a direct financial interest in the subject matter or materials discussed in the article.

Declaration of competing interest

The authors also declare that they do not have any conflict of interest.

Acknowledgement

We thank all IFSPT member organizations that worked to disseminate the survey through its associates. We also thankful to all sports PTs that participated in this study

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ptsp.2021.06.002.

References

Ageberg, E., Bunke, S., Lucander, K., Nilsen, P., & Donaldson, A. (2019). Facilitators to support the implementation of injury prevention training in youth handball: A concept mapping approach. *Scandinavian Journal of Medicine & Science in Sports, 29*(2), 275–285.

Al Attar, W. S., Soomro, N., Pappas, E., Sinclair, P. J., & Sanders, R. H. (2016). How effective are F-MARC injury prevention programs for soccer players? A systematic review and meta-analysis. *Sports Medicine, 46*(2), 205–217. https://doi.org/10.1007/s40279-015-0404-x

Al Attar, W. S. A., Soomro, N., Sinclair, P. J., Pappas, E., & Sanders, R. H. (2017). Effect of injury prevention programs that include the nordic hamstring exercise on hamstring injury rates in soccer players: A systematic review and meta-analysis. *Sports Medicine, 47*(5), 907–916. https://doi.org/10.1007/s40279-016-0638-2

Andrade, R., Wik, E. H., Rebelo-Marques, A., Blanch, P., Whiteley, R., Espregueira-Mendes, J., & Gabbett, T. J. (2020). Is the acute: Chronic workload ratio (acwr) associated with risk of time-loss injury in professional team sports? A systematic review of methodology, variables and injury risk in practical situations. *Sports Medicine, 50*(9), 1613–1635. https://doi.org/10.1007/s40279-020-01308-6

Asker, M., Brooke, H. L., Waldén, M., Tranaeus, U., Johansson, F., Skillgate, E., & Holm, L. W. (2018). Risk factors for, and prevention of, shoulder injuries in overhead sports: A systematic review with best-evidence synthesis. *British Journal of Sports Medicine, 52*(20), 1312–1319. https://doi.org/10.1136/bjsports-2017-098254

Bahr, R., Thorborg, K., & Ekstrand, J. (2015). Evidence-based hamstring injury prevention is not adopted by the majority of champions league or Norwegian premier league football teams: The nordic hamstring survey. *British Journal of Sports Medicine, 49*, 1466–1471.

Benson, B. W., Hamilton, G. M., Meeuwisse, W. H., McCrory, P., & Dvorak, J. (2009). Is protective equipment useful in preventing concussion? A systematic review of the literature. *British Journal of Sports Medicine, 43*(Suppl 1), i56–i67. https://doi.org/10.1136/bjsm.2009.058271

Bittencourt, N. F. N., Meeuwisse, W. H., Mendonça, L. D., Nettel-Aguirre, A., Ocarino, J. M., & Fonseca, S. T. (2016). Complex systems approach for sports injuries: Moving from risk factor identification to injury pattern recognition-narrative review and new concept. *British Journal of Sports Medicine, 50*(21), 1309–1314. https://doi.org/10.1136/bjsports-2015-095850

Bleakley, C., Tully, M., & O'Connor, S. (2011). Epidemiology of adolescent rugby injuries: A systematic review. *Journal of Athletic Training, 46*(5), 555–565. https://doi.org/10.4085/1062-6050-46.5.555. PMID: 22488143.

Bonazza, N. A., Smuin, D., Onks, C. A., Silvis, M. L., & Dhawan, A. (2017). Reliability, validity, and injury predictive value of the functional movement screen: A systematic review and meta-analysis. *The American Journal of Sports Medicine, 45*(3), 725–732. https://doi.org/10.1177/0363546516641937

Bonnar, D., Bartel, K., Kakoschke, N., & Lang, C. (2018). Sleep interventions designed to improve athletic performance and recovery: A systematic review of current approaches. *Sports Medicine, 48*(3), 683–703. https://doi.org/10.1007/s40279-017-0832-x

Breslin, G., Shannon, S., Haughey, T., Donnelly, P., & Leavey, G. (2017). A systematic review of interventions to increase awareness of mental health and well-being in athletes, coaches and officials. *Systematic Reviews, 6*(1), Article 177. https://doi.org/10.1186/s13643-017-0568-6

Chalmers, D. J. (2002). Injury prevention in sport: Not yet part of the game? *Injury Prevention, 8*(Suppl 4), IV22–25. https://doi.org/10.1136/ip.8.suppl_4.iv22

Collings, T. J., Bourne, M. N., Barrett, R. S., du Moulin, W., Hickey, J. T., & Diamond, L. E. (2021). Risk factors for lower limb injury in female team field and court sports: A systematic review, meta-analysis, and best evidence synthesis. *Sports Medicine, 51*(4), 759–776. https://doi.org/10.1007/s40279-020-01410-9. Epub 2021 Jan 5. PMID: 33400215.

Dallinga, J. M., Benjaminse, A., & Lemmink, K. A. (2012). Which screening tools can predict injury to the lower extremities in team sports?: A systematic review. *Sports Medicine, 42*(9), 791–815. https://doi.org/10.1007/BF03262295

Dejonghe, L. A. L., Becker, J., Froboese, I., & Schaller, A. (2017). Long-term effectiveness of health coaching in rehabilitation and prevention: A systematic review. *Patient Education and Counseling, 100*(9), 1643–1653. https://doi.org/10.1016/j.pec.2017.04.012

DiFiori, J. P., Benjamin, H. J., Brenner, J. S., et al. (2014). Overuse injuries and burnout in youth sports: A position statement from the American medical society for sports medicine. *British Journal of Sports Medicine, 48*(4), 287–288.

DiStefano, L. J., Frank, B. S., Root, H. J., & Padua, D. A. (2017). Dissemination and implementation strategies of lower extremity preventive training programs in youth: A clinical review. *Sport Health, 9*(6), 524–531. https://doi.org/10.1177/1941738117731732

Donaldson, A., Callaghan, A., Bizzini, M., Jowett, A., Keyzer, P., & Nicholson, M. (2019). A concept mapping approach to identifying the barriers to implementing an evidence-based sports injury prevention programme. *Injury Prevention, 25*(4), 244–251. https://doi.org/10.1136/injuryprev-2017-042639. Epub 2018 Jan 20.

Donaldson, A., & Finch, C. F. (2013). Applying implementation science to sports injury prevention. *British Journal of Sports Medicine, 47*, 473–475.

Donaldson, A., Lloyd, D. G., Gabbe, B. J., Cook, J., Young, W., White, P., & Finch, C. F. (2016). Scientific evidence is just the starting point: A generalizable process for developing sports injury prevention interventions. *J Sport Health Sci, 5*(3), 334–341. https://doi.org/10.1016/j.jshs.2016.08.003

Donaldson, A., Lloyd, D. G., Gabbe, B. J., et al. (2017). We have the programme, what next? Planning the implementation of an injury prevention programme. *Injury Prevention, 23*, 273–280.

van Dyk, N., Behan, F. P., & Whiteley, R. (2019). Including the nordic hamstring exercise in injury prevention programmes halves the rate of hamstring injuries: A systematic review and meta-analysis of 8459 athletes. *British Journal of Sports Medicine, 53*, 1362–1370.

von Elm, E., Altman, D. G., Egger, M., Pocock, S. J., Gøtzsche, P. C., Vandenbroucke, J. P., & STROBE Initiative. (2014). The strengthening the reporting of observational studies in epidemiology (STROBE) statement: Guidelines for reporting observational studies. *International Journal of Surgery, 12*(12), 1495–1499. https://doi.org/10.1016/j.ijsu.2014.07.013

Emery, C. A., Roy, T. O., Whittaker, J. L., Nettel-Aguirre, A., & van Mechelen, W. (2015). Neuromuscular training injury prevention strategies in youth sport: A systematic review and meta-analysis. *British Journal of Sports Medicine, 49*(13), 865–870. https://doi.org/10.1136/bjsports-2015-094639

Emery, C., & Tyreman, H. (2009). Sport participation, sport injury, risk factors and sport safety practices in Calgary and area junior high schools. *Paediatrics and Child Health, 14*(7), Article 439.

Finch, C., & Cassell, E. (2006). The public health impact of injury during sport and active $_{31}$ recreation. *Journal of Science and Medicine in Sport, 9*, Article 490e7.

Foss, K. D. B., Thomas, S., Khoury, J. C., Myer, G. D., & Hewett, T. E. (2018). A school-based neuromuscular training program and sport-related injury incidence: A prospective randomized controlled clinical trial. *Journal of Athletic Training, 53*(1), 20–28. https://doi.org/10.4085/1062-6050-173-16

Fullagar, H. H., Skorski, S., Duffield, R., Hammes, D., Coutts, A. J., & Meyer, T. (2015). Sleep and athletic performance: The effects of sleep loss on exercise performance, and physiological and cognitive responses to exercise. *Sports Medicine, 45*(2), 161–186. https://doi.org/10.1007/s40279-014-0260-0

Grant, M.-E., Steffen, K., Glasgow, P., et al. (2014). The role of sports physiotherapy at the London 2012 Olympic Games. *British Journal of Sports Medicine, 48*, 63–70.

Green, B., Bourne, M. N., van Dyk, N., & Pizzari, T. (2020). Recalibrating the risk of hamstring strain injury (HSI): A 2020 systematic review and meta-analysis of risk factors for index and recurrent hamstring strain injury in sport. *British Journal of Sports Medicine, 54*(18), 1081–1088. https://doi.org/10.1136/bjsports-2019-100983

Gupta, L., Morgan, K., & Gilchrist, S. (2017). Does elite sport degrade sleep quality? A systematic review. *Sports Medicine, 47*(7), 1317–1333. https://doi.org/10.1007/s40279-016-0650-6

Hanson, D., Allegrante, J. P., Sleet, D. A., et al. (2014). Research alone is not sufficient to prevent sports injury. *British Journal of Sports Medicine, 48*, 682–684.

Hill, L., Collins, M., & Posthumus, M. (2015). Risk factors for shoulder pain and injury in swimmers: A critical systematic review. *Physiotherapy in Sport, 43*(4), 412–420. https://doi.org/10.1080/00913847.2015.1077097

Hollis, S. J., Stevenson, M. R., McIntosh, A. S., et al. (2012). Compliance with return-to-play regulations following concussion in Australian schoolboy and community rugby union players. *British Journal of Sports Medicine, 46*, 735–740.

Huang, Y. L., Jung, J., Mulligan, C. M. S., Oh, J., & Norcross, M. F. (2020). A majority of anterior cruciate ligament injuries can Be prevented by injury prevention programs: A systematic review of randomized controlled trials and cluster-randomized controlled trials with meta-analysis. *The American Journal of Sports Medicine, 48*(6), 1505–1515. https://doi.org/10.1177/0363546519870175

Jones, S., Almousa, S., Gibb, A., Allamby, N., Mullen, R., Andersen, T. E., & Williams, M. (2019). Injury incidence, prevalence and severity in high-level male youth football: A systematic review. *Sports Medicine, 49*(12), 1879–1899. https://doi.org/10.1007/s40279-019-01169-8

Jones, C. M., Griffiths, P. C., & Mellalieu, S. D. (2017). Training load and fatigue marker associations with injury and illness: A systematic review of longitudinal studies. *Sports Medicine, 47*(5), 943–974. https://doi.org/10.1007/s40279-016-0619-5

Kilic, O., Kemler, E., & Gouttebarge, V. (2018). The "sequence of prevention" for musculoskeletal injuries among adult recreational footballers: A systematic review of the scientific literature. *Physical Therapy in Sport, 32*, 308–322. https://doi.org/10.1016/j.ptsp.2018.01.007

López-Valenciano, A., Ruiz-Pérez, I., Garcia-Gómez, A., Vera-Garcia, F. J., De Ste Croix, M., Myer, G. D., & Ayala, F. (2020). Epidemiology of injuries in professional football: A systematic review and meta-analysis. *British Journal of Sports Medicine, 54*(12), 711–718. https://doi.org/10.1136/bjsports-2018-099577

Lund, J., & Aaro, L. E. (2004). Accident prevention. Presentation of a model placing emphasis on human, structural and cultural factors. *Safety Science, 42*(4), 271–324.

Mah, C. D., Kezirian, E. J., Marcello, B. M., & Dement, W. C. (2018). Poor sleep quality and insufficient sleep of a collegiate student-athlete population. *Sleep Health, 4*(3), 251–257. https://doi.org/10.1016/j.sleh.2018.02.005

Mah, C. D., Mah, K. E., Kezirian, E. J., & Dement, W. C. (2011). The effects of sleep extension on the athletic performance of collegiate basketball players. *Sleep, 34*(7), 943–950. https://doi.org/10.5665/SLEEP.1132

van Mechelen, W., Hlobil, H., & Kemper, H. C. (1992). Incidence, severity, aetiology and prevention of sports injuries. A review of concepts. *Sports Medicine, 14*(2), 82–99. https://doi.org/10.2165/00007256-199214020-00002

Norcross, M., Johnson, S., & Hoffman, M. (2014). The prevalence of injury prevention program use by high school teams. *British Journal of Sports Medicine, 48*, Article 645.

O'Brien, J., & Finch, C. F. (2014). A systematic review of core implementation components in team ball sport injury prevention trials. *Injury Prevention, 20*, 357–362.

Petushek, E. J., Sugimoto, D., Stoolmiller, M., Smith, G., & Myer, G. D. (2019). Evidence-based best-practice guidelines for preventing anterior cruciate ligament injuries in young female athletes: A systematic review and meta-analysis. *The American Journal of Sports Medicine, 47*(7), 1744–1753. https://doi.org/10.1177/0363546518782460

Pickett, W., Molcho, M., Simpson, K., et al. (2005). Cross national study of injury and social $_{30}$ determinants in adolescents. *Injury Prevention, 11*, 213–218.

Plummer, A., Mugele, H., Steffen, K., Stoll, J., Mayer, F., & Müller, J. (2019). General versus sports-specific injury prevention programs in athletes: A systematic review on the effects on performance. *PloS One, 14*(8), Article e0221346. https://doi.org/10.1371/journal.pone.0221346

Reilly, T., & Edwards, B. (2007). Altered sleep-wake cycles and physical performance in athletes. *Physiology & Behavior, 90*(2–3), 274–284. https://doi.org/10.1016/j.physbeh.2006.09.017

Richmond, S. A., Donaldson, A., Macpherson, A., Bridel, W., van den Berg, C., Finch, C. F., Hagel, B., & Emery, C. A. (2020). Facilitators and barriers to the implementation of iSPRINT: A sport injury prevention program in junior high schools. *Clinical Journal of Sport Medicine, 30*(3), 231–238. https://doi.org/10.1097/JSM.0000000000000579

Robey, E., Dawson, B., Halson, S., Gregson, W., King, S., Goodman, C., & Eastwood, P. (2013). Effect of evening postexercise cold water immersion on subsequent sleep. *Medicine & Science in Sports & Exercise, 45*(7), 1394–1402. https://doi.org/10.1249/MSS.0b013e318287f321

Sadigursky, D., Braid, J. A., De Lira, D. N. L., Machado, B. A. B., Carneiro, R. J. F., & Colavolpe, P. O. (2017). The FIFA 11+ injury prevention program for soccer players: A systematic review. *BMC Sports Sci Med Rehabil, 9*(18). https://doi.org/10.1186/s13102-017-0083-z

Saragiotto, B. T., Di Pierro, C., & Lopes, A. D. (2014). Risk factors and injury prevention in elite athletes: A descriptive study of the opinions of physical therapists, doctors and trainer. *Brazilian Journal of Physical Therapy, 18*(2), 137–143. https://doi.org/10.1590/S1413-35552012005000147

Slimani, M., Bragazzi, N. L., Znazen, H., Paravlic, A., Azaiez, F., & Tod, D. (2018). Psychosocial predictors and psychological prevention of soccer injuries: A systematic review and meta-analysis of the literature. *Physical Therapy in Sport, 32*, 293–300. https://doi.org/10.1016/j.ptsp.2018.05.006

Smyth, E. A., Newman, P., Waddington, G., Weissensteiner, J. R., & Drew, M. K. (2019). Injury prevention strategies specific to pre-elite athletes competing in Olympic and professional sports - a systematic review. *Journal of Science and Medicine in Sport, 22*(8), 887–901. https://doi.org/10.1016/j.jsams

Soomro, N., Sanders, R., Hackett, D., Hubka, T., Ebrahimi, S., Freeston, J., & Cobley, S. (2016). The efficacy of injury prevention programs in adolescent team sports: A meta-analysis. *The American Journal of Sports Medicine, 44*(9), 2415–2424. https://doi.org/10.1177/0363546515618372

Sprague, A. L., Smith, A. H., Knox, P., Pohlig, R. T., & Grävare Silbernagel, K. (2018). Modifiable risk factors for patellar tendinopathy in athletes: A systematic review and meta-analysis. *British Journal of Sports Medicine, 52*(24), 1575–1585. https://doi.org/10.1136/bjsports-2017-099000

Taylor, J. B., Ford, K. R., Nguyen, A. D., Terry, L. N., & Hegedus, E. J. (2015). Prevention of lower extremity injuries in basketball: A systematic review and meta-analysis. *Sport Health, 7*(5), 392–398. https://doi.org/10.1177/1941738115593441

Thorborg, K., Krommes, K. K., Esteve, E., Clausen, M. B., Bartels, E. M., & Rathleff, M. S. (2017). Effect of specific exercise-based football injury prevention programmes on the overall injury rate in football: A systematic review and meta-analysis of the FIFA 11 and 11+ programmes. *British Journal of Sports*

Medicine, 51(7), 562–571. https://doi.org/10.1136/bjsports-2016-097066
Toohey, L. A., Drew, M. K., Cook, J. L., Finch, C. F., & Gaida, J. E. (2017). Is subsequent lower limb injury associated with previous injury? A systematic review and meta-analysis. *British Journal of Sports Medicine, 51*(23), 1670–1678. https://doi.org/10.1136/bjsports-2017-097500
Twomey, D., Finch, C., Roediger, E., et al. (2009). Preventing lower limb injuries: Is the latest evidence being translated into the football field? *Journal of Science and Medicine in Sport, 12*, 452–456.
Webster, K. E., & Hewett, T. E. (2018). Meta-analysis of meta-analyses of anterior cruciate ligament injury reduction training programs. *Journal of Orthopaedic Research, 36*(10), 2696–2708. https://doi.org/10.1002/jor.24043
Whittaker, J. L., Booysen, N., de la Motte, S., Dennett, L., Lewis, C. L., Wilson, D., McKay, C., Warner, M., Padua, D., Emery, C. A., & Stokes, M. (2017). Predicting sport and occupational lower extremity injury risk through movement quality screening: A systematic review. *British Journal of Sports Medicine, 51*(7), 580–585. https://doi.org/10.1136/bjsports-2016-096760
Whittaker, J. L., Small, C., Maffey, L., & Emery, C. A. (2015). Risk factors for groin injury in sport: An updated systematic review. *British Journal of Sports Medicine, 49*(12), 803–809. https://doi.org/10.1136/bjsports-2014-094287
Wiggins, A. J., Grandhi, R. K., Schneider, D. K., Stanfield, D., Webster, K. E., & Myer, G. D. (2016). Risk of secondary injury in younger athletes after anterior cruciate ligament reconstruction: A systematic review and meta-analysis. *The American Journal of Sports Medicine, 44*(7), 1861–1876. https://doi.org/10.1177/0363546515621554
van der Worp, M. P., ten Haaf, D. S., van Cingel, R., de Wijer, A., Nijhuis-van der Sanden, M. W., & Staal, J. B. (2015). Injuries in runners; a systematic review on risk factors and sex differences. *PloS One, 10*(2), Article e0114937. https://doi.org/10.1371/journal.pone.0114937