

Youth sport injury research: a narrative review and the potential of interdisciplinarity

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ABSTRACT

To prevent sports injuries, researchers have aimed to understand injury aetiology from both the natural and social sciences and through applying different methodologies. This research has produced strong disciplinary knowledge and a number of injury prevention programmes. Yet, the injury rate continues to be high, especially in youth sport and youth football. A key reason for the continued high injury rate is the development of injury prevention programmes based on monodisciplinary knowledge that does not account for the complex nature of sport injury aetiology. The purpose of this paper is to consider and outline an interdisciplinary research process to research the complex nature of sport injury aetiology. To support our proposition, we first present a narrative review of existing youth football and youth sport injury research demonstrating an absence of paradigmatic integration across the research areas' main disciplines of biomedicine, psychology and sociology. We then demonstrate how interdisciplinary research can address the complexity of youth sport injury aetiology. Finally, we introduce the interdisciplinary process we have recently followed in a youth football injury research project. While further research is necessary, particularly regarding the integration of qualitative and quantitative sport injury data, we propose that the pragmatic interdisciplinary research process can be useful for researchers who aim to work across disciplines and paradigms and aim to employ methodological pluralism in their research.

INTRODUCTION

Youth sport injury research has during the past years produced important knowledge concerning injury aetiology and injury prevention. Most of this scholarship has emerged from research conducted in specific scientific disciplines, primarily biomechanics, sport medicine, exercise physiology, sport psychology and sport sociology.¹ Broadly speaking, researchers of these disciplines follow distinctive assumptions of what an injury is and what research questions, ethical stances, research methods and interpretations and explanations of results are most appropriate to study this phenomenon.^{2,3} These constellations of beliefs, values

What is already known?

- ▶ Youth athletes sustain injuries.
- ▶ Youth sport injuries have been researched from multiple scientific disciplines.
- ▶ There is growing support for the application of a complexity approach to sport injury research.

What are the new findings?

- ▶ An overview of youth football and youth sport injury research from the scientific disciplines of biomedicine, psychology and sociology.
- ▶ Paradigmatic distinctions in youth football and youth sport injury research create scientific differences between bodies of injury research.
- ▶ Youth football and youth sport injury research lacks integration across disciplines and paradigms.
- ▶ Our proposed interdisciplinary research process consists of five phases that demonstrates the working process of a project researching youth football injuries.
- ▶ The five-phase process can be considered a response to the call for interdisciplinarity in sport injury research as well as a practical guide.

and methodologies are referred to as scientific *paradigms*. Existing youth sport injury research can be categorised by three paradigms: positivism, postpositivism and interpretivism. The positivist paradigm is closely related to reductionism, and reality and truth are understood as singular and identifiable. Positivist sport injury research has specifically focused on identifying and separating risk factors.⁴ Methodologically, objectivity is paramount, which requires researchers to detach themselves from the study object. In analysis, the identified risk factors are used to generalise causality.^{3,5} In the postpositivist paradigm, reality and truth are understood alike positivism. However, researchers adopt diverse research methods to establish causality, including through qualitative methodology.³ In the interpretivist paradigm, reality



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and truth are understood as multiple and relative.^{2 3} Researcher objectivity is not considered possible as it is assumed that truth is constructed between researchers and the researched. The overall aim is to gain a deeper understanding of what an injury means, and how it is experienced and made sense of.

Scientific paradigms guide researchers and research,^{2 3 5} and they have shaped research on youth sport injury aetiology. The existing body of knowledge is comprehensive, however, seldom brought together to understand sport injury and sport injury aetiology from the perspectives presently adopted. Thus, an interdisciplinary understanding that is interparadigmatic is missing. Recently, a number of sport injury researchers have critiqued the reductionist methodology that characterises most research on sport injury aetiology and suggested a turn to complexity to account for the multidimensional nature of sport injury aetiology.^{4 6-9} At present, however, relatively few researchers adopt a complexity approach and scholarship is only at the conceptual level. Moreover, current discussions have not included ways to integrate the influence socio-cultural context has.

