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Perspectives on reasons why football and handball players sustain acute and severe knee injuries: a mixed-methods concept mapping study

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ABSTRACT

Background The high incidence of knee injuries in football/handball challenges effective prevention. Identifying tangible and modifiable factors associated with a knee injury may innovate preventive actions. Engaging key stakeholders can reveal crucial insights that could improve knee injury prevention in football/handball.

Objective To investigate football/handball stakeholders' perspectives on reasons for acute and severe knee injuries to generate a conceptual model on important factors associated with knee injuries in football/handball.

Methods Mixed-method participatory Group Concept Mapping was applied to collect statements from football/handball stakeholders (players/coaches/healthcare staff/researchers) on the question, '*What may explain why some players sustain a knee injury?*'. Participants rated the importance and feasibility of screening for each statement. Multidimensional scaling and hierarchical cluster analysis produced a cluster map, forming the basis for developing a final conceptual model.

Results Stakeholders (n=37) generated and sorted 100 statements. Cluster analysis followed by cluster map validation yielded seven themes: (1) the player's physical and motor skill profile, (2) preparation and training, (3) footwear and playing surface, (4) the sport's impact on the risk of injury, (5) mental and physical fatigue, (6) history of injury and 7) genetics and context. A final conceptual model illustrating factors associated with knee injuries in football/handball was developed. Forty-six statements were identified as both important and feasible to screen for.

Conclusions Stakeholders' perspectives on knee injuries in football/handball revealed a complex interplay of factors. We developed a conceptual model fostering stakeholder dialogue for enhanced prevention. Key among its themes is 'preparation and training'.

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ Acute and severe knee injuries in football/handball are frequent, devastating and costly.
⇒ It is imperative—but difficult to mitigate knee injuries in football/handball.
⇒ Key stakeholder involvement is essential to enhance knee injury prevention in football/handball.

WHAT THIS STUDY ADDS

⇒ Perspectives of football/handball stakeholders, including players, coaches, clinicians and researchers, enrich the current research evidence on knee injury risk factors in these sports.
⇒ Seven key themes covering important aspects associated with knee injuries in football and handball were identified: (1) the player's physical and motor skill profile, (2) preparation and training, (3) footwear and playing surface, (4) the sport's impact on the risk of injury, (5) mental and physical fatigue, (6) history of injury and (7) genetics and context.
⇒ A conceptual model was developed on important factors associated with knee injuries in football/handball, benefitting the prevention endeavours.
⇒ Preparation and training, a prominent theme in the conceptual model, offers actionable ideas for injury prevention enhancement in football/handball communities.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ The conceptual model may catalyse dialogue and engagement of stakeholders to develop further, refine and implement knee injury prevention tools or strategies in football/handball.
⇒ The conceptual model may strengthen collaborative knee injury prevention efforts across research and football/handball practice.
⇒ The conceptual model may guide identifying and prioritising new research questions for knee injury prevention in football/handball.

INTRODUCTION

Acute and severe knee injuries are common in football and handball,[1–4] often requiring surgery and long-term rehabilitation.[5] Despite these interventions, knee function remains inferior to pre-injury levels.[6–9] This may limit the success of return to play and participation in other physical activities.[10] Furthermore, traumatic knee injury is a known risk factor

for later development of knee osteoarthritis (OA),[11 12] which is the leading cause of disability worldwide.[13] Thus, knee injury prevention is imperative to maintain sports participation and functional ability and mitigate the risk of OA. However, knee injury prevention is complex,[14] and so far, no prognostic tools exist to identify players at risk of knee injury in football/handball.[15] Thus, innovative actions are needed to improve knee injury prevention in football/handball. For this purpose, relevant knee injury risk factors must be elucidated thoroughly, continuously and using different approaches.

Multiple factors may explain the high rate of acute knee injuries, including extrinsic factors such as playing surface, footwear, weather conditions and intrinsic factors such as body composition/anatomy, neuromuscular control and movement biomechanics.[16–23] While these suggested factors primarily stem from theoretical models and sports medicine/epidemiology research,[24] the experiences of key stakeholders (eg, players, coaches, healthcare staff) are missing.[14] However, these stakeholders may possess valuable and novel perspectives that can be used to create conceptual frameworks to enhance knee injury prevention. Accordingly, the study investigated football/handball stakeholders' perspectives on reasons for knee injuries, including exploring the importance and feasibility of screening for the suggested reasons in relation to knee injury prevention. This was used to generate a conceptual model on important factors associated with knee injuries in football/handball.

METHODS

Study design and procedures

To address the aim of the study, we applied group concept mapping (GCM).[25–31] GCM is based on a mixed-methods participatory approach to generate and structure ideas on a specific topic.[29] The structured GCM process included six steps: (1) preparing for GCM, (2) generating the ideas (brainstorming), (3) structuring the statements (sorting and rating), (4) GCM analysis (data analysis), (5) interpretation (validation) and (6) utilisation (developing a conceptual model).[29] GCM was performed using the Concept System Groupwisdom software: Concept Systems, Inc. Copyright 2004–2020; all rights reserved (hereafter: Groupwisdom). Steps 2–3 (brainstorming, sorting/rating) were conducted online individually by the participants, while Steps 5–6 were face-to-face meetings. The study was conducted in Danish. For international communication, including this publication, the statements were subsequently translated into English by a native English-speaking employee.

Step 1: preparation

Focus prompt

Before the data collection, a focus prompt was formulated and piloted among one football player (sub-elite level), two football coaches (amateur level) and one researcher (physiotherapy with relation to football). The final prompt for the brainstorming (Step 2) was '*What may explain why some players sustain a knee injury?*' To clarify our definition of 'knee injury', we added *'Knee injury is defined as acute knee injury requiring treatment, resulting in the player being unable to participate in football/handball for a longer period (months/years)'.*

Participants and recruitment

Players, coaches, healthcare staff and researchers in football/handball were informed about the study and invited to participate. Participants were required to be able to read and write in Danish and willing to join at least one of three activities: brainstorming (Step 2), sorting and rating of data (Step 3) and/or validation of data (Step 5). Coaches were recruited from Danish football/handball clubs. Other participants were recruited in clubs (sub-elite level); within the professional network at the University of Copenhagen and The Parker Institute, Bispebjerg-Frederiksberg Hospital, Copenhagen, Denmark; and via the extended professional networks outside these institutions.

Step 2: generating the ideas

Brainstorming

Potential participants were contacted via email and invited to participate. Those who volunteered were emailed a link to the brainstorming process in Groupwisdom. They were instructed to brainstorm with as many brief statements/ideas as possible for the focus prompt. They were asked to keep each statement/idea short, containing only one meaning (eg, 'congestion' or 'playing too many games'). The brainstorming lasted 3 weeks, and one reminder was sent before concluding the step.

Brainstorming data processing

Based on the participants' brainstorming, an overall list of statements was generated. Identical statements (ie, ideas with the same wording or meaning) were individually identified by two authors (EB and TA) and removed after reaching a consensus. When consensus was lacking on idea duplication, unique ideas were retained. If needed, statements with multiple meanings were split, and language was edited to ensure readability. Subsequently, the list of statements was imported into Groupwisdom for Step 3 (sorting/rating).

Step 3: structuring the statements

Statement sorting and rating

Participants were invited to participate in the sorting/rating process (Step 3), even if they had not contributed to Step 2.

First, the participants were asked to sort the statements into piles that made sense to them and then label each pile. The participants should create more than one pile but fewer than the total number of statements. They were instructed to avoid creating prioritised or valued piles and to refrain from grouping dissimilar statements. If necessary, they could leave unrelated statements in separate piles. Second, the participants rated each statement

with respect to the importance of screening on a four-point ordinal scale: (1) 'not important', (2) 'somewhat important', (3) 'important' and (4) 'very important'. The prompting question was '*How important is it to screen for this particular aspect in relation to knee injury prevention?*'. Similarly, participants rated the screening feasibility of each statement on a four-point ordinal scale: (1) 'not easy', (2) 'somewhat easy', (3) 'easy' and (4) 'very easy'. The prompting question was '*How easy is it to screen for this particular aspect in relation to knee injury prevention?*'. Each participant performed the sorting and rating tasks individually. One reminder was emailed before concluding Step 3, which lasted 4 weeks.

Step 4: concept mapping analysis

Single participant data from Step 3 (sorting and rating) were included in the cluster analysis if more than 75% of the statements were sorted. Based on the sorting and rating tasks, multidimensional scaling and hierarchical cluster analysis were performed using the Groupwisdom software, grouping related statements into clusters.[29] Three authors (TA, EB and EEW) reviewed six different cluster solutions, representing cluster maps of five to ten clusters from which the solution with the best data representation (ie, the solution preserving the most useful information) was selected. Potential cluster labels were automatically suggested by the Groupwisdom software from the labels provided by the participants in Step 3.

A stress value is calculated as part of the multidimensional scaling analysis and used to determine if the results are interpretable. Stress values of <0.39 indicate congruence between the raw data and processed data,[29] supporting that results are interpretable.[32]

The importance and feasibility ratings for screening were calculated and reported as median values, along with their ranges for each cluster. Furthermore, we produced a modified version of the so-called 'go-zones'.[29] Four go-zones were defined by dichotomising the importance of the screening rating scale, that is, ratings of 1 and 2 were considered low importance of screening and ratings of 3 and 4 high importance of screening. The same procedure was applied to the screening feasibility rating scale, resulting in a plot divided into four quadrants. Then, median values of the importance of screening and screening feasibility for each statement were plotted against each other, placing each statement in one of the four quadrants.

Step 5: interpretation (validation)

All participants were invited by e-mail to join the interpretation/validation process. The group convened for Step 5 comprised participants from all pertinent stakeholder groups to interpret and validate the results from Step 4. The senior author (EEW) presented the point map, including a bridging values cluster map and an overview of clusters and statements and invited the participants to (a) determine if each statement was placed in the right cluster, (b) consider the number of clusters and (c) consider if the cluster labels illustrated the theme of the cluster. Statements considered by the participants to be fitting into more than one cluster were to remain in their designated cluster, and only statements misplaced were to be moved. Based on the presented map, reflections and suggestions were discussed to obtain consensus.

Step 6: utilisation (conceptual model development)

Four members of the author group (EB, MKZ, KT and TA) met to develop a conceptual model integrating findings from both the GCM analyses (Step 4) and the validation process (Step 5). The development of this model adhered to guiding principles that underscored the prioritisation of modifiable elements[17] and those closely linked to the players, thus crucial for injury prevention considerations.

Participant characteristics

Participants provided information regarding gender (male/female/other), age (years), sports relationship (football/handball), role as player/coach/healthcare staff/researcher, experience in role (years), lived experience of knee injury (yes/no) and experience with knee injuries of others. Furthermore, the types of involvement in the GCM process were registered.

RESULTS

The brainstorming, sorting and rating tasks were conducted from April to June 2022. The validation meeting (6 October 2022) and the conceptual model development meeting (6 January 2023) occurred at the Parker Institute, Bispebjerg-Frederiksberg Hospital, Copenhagen, Denmark.

Participants

Table 1 presents the participant characteristics by study steps. Thirty-seven participants contributed to the brainstorming, of which 17 assisted in structuring statements (sorting/rating). Finally, the validation meeting was attended by 11 participants; four participated for the first time in this GCM process, while the remaining seven had prior involvement.

GCM data

A total of 123 statements were generated in Step 2 (generating ideas), and after removing 27 identical statements and splitting statements with more than one meaning, 100 unique statements were included for sorting/rating. Minor statement revisions were done to clarify the meaning.

In Step 3 (sorting and rating), 22 participants were assigned the tasks, and the sorting of statements of 17 participants was approved (median number of sorted statements=100, range: 97 to 100). These participants sorted the statements into 2 to 15 groups (median number of groups=7). Data from the remaining five participants could not be approved as they left >75% of the statements unsorted. The importance of screening ratings was approved for all 17 participants (median number of statements=100, range: 99 to 100). The

Table 1 Participant characteristics

	Step 2 generating ideas (n=37)	Step 3 structuring statements (n=17)	Step 5 interpretation (validation) (n=11)
Age years, median (min–max)	35 (20–55)*	40 (20–55)	41 (26–55)
Gender, n (%)†			
M	25 (67.6)	9 (52.9)	3 (27.3)
F	11 (29.7)	8 (47.1)	8 (72.7)
Other	0 (0)	0 (0)	0 (0)
Previously knee injured, n (%)	17 (51.5)*	9 (52.9)	5 (45.5)
Know anyone with a knee injury, n (%)	31 (93.9)*	16 (94.1)	11 (100)
Role, n (%)			
Player	17 (45.9)	6 (35.3)	2 (18.2)
Coach	7 (18.9)	1 (5.9)	1 (9.1)
Healthcare staff	8 (21.6)	5 (29.4)	4 (36.4)
Researcher	5 (13.5)	5 (29.4)	4 (36.4)
Sport, n (%)			
Football	30 (81.1)	12 (70.6)	6 (54.5)
Handball	7 (18.9)	5 (29.4)	5 (45.5)
Experience, years, median (min–max)			
Player	15 (4–45)‡	14.5 (4–32)	26 (20–32)
Coach	21 (10–28)§	10 (10)	24 (24)
Healthcare staff	15 (1–17)¶	14 (1–17)	15.5 (1–17)
Researcher	20 (7–28)	20 (7–28)	20 (12–28)

*4 missing observations.
†1 (Step 2) missing observation.
‡1 missing observation.
§2 missing observations.
¶1 missing observation.

screening feasibility ratings were approved for 15 participants (median number of statements=100, range: 96 to 100). Two participants never initiated the screening feasibility rating of statements.

The multidimensional scaling analysis (Step 4; concept mapping analysis) revealed a stress value of 0.21. The eight-cluster solution was chosen for further examination at the validation meeting. The eight clusters contained

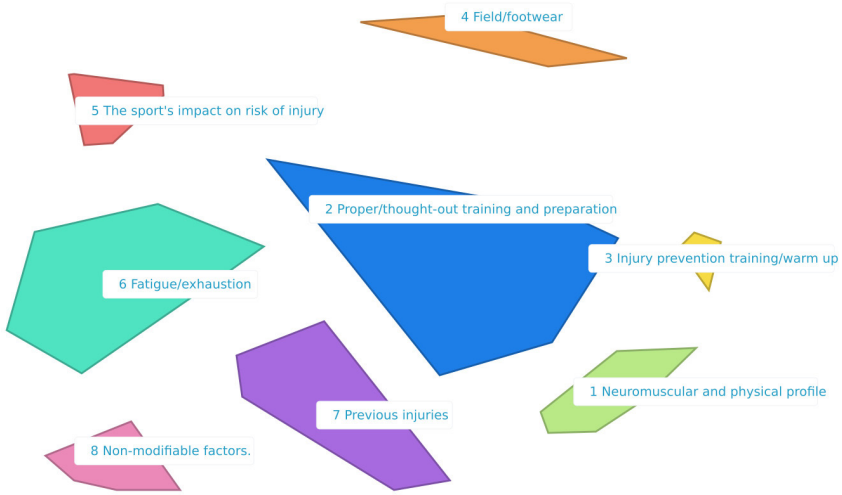

Figure 1 Cluster map with eight clusters. The proximity of clusters on the map indicates how related they are.

9 to 19 statements and were presented as a cluster map (figure 1).

At the validation meeting (Step 5; interpretation/validation), two pairs of identical statements were identified and removed from the final list of statements intended to accompany the conceptual model. Discussions and further examination of the map led to consensus-based decisions on the location of the remaining 98 statements; most (n=86, 87.7%) stayed in the original cluster, while a few (n=12, 14.3%) were moved between clusters (online supplemental material table S1). Furthermore, the participants suggested merging clusters 2 and 3 (figure 1) into one single cluster (c.f. '(2) Preparation and training', table 2). This concurred with the six-cluster solution reviewed in Step 4, where clusters 2 and 3 formed one single cluster. Hence, the validation process resulted in seven themes containing between five and 27 statements (table 2, online supplemental material table S1). Furthermore, the participants suggested new labels, resulting in seven final themes (table 2).

Statements were predominantly rated as 'important' (n=66, 67.3%) or 'very important' (n=14, 14.3%). The importance ratings of the statements were also reflected by a median value of three in all themes, except for

Table 2 Description of the final seven themes

Themes		Summary of content
The player's physical and motor skill profile		
No. of statements (%)	13 (13.3)	Muscle strength deficit or strength asymmetry, both in general and muscle-specific (hip external rotators and hamstring muscles), together with insufficient neuromuscular control of the knee, were prominent aspects. Soft tissue (eg, ligaments, menisci) weakness and instability, together with movement patterns or non-automatised activation patterns leading to uneven knee loadings, were also aspects of this theme.
Importance of screening, median (range)*	3 (2–3)	
Screening feasibility, median (range)*	2 (1–3)	
Preparation and training		
No. of statements (%)	27 (27.6)	Limited, wrong or no implementation of injury prevention were prominent aspects. Lack of warm-up and insufficient recovery after injury/illness, nutrition and intake of pain medication before playing together with too high training and match intensity/frequency, especially among young players, were also aspects of this theme.
Importance of screening, median (range)*	3 (2–4)	
Screening feasibility, median (range)*	3 (1–3)	
Footwear and playing surface		
No. of statements (%)	18 (18.4)	The combination of specific footwear and specific playing surfaces was crucial. One highlighted scenario was the fixation of football boots on particularly artificial grass, leading to knee/ankle twisting. Other aspects were slippery or uneven playing surfaces.
Importance of screening, median (range)*	3 (2–3)	
Screening feasibility, median (range)*	3 (3–4)	
The sport's impact on the risk of injury		
No. of statements (%)	14 (14.3)	Sport-specific issues such as contact/non-contact pushes/collisions and unforeseen events/movements were prominent aspects. The specialisation of young players was too early, and limited player experience was also highlighted.
Importance of screening, median (range)*	3 (2–3)	
Screening feasibility, median (range)*	2 (1–4)	
Mental and physical fatigue		
No. of statements (%)	12 (12.2)	Mental and physical fatigue in general and due to overloading of matches/training, insufficient restitution or sleep and imbalanced recovery/exposure were prominent aspects.
Importance of screening, median (range)*	3 (2–4)	
Screening feasibility, median (range)*	2 (1–3)	
History of injury		
No. of statements (%)	5 (5.1)	Previous injuries and minor injuries (all types) were a prominent aspect.
Importance of screening, median (range)*	3 (3–4)	
Screening feasibility, median (range)*	3 (2–4)	
Genetics and context		
No. of statements (%)	9 (9.2)	Genetics, genetic susceptibility, sex, age, biology, physiology, anatomy, social context and societal expectations of females (adorable rather than muscular) were prominent aspects.
Importance of screening, median (range)*	2 (2–3)	
Screening feasibility, median (range)*	2 (1–4)	

*Note. The medians (range) are calculated based on median values of ratings of the importance of screening and screening feasibility for each statement within each theme, and the range values represent the lowest and highest median values, respectively, for the statements of the theme.

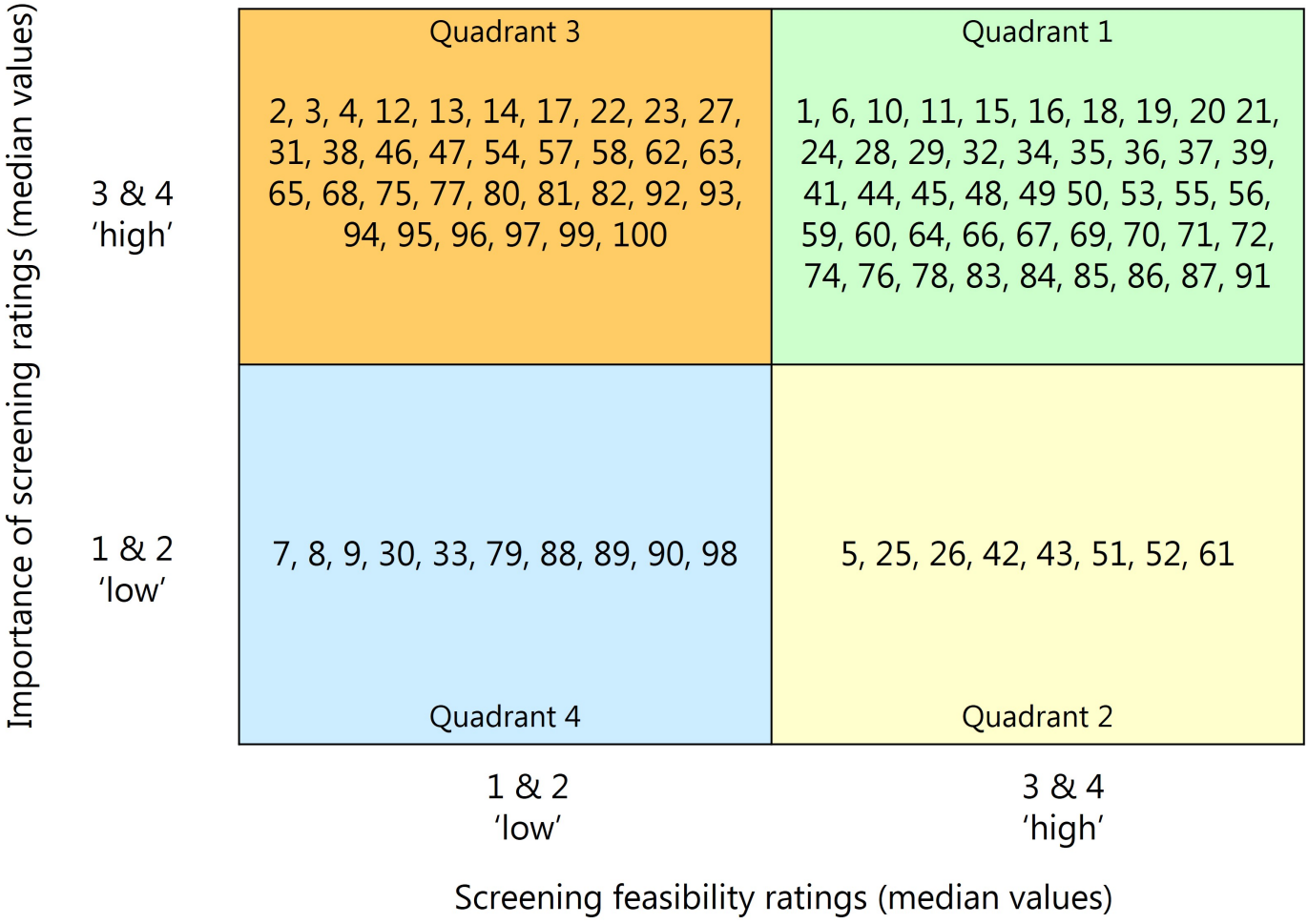

Figure 2 Go-zone plot illustrating the median values of ratings of the importance of screening (y-axis) against screening feasibility ratings (x-axis) for each statement. Ratings of 3 and 4 were labelled as 'high', and values of 1 and 2 were labelled as 'low'. Numbers in the four quadrants represent each statement. Quadrant 1 (green): 'high' ratings for the importance of screening and screening feasibility. Quadrant 2 (yellow): 'low' importance of screening and 'high' screening feasibility ratings. Quadrant 3 (orange): 'high' importance of screening and 'low' screening feasibility ratings. Quadrant 4 (blue): 'low' ratings for the importance of screening and screening feasibility. Quadrant 1 (green; top right) contains the highest-rated statements.

'genetics and context' (median value 2). Regarding the screening feasibility, more than half of the statements were rated as 'easy' (n=45, 45.9%) or 'very easy' (n=10, 10.2 %) to screen for. Three themes ('preparation and training', 'footwear and playing surface' and 'history of injury') predominantly contained statements rated as easy to screen for (table 2). The final themes, including all the statements, are presented in online supplemental material table S1.

The relationship between the importance of screening and screening feasibility ratings of all statements ('go-zones') is shown in figure 2. Quadrant 1 (top right) contains the statements with the highest ratings (3 and 4) regarding both the importance of screening and screening feasibility (n=46, online supplemental material table S2). The majority of quadrant 1 statements (21/46) were from 'preparation and training', followed by statements from 'footwear and playing surface' (14/46).

A final conceptual model (Step 6) was developed based on the GCM analyses and the validation session. We chose a puzzle model to serve as a dialogue tool to enhance injury prevention in the football/handball environments (figure 3).

DISCUSSION

This study aimed to conceptualise key stakeholders' perspectives on reasons for acute, severe knee injuries in football/handball. Furthermore, we aimed to identify reasons that were both important and easy to screen in relation to knee injury prevention. GCM was used to gather and synthesise perspectives of football/handball stakeholders, resulting in a final conceptual model comprising seven themes: (1) the player's physical and motor skill profile, (2) preparation and training, (3) footwear and playing surface, (4) the sport's impact on the risk of injury, (5) mental and physical fatigue, (6) history of injury and 7) genetics and context. Our results reflect the values and preferences of the included football/handball stakeholders (players, coaches, clinicians, researchers). This type of results can supplement the

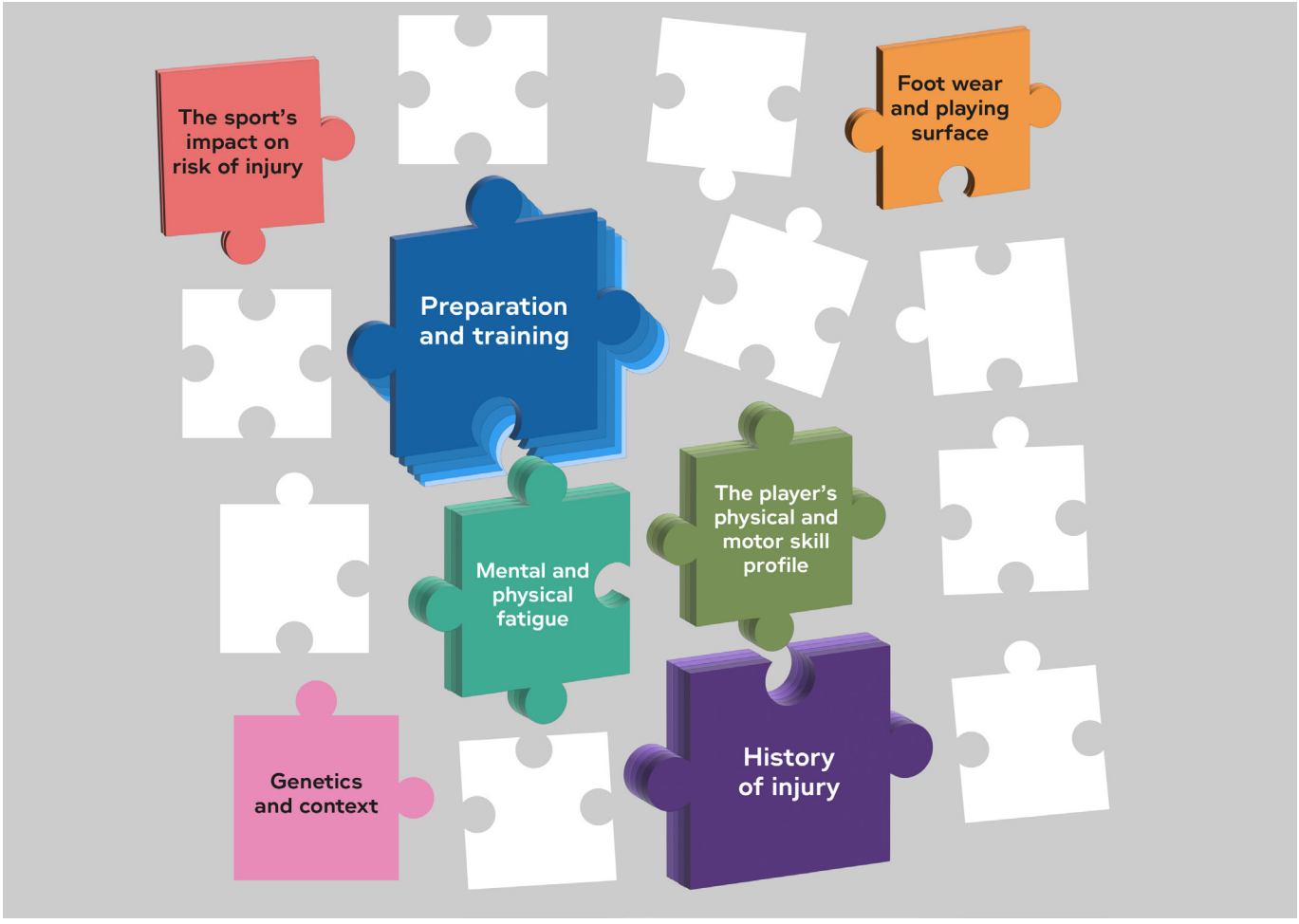

Figure 3 Conceptual model. A puzzle model with the seven final themes (c.f. table 2) is illustrated as puzzle pieces of different heights/sizes (the higher/wider reflects aspects considered important aspects that are modifiable and/or very important to consider concerning injury prevention). Themes representing basic terms/external factors/non-modifiable factors are either corners or one-siders (ie, at the edge). In contrast, themes representing intrinsic/modifiable factors linked to the player or the training context are placed in the middle. The total of 16 pieces signifies the comprehensive nature of our conceptual model, aiming to capture various elements contributing to knee injury risk in football/handball, with the acknowledgement that there may be undiscovered factors.

current research on knee injury risk factors in football/handball and provide a conceptual model to enhance prevention through stakeholder dialogue.

The conceptual model reflects that perspectives on knee injury reasons in football/handball are complex. This is consistent with theoretical sports injury models and research suggesting that a multifactorial approach is needed to understand why injuries occur.[17 24 33] Literature on knee injury risk factors and prevention focuses on many topics, such as neuromuscular factors, injury prevention training, sport specificity and previous injuries.[1 34–37] These aspects were also reflected in our results. Furthermore, our results highlighted that themes related to the players' physical/motor skills, preparation/training, mental/physical fatigue condition and previous injuries were important to screen for and closely related. This reflects that many factors interact in complex ways, potentially increasing a player's susceptibility to knee injury and emphasises that knee injury prevention requires systemic consideration of multiple factors.

In contrast, the 'footwear and playing surface' theme differed. Moreover, this theme seems to contain tangible factors calling for immediate further sport-specific examinations, as football and handball are performed with specialised shoes/boots on special playing/training surfaces. Existing reports regarding footwear and playing surfaces as knee injury risk factors show inconclusive results.[38] Our results mentioned the fixation of football boots on artificial grass, which led to knee twisting, among the statements. Thus, further research on knee joint biomechanics related to specific combinations of football boots-playing surfaces is relevant.[39–41]

The themes 'the sport's impact on the risk of injury' and 'genetics and context' represent factors that are difficult/impossible to change. However, one statement regarding societal expectations for female players to be

attractive rather than muscular was mentioned in the 'genetics and context' theme. Other researchers have recently recognised this issue[42] and are advocating for increasing the focus on gendered factors to enhance injury prevention.

Injury prevention training interventions have effectively reduced knee injuries in handball and football.[43] Our participants also recognised the importance of injury prevention training, which was one of the most prominent aspects under the 'preparation and training' theme. Our participants also considered the history of injury important. Prospective cohort studies among team ball sport athletes support that previous injuries, particularly previous knee injuries, increase the risk of new acute knee injuries.[34–36] This re-emphasises that players with previous injuries need special care and attention.

Our conceptual model may catalyse dialogue engaging football/handball stakeholders by presenting diverse aspects related to knee injuries fostering discussions that benefit collaboration, a crucial task in sports injury prevention.[14 27 28 44 45] This may also inspire the co-creation of effective injury prevention strategies within the football/handball community. An example of the engagement of stakeholders and interdisciplinary researchers to develop injury prevention training has recently been documented within handball.[44] A future study could test our conceptual model's efficacy as a dialogue catalyst.

Forty-six statements deemed important and feasible for screening can be transformed into a football/handball practice checklist. We identify coaches as the primary target audience for this checklist, as the 46 statements primarily pertain to preparation and training. Additionally, emphasising the footwear and playing surface statements encourage coaches and players to prioritise these aspects.

Our study is subject to limitations. First, our participants were Danish from football/handball environments in Denmark. This may limit the generalisability of the results in relation to football/handball outside Denmark. Second, as participants were from both football and handball, our results apply to both sports, meaning that sport-specific issues may have been masked. Most of our participants in the brainstorming and sorting/rating processes were from football, while the football/handball representation was equal in the validation process. Still, we cannot rule out that our results apply more to football than handball. Third, participant bias may arise from instructions in Step 2, which included examples introducing uncertainty. Fourth, stakeholders' screening ratings may vary due to differences in familiarity/expertise, especially among players and coaches. However, as the ratings were successfully completed, these variations are considered minor. Finally, our participants may share a common pre-understanding of the problem, which could introduce cognitive biases and lead to omission of important aspects.

CONCLUSION

Stakeholders' perspectives on reasons for knee injuries in football/handball revealed a complex interplay of factors, including both specific/actionable and more generic/intangible elements. We developed a conceptual model that could catalyse dialogue among stakeholders and be beneficial for enhancing knee injury prevention in football/handball. Key among its themes is 'preparation and training', offering actionable insights for injury prevention in these sports.

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Contributors All authors contributed to the writing and reviewing of the manuscript. TA, EB, MH and EEW conceived the idea of the study and managed the methodological process. All authors participated in the data interpretation. Approval of the final manuscript was obtained from all authors. All authors take responsibility for the integrity of the work from conception to publication. TA is the study guarantor.

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Competing interests MH is on the scientific advisory board of the Thuasne group. All other authors (RC, TA, MKZ, KT, JB, PMH, EB, EEW) have no conflicts of interests.

Patient and public involvement Patients and/or the public were involved in the design, conduct, 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 involved human participants but was not approved by the Committee on Health Research Ethics, and according to Danish legislation, the Danish Data Protection Agency was not required, as no subjects were exposed to medical interventions/devices and no sensitive data were collected. Electronic

informed consent was obtained, and all participants were informed about their right to withdraw at any time from the study. Participants gave informed consent to participate in the study before taking part.

Provenance and peer review Not commissioned; externally peer reviewed.

Data availability statement All data relevant to the study are included in the article or uploaded as supplementary information.

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