The purpose of this paper is to advance existing youth sport injury aetiology scholarship by considering and outlining an interdisciplinary research process to research the complex nature of youth sport injury aetiology. In our view, an interdisciplinary approach that is interparadigmatic has potential to generate data that can address the complexity of an injury. To support our proposition for interdisciplinarity, the paper aims to: (1) present the results of a narrative review that examined multidisciplinary literature on youth sport injury aetiology; (2) discuss interdisciplinary research to consider how such an approach can address the complexity of youth sport injury aetiology and (3) introduce an interdisciplinary research process that we have adopted in a research project on youth football injury aetiology.

To achieve the above aims, we draw on the research context of the ongoing project 'Injury free children and adolescents: towards best practice in Swedish football' (FIT project).¹⁰ The purpose of the FIT project is to provide evidence-based interdisciplinary injury prevention strategies. To achieve this, the project aims to produce a comprehensive picture of injury aetiology in a sample of male and female Swedish football players aged 10–19 years through integrating natural and social science and producing quantitative and qualitative data. The research team includes scholars from biomechanics, sport medicine, sociology and sport coaching. The project started in January 2017 and involved a prospective questionnaire to record incidence and prevalence of injuries over a 5-month period, one-time biomedical testing (clinical examination, isometric strength measurements, running analysis and knee stability), a 5-month analysis of training protocols, observation of training sessions of players and their coaches and interviews with players and coaches. At present, the project is working towards the integration of collected quantitative and qualitative data.

NARRATIVE REVIEW OF YOUTH FOOTBALL AND SPORT INJURY RESEARCH

We conducted a narrative review of literature relevant to youth football injury aetiology to provide a critical synthesis of existing literature and to specifically identify paradigmatic and methodological assumptions, research approaches, research methods and data analysis procedures. The focus on existing literature's paradigmatic distinctions is an important first step in interdisciplinary work.³ According to Phoenix *et al*⁸ (p. 220), a 'step back' to understand underlying assumptions can advance knowledge and awareness of the respective research field as a way to 'move beyond debates about right or wrong ways of approaching research'.

The first author has from January 2017 to May 2020 searched for literature on youth football injuries in the databases PubMed, Scopus, PsycINFO and Web of Science. Search terms included various combinations of 'youth', 'soccer', 'football', 'injury', 'aetiology' and 'risk'. Inclusion criteria were set to youth football players aged approximately 10–19 years and injury aetiology, injury prevention and/or injury risk factors. The search revealed a paucity of sociological youth football injury research. Thus, the search was broadened to sociological injury research in different sports and age groups, which identified research in biathlon, figure skating, rhythmic gymnastics, rugby and softball. To identify assumptions underlying paradigmatic distinctions, we predefined three analytic areas: body and injury perspective (state of the art regarding how an injury is explained and defined); paradigmatic assumptions (reality/truth/knowledge) and research approaches (methodology). Based on how these categories were approached in the literature included in the review, as well as discussions in the FIT project team and a presentation at a scientific conference,¹¹ we placed the literature in the three paradigms dominant for youth sport injury research: positivism, postpositivism and interpretivism. Furthermore, five dominant disciplines of youth sport injury research were identified based on the reviewed literature; biomedicine (biomechanics, sport medicine and exercise physiology), sport psychology and sport sociology. **Table 1** summarises key findings of the narrative review.

Biomedical research

Biomedical research on injuries in youth football has mostly focused on individual injury risk factors relating to kinematics, kinetics and spatiotemporal variables, physical development and amount of training and competitions. Key findings from our literature search show that age, growth and biological maturation contribute to an increased risk of injuries, especially during the year of peak height velocity.¹²⁻¹⁴ Possible risk factor for injuries in youth football players during this period include muscle strength,¹⁵ familial disposition,¹⁶ previous injury,¹⁷ physical stress (ie, training and match duration and perceived exertion)¹⁸ and match playing.^{12 16} Furthermore, external factors such as playing turf and type of shoes are associated with injuries among

Table 1 Distinctions of youth football and sport injury aetiology research

	Biomedical research	Psychological research	Sociological research
State of the art	Injury is specific epidemiological/physical damage to tissue/muscles/bones. Injury aetiology is a result of the accumulating effect of internal/external risk factors. Injury aetiology is a result of complex interactions of multiple components in and around the athlete (complexity approach). Injury aetiology is explained/theorised in models and frameworks. Injury prevention is possible through interventions that target the physical body, mind and environment.		Injury is interpreted by athletes and researchers. Injury can be explained/understood by examining sociocultural context. Injury aetiology is a (non-linear) process. Injury aetiology is explained and understood through conceptualisation and theorisation. Injury prevention is possible through education and adapting sociocultural conditions.
Reality/Truth	Injury is an objective reality. Injury aetiology can be measured and studied.	Injury is an objective reality. Injury aetiology can be measured and studied, but never fully grasped.	Injury is a socially constructed reality. Injury aetiology is constructed intersubjectively through the meanings and understandings relative to sociocultural context.
Nature of knowledge	Injury aetiology knowledge is objective. To generate injury aetiology knowledge, researchers detach themselves from athletes and context.	Injury aetiology knowledge is approximate. To generate injury aetiology knowledge, researchers keep interactions with athletes and context minimal.	Injury aetiology knowledge is socially constructed. To generate injury aetiology knowledge, researchers interact with athletes and context to construct knowledge.
Research approach	Monodisciplinary. Multidisciplinary. Complexity (biomedical/positivist research, no empirical data yet).		Monodisciplinary. Multidisciplinary.
Research methodology and data analysis	Experimental-manipulative methodology. Falsification principle. Mathematical and statistical techniques. Deductive reasoning and generalisation. Quantitative methods (mostly physical testing in laboratories, questionnaires and registration of injuries and training volume). Qualitative methods (psychology/postpositivist: mostly interviews).		Naturalistic methodology. Interpretive science in search of meaning and understanding of injury aetiology. Interpretive analysis techniques. Inductive reasoning and social relevance. Qualitative method (mostly interviews and observations).
Paradigm	Positivism.	Positivism/Postpositivism.	Interpretivism.

Table 1 summarises the key findings of a narrative review of existing youth football and youth sport injury research, which demonstrates an absence of paradigmatic integration across the research areas' main disciplines of biomedicine, psychology and sociology.

youth football players.¹⁹ Findings from the biomedical discipline have resulted in the development of injury prevention interventions applied to youth through programmes such as the Nordic hamstring strengthening exercise,²⁰ the FIFA 11+ exercise programme²¹ and a neuromuscular warm-up programme called 'Knee control'.²² These exercise-based programmes include multiple training components, such as agility, balance, mobility, running and strength activities.

In addition to identifying risk factors, biomedical research has contributed with a number of sport-general models on injury causation, including the Sequence of Prevention model,²³ and the Multifactorial Model of Athletic Injury Aetiology,²⁴ which was later revised and updated to a more dynamic model.²⁵ McIntosh²⁶ also proposed a multifactorial model of injury causation but with a biomechanical focus on tissue properties and injury. Furthermore, sport injury research frameworks such as the Translating Research into Injury Prevention Practice framework,²⁷ and the extension of the Reach;

Effectiveness; Adoption; Implementation; Maintenance framework²⁸ have been developed in order to close the gap between research and implementation of interventions. These models and frameworks have, in general, been used by youth football injury aetiology researchers.

Biomedical youth football injury research reviewed in this paper is situated in the positivist paradigm. Given its assumptions of a singular and identifiable reality and truth, an injury is objectively defined as a specified damage to the physical body. Injury aetiology is often linear and related to identifiable individual physical factors. Methodologically, researchers are required to stay objective and abstain from interacting with research participants. A hypothetic-deductive reasoning leads the research from broad hypotheses to testing using quantitative methods (eg, physical testing, questionnaires), often in isolation and through manipulation of typical risk factors, often in a laboratory setting.

Psychological research

Psychological research on injuries in youth football players has mainly focused on psychosocial dimensions. Main risk factors identified in this research are personality traits (eg, high level of trait anxiety; low level of mistrust; ineffective coping),²⁹ history of stressors (eg, negative life event, daily hassles),³⁰ mental and physical fatigue³¹ and team climate (eg, lack of support from coach and teammates).^{31 32}

Findings from the psychological discipline have resulted in prevention and research focusing on stress management techniques and goal setting skills.^{33–35} Furthermore, the Model of Stress and Athletic Injury,^{36 37} which demonstrates how the magnitude of stress and athletes' appraisal of the situation may be influenced by the interplay between various psychosocial factors (eg, personality, history of stressors, coping resources), has become one of the most cited research models. In extending this model through the Biopsychosocial Model of Stress Athletic Injury and Health, the authors suggest that behavioural mechanisms associated with stress response (eg, impaired self-care; poor sleep quality) should also be addressed.³⁸ Moreover, emotions and environmental factors have been included in the Biopsychosocial Sport Injury Risk Profile,³⁹ as important risk factors related to sport injury.

Psychological youth football injury research reviewed in this paper is mainly situated in the positivist paradigm, with some research fitting into the postpositivist paradigm. Like the positivist paradigm, injury and injury aetiology definition is specific and related to the physical body, but adds the mind. Methodologically, researchers keep interaction with athletes to a minimum, and similar to positivist researchers, tend to follow a hypothetic-deductive reasoning as a method to gain knowledge. Assuming that establishing truth requires diverse sets of data, some researchers test the hypotheses by using qualitative methods, such as questionnaires and in-depth interviews.

Sociological research

Sociological research on youth sport injury has examined injuries from the perspective of athletes and by analysing the sporting culture athletes are immersed in. Key findings from our search show that sociocultural values (eg, sporting success; discipline and striving for perfection), social norms (eg, femininity; masculinity; power; being on time; respecting the coach),^{40–43} pressure to play through injury and pain (especially socialisation to accept training/competing with pain; silence around pain and injury),^{41 44 45} medical support (eg, lack of medical support; information being withheld)^{44 46} and coach-athlete relationships,^{42 47} can influence injury aetiology among athletes.

Sociological injury researchers do not use models to conceptualise injury aetiology, but employ theoretical frameworks such as sport ethic (a set of ideas and beliefs that together comprise norms of traditional athleticism),⁴² narratives of self,⁴⁷ culture of risk,⁴⁸ social control

(eg, individuals become inscribed and normalised by particular dominant standards) and masculinity theories,⁴⁹ in order to understand and explain sport injury aetiology.

Sociological youth sport injury research reviewed in this paper tends to be situated in the interpretivist paradigm. An injury and its aetiology are interpreted by athletes and researchers and can be explained or understood by examining athletes' sociocultural context. To examine injury aetiology, researchers interact with athletes and the context. Methodologically, sociological researchers sometimes use deductive reasoning as described above, but they also use inductive reasoning, where the process of creating insight develops from empirical data towards a theory (ie, patterns, themes and categories of analysis emerge out of the data). Researchers in the interpretivist paradigm apply qualitative methods such as observation and interviews, and interpretive analysis techniques such as thematic, content, discourse and narrative analysis.

REFLECTIONS ON DISTINCTIONS OF YOUTH FOOTBALL AND YOUTH SPORT INJURY RESEARCH

The narratively reviewed literature on youth football and youth sport injury research shows two paradigmatic distinctions. First, the literature is monoparadigmatic and tends to focus on one subdiscipline of sport science. Most of the literature is biomedical, sport psychological and sport sociological, and often based on either quantitative or qualitative research techniques. The French philosopher and sociologist Edgar Morin⁵⁰ argues that by approaching research from single disciplines, complexity becomes invisible. The disintegration of complexity through monodisciplinarity is not due to the discipline in itself, but as Morin⁵⁰ (p. 2) emphasises, because 'of the discipline as it is conceived, non-communicating with the other disciplines, closed to itself'. Monodisciplinarity in research reduces the phenomenon into separate parts, thus making the whole as well as interactions between parts and between parts and the whole, invisible.^{7 50} Second, and related to monodisciplinarity, there is no integration of research across the three paradigms.

These limitations can be clearly seen in our narratively reviewed literature included in [table 1](#). Thus, current youth sport injury research can be seen to shield off—or in other words leave out—possibly important aspects, creating a picture that is not actually representative of the complex phenomenon under study (eg, injury aetiology).⁵¹ For example, biomedical and psychological disciplines, by mainly focusing on athletes' physical bodies and minds, leave out their interaction with and in the larger sociocultural context the athletes participate in. Similarly, sociological research, by focusing on sociocultural context, often ignores how the physical body and mind interact with and influence athletes.

Researchers operating in these paradigms and disciplines can and do apply different research approaches and methods, thus, paradigms do not confine. Indeed, researchers have adopted approaches to be more

inclusive, such as an ‘ecological’, ‘integrated’ or more ‘real-world’ approach to sport injuries.^{52–54} However, these approaches either miss to account for multiple and complex interactions between different ‘parts of the whole’,⁷ or do not attempt to integrate disciplines across paradigms or use multiple quantitative and qualitative research methods.

THE COMPLEXITY APPROACH TO SPORT INJURY RESEARCH

The recognition that sport injury aetiology involves numerous interactions between various variables across multiple dimensions has led some researchers to explore the potential of a complex systems approach for understanding and researching sport injury aetiology.^{4 6–9} Although researchers understand and apply complexity to sport injury research differently, three elements characterise current discussions. First, a complexity approach embraces an understanding of context as open systems consisting of components that are actively connected through mostly non-linear relationships.^{4 7 8} A non-linear relationship between components in the system implies that A plus B does not necessarily equal C. For example, a weak muscle plus psychological stress does not necessarily result in an injury. Second, these non-linear relationships between the components can induce dramatic new effects giving rise to unexpected structures and events, also known as emergence.^{55 56} Emergence can, for example, be certain tendencies, powers or complex phenomena such as a sport injury. Emergence, or the injury and its aetiology is constantly evolving, and not strictly predictable.⁵⁵ In other words, emergence is self-organising, meaning a complex system can transform over time, either growing or shrinking.⁵⁵ Emergence should be accounted for when researching sport injury aetiology, for example, through longitudinal studies. Finally, and what Newell⁵⁵ argues is typically overlooked in the understanding of complex systems, is the importance of ‘local knowledge’, or knowledge of specific parts of the system. An athlete can, for example, be stressed over an upcoming exam at school and is injured right before the exam. The athlete might believe exam stress caused the injury. A closer examination may, however, show that it was the way the coach had changed behaviour towards the athlete that affected the injury aetiology. When applying a complex systems approach to injury research, the focus moves from identifying single risk factors for injuries to recognising patterns of interaction among multilevel components, acknowledging that these components interact in unpredictable ways and may be moderated by a number of individual and contextual factors.^{4 6 8}

Researchers are currently discussing how the implementation of complex systems thinking can advance sport injury research, specifically through statistical mathematical models and computer-based simulations guided by equations, rules and laws. Complex models⁴ and statistical procedures such as the Agent-Based Modelling (ABM) and Systems Dynamics (SD) modelling⁹ are

recent examples. According to Bekker⁶ (p. 80), however, this development represents an “overemphasis on the epistemological question of how multifactorialism is accounted for in research and a corresponding underemphasis on the ontological considerations and assumptions we make about the world”, which reflects a dissonance in how complexity is understood and applied to sport injury research. The current argument for complexity assumes a reductionist positivist/postpositivist view where complexity is understood as emerging from the rule-based interactions of simple agents/elements and explored through agent-based modelling.⁵⁶ Consequently, it tends to ignore that there is more to emergence than the product of interactions of agents; athletes are themselves complex systems, and more complex than agents in agent-based simulations.⁵⁶ Thus, the current argument for complexity is limited in recognising the importance of understanding athletes’ interactions with and in a certain context; hence, it is ignoring the significance of incorporating sociocultural conditions that researchers from the interpretivist paradigm have identified as relevant. Bekker further argues that injury researchers’ focus should not be on methodological preferences, but rather on ‘understanding system goal behaviour using methodological pluralism’⁶ (p. 81). We agree. A complexity approach requires alternative research methodologies. One such approach, which we have found to have potential in the FIT project to account for the multiple dimensions of injury aetiology, is an interdisciplinary research process that includes scientific disciplines from different paradigms and integrates qualitative and quantitative research methods.

THE POTENTIAL OF INTERDISCIPLINARY SPORT INJURY RESEARCH

Drawing on research by Klein and Newell,⁵⁷ we understand interdisciplinarity as a research process aiming to address a topic that is too broad or complex to be dealt with adequately by a single discipline. Furthermore, an interdisciplinary research process integrates disciplinary perspectives through construction of a more comprehensive perspective.⁵⁷ Both Newell⁵⁵ and sports researchers such as Buekers *et al*⁵⁸ argue that complex systems and phenomena are a necessary condition for interdisciplinary studies. The rationale for this argument lies in the way complex phenomena can be understood and studied. If an injury is to be understood as complex, then this would mean, as argued earlier, that the phenomenon is multidimensional. Seeing it from one single angle, such as from biomedicine or sociology, only, the phenomenon appears different than from another angle. Since the overall pattern of behaviour is non-linear and dynamic, an effective method for modelling such a phenomenon must offer insight into the separate parts as well as the complex pattern produced by their overall interactions.⁵⁵ An interdisciplinary research process, which draws insights from relevant disciplines and integrates these insights into a more comprehensive understanding, is

thus proposed to have potential to study sport injury aetiology.¹

The benefits of interdisciplinarity have been pointed out in a recent *Nature* editorial.⁵⁹ The editor specifically endorsed the incorporation of social sciences, cautioning that '[i]f social, economic and/or cultural factors are not included in the framing of the questions' then 'a great deal of creativity can be wasted'. Recently, sports sociologists Pringle and Falcous⁶⁰ have also advocated a collaboration between the social and natural sciences. They argue that a collaboration between biomedical researchers and sport sociologists, which they refer to as methodological border crossing, could improve the political impact of research from the sociology of sport. Regarding sport injury research, Burwitz *et al*¹ argued for the benefits of interdisciplinarity over two decades ago. Despite their call, however, very little empirical work has been conducted to this end. Reasons provided for this reservation have been related to various obstacles that prevent high quality, truly integrated interdisciplinary work, as well as practical difficulties relating to gaining funding and publishing.^{1 58} Philosophical obstacles relating to paradigmatic differences may also result in a lack of shared understandings, research approaches and methods,^{61–63} preventing researchers from adopting such an approach. Nevertheless, our research in the FIT project has demonstrated that interdisciplinarity has potential for sport injury research.

THE INTERDISCIPLINARY RESEARCH PROCESS OF THE FIT PROJECT

The interdisciplinary research process of the FIT project consisted of five phases depicted in figure 1. The five-phase research process was developed based on key interdisciplinary research steps outlined by interdisciplinary researchers such as Alan Repko, Rick Szostak and William H. Newell.^{55 64} While presented sequentially, the five-phase research process is an iterative and non-linear process. At times it was necessary to move back to an earlier phase or forward towards later phases, which is common and reflects the complexity of the interdisciplinary research process.^{55 64}

In the first phase of the process, the FIT project research group came together from multiple scientific disciplines and agreed on researching injury aetiology in youth football using an interdisciplinary approach. In the second phase, the project team members decided which scientific disciplines to draw on to study the problem, a process that took place through meetings, discussions, reviewing literature and presentations of research within and outside of the project group. In phase III, we conducted research applying the following research methods to study youth football injury aetiology: questionnaire; measures of weight and height; injury diagnostics; clinical examinations; strength testing; running analyses; knee laxity measurements; examination of training protocols; field observations and interviews. Research methods were chosen based on knowledge gained from

AN INTERDISCIPLINARY RESEARCH PROCESS TO STUDY YOUTH FOOTBALL/SPORT INJURY AETIOLOGY

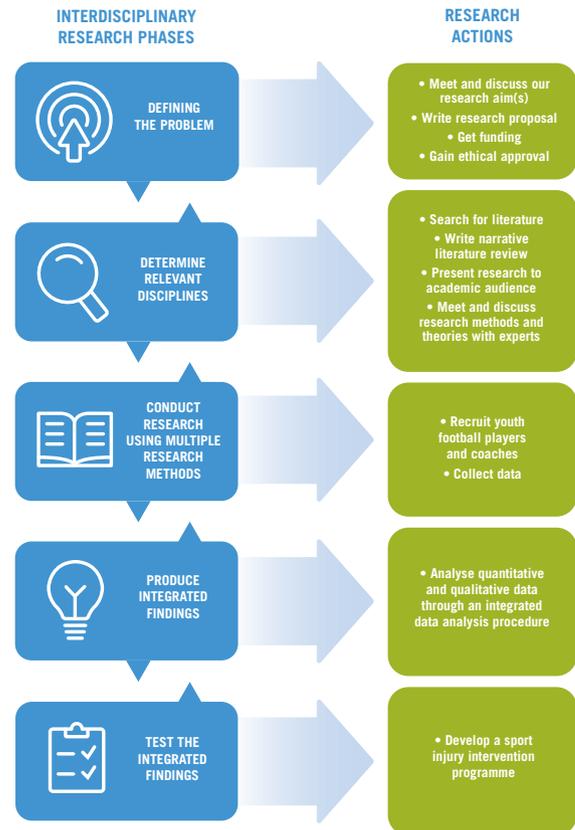


Figure 1 The interdisciplinary research process of the FIT project. The figure illustrates the five-phase interdisciplinary research process adopted for the study of youth football injury aetiology.¹⁰ The blue boxes present the main theme of each of the five phases of the process. The green boxes entail research actions. The interdisciplinary research process was not linear, but involved the researchers moving back to an earlier phase or forward towards later phases during the process.

project team members' disciplinary expertise, existing literature, internal meetings and discussions with experts outside of the research group. Additionally, phase III entailed recruitment of research participants.

In the final two phases, data were analysed through measurement-specific analyses (eg, three-dimensional kinematics to analyse movement-specific characteristics; isometric strength to analyse muscle weakness and/or muscle imbalance; content analysis of field notes and interview transcripts) and an analytic procedure was prepared that makes integrated analysis of measurement-specific analysis possible.

During the FIT project's five-phase interdisciplinary research process, the research group encountered paradigmatic challenges typical of working interdisciplinarily.⁶¹ One example is sample size and recruitment. Where positivist paradigmatic distinctions require a statistically powerful sample size, the interpretivist paradigm demands possibilities for in-depth and detailed

examination of one or a few cases. A further challenge was the lack of an integrated data analysis procedure that would allow us to integrate the measurement-specific analysis referred to above. As we could not locate a suitable analytical procedure, we needed to spend time and effort to develop and test such a procedure. Finally, we have found that presenting the FIT project research in multiple cases resulted in misunderstanding and scientific criticism. As a result, we had to place extra effort in considering the communication of the FIT project's scientific rationale, methodology and results. Indeed, while we have not struggled to respect our different paradigmatic worldviews and demands, it has been challenging to find and communicate what interdisciplinary researchers like Repko and Szostak⁶⁴ and Welch⁶⁵ call the 'space in between' scientific paradigms and disciplines we have been trying to create. The key measure that helped us to move forward in the interdisciplinary research process was a negotiation process that entailed regular meetings.

CONCLUSION

The purpose of this paper was to consider and outline an interdisciplinary research process to research the complex nature of youth sport injury aetiology. To facilitate this proposal, our narrative review of existing biomedical, sport psychological and sociological literature summarised youth football and youth sport injury research and demonstrated paradigmatic distinctions and methodological assumptions, research approaches, research methods and data analysis procedures. The narrative review has shown a paucity on youth football injury research in the sociological discipline as well as a dominance of monodisciplinary research and a lack of integration across research disciplines and paradigms.

Our paper has further shown that to advance youth sport injury research, specifically considering complexity, an interdisciplinary research process, such as proposed in figure 1, has potential to integrate disciplinary knowledge and measurement-specific data across research paradigms. The integrated potential is particularly promising for research aiming to examine the interactions of components proposed vital to understand the complexity of injury aetiology. We recognise, however, that to advance this potential, additional research is necessary. We particularly see a need to develop and trial analytical procedures that integrate qualitative and quantitative injury aetiology data to produce complex injury aetiology findings, and to explore interdisciplinary research teams' pragmatic negotiation of the challenges of melding seemingly opposing paradigms in the interests of better understanding the complexities of sport injury processes.

Contributors NB-R and SG conceptualised the FIT project, which is the basis for this paper. NB-R acquired the funding. AS, NB-R, SG and SEH-S contributed with the preparation of tools and data production for the FIT project. SEH-S is the PhD student in the FIT project. NB-R and SEH-S were responsible for the initial preparation and writing of the manuscript. RP, AS and SG contributed to the accurate and critical revision of the manuscript as well as approval of the final version. All authors were involved in the preparation and editing of the manuscript.

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REFERENCES

- Burwitz L, Moore PM, Wilkinson DM. Future directions for performance-related sports science research: an interdisciplinary approach. *J Sports Sci* 1994;12:93–109.
- Markula P, Silk M. *Qualitative research for physical culture*. Basingstoke: Palgrave Macmillan, 2011: 252.
- Phoenix C, Osborne NJ, Redshaw C, et al. Paradigmatic approaches to studying environment and human health: (forgotten) implications for interdisciplinary research. *Environ Sci Policy* 2013;25:218–28.
- 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.
- Sparkes AC. Developing mixed methods research in sport and exercise psychology: critical reflections on five points of controversy. *Psychol Sport Exerc* 2015;16:49–59.
- Bekker S. Shuffle methodological deck chairs or abandon theoretical ship? The complexity turn in injury prevention. *Inj Prev* 2019;25:80–2.
- Bekker S, Clark AM. Bringing complexity to sports injury prevention research: from simplification to explanation. *Br J Sports Med* 2016;50:1489–90.
- Hulme A, Finch CF. From monocausality to systems thinking: a complementary and alternative conceptual approach for better understanding the development and prevention of sports injury. *Inj Epidemiol* 2015;2:31.
- Hulme A, Thompson J, Nielsen RO, et al. Towards a complex systems approach in sports injury research: simulating running-related injury development with agent-based modelling. *Br J Sports Med* 2019;53:560–9.
- Hausken S, Barker-Ruchti N, Schubring A, et al. Injury-free children and adolescents: towards better practice in Swedish football (fit project). *Res Ideas Outcomes* 2018;4:e30729.
- Hausken SES, Barker-Ruchti N, Schubring A. Understanding and researching youth football injuries with an interdisciplinary approach: current literature and project experiences. *ISSA 2018 Book of Abstracts. World Congress of Sociology of Sport*; June 5–8, Lausanne, Switzerland, 2018:118.
- Pfirmann D, Herbst M, Ingelfinger P, et al. Analysis of injury incidences in male professional adult and elite youth soccer players: a systematic review. *J Athl Train* 2016;51:410–24.
- Read PJ, Oliver JL, De Ste Croix MBA, et al. A prospective investigation to evaluate risk factors for lower extremity injury risk in male youth soccer players. *Scand J Med Sci Sports* 2018;28:1244–51.
- van der Sluis A, Elferink-Gemser MT, Coelho-e-Silva MJ, et al. Sport injuries aligned to peak height velocity in talented pubertal soccer players. *Int J Sports Med* 2014;35:351–5.
- De Ridder R, Witvrouw E, Dolphens M, et al. Hip strength as an intrinsic risk factor for lateral ankle sprains in youth soccer players: a 3-season prospective study. *Am J Sports Med* 2017;45:410–6.
- Häggglund M, Waldén M. Risk factors for acute knee injury in female youth football. *Knee Surg Sports Traumatol Arthrosc* 2016;24:737–46.
- Steffen K, Myklebust G, Andersen TE, et al. Self-reported injury history and lower limb function as risk factors for injuries in female youth soccer. *Am J Sports Med* 2008;36:700–8.
- Brink MS, Visscher C, Arends S, et al. Monitoring stress and recovery: new insights for the prevention of injuries and illnesses in elite youth soccer players. *Br J Sports Med* 2010;44:809–15.

- 19 O'Kane JW, Gray KE, Levy MR, *et al.* Shoe and field surface risk factors for acute lower extremity injuries among female youth soccer players. *Clin J Sport Med* 2016;26:245–50.
- 20 Al Attar WSA, Soomro N, Sinclair PJ, *et al.* 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 Med* 2017;47:907–16.
- 21 Bizzini M, Dvorak J. FIFA 11+: an effective programme to prevent football injuries in various player groups worldwide—a narrative review. *Br J Sports Med* 2015;49:577–9.
- 22 Waldén M, Atroshi I, Magnusson H, *et al.* Prevention of acute knee injuries in adolescent female football players: cluster randomised controlled trial. *BMJ* 2012;344:e3042.
- 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 Meeuwisse WH. Assessing causation in sport injury: a multifactorial model. *Clin J Sport Med* 1994;4:166–70.
- 25 Meeuwisse WH, Tyreman H, Hagel B, *et al.* A dynamic model of etiology in sport injury: the recursive nature of risk and causation. *Clin J Sport Med* 2007;17:215–9.
- 26 McIntosh AS. Risk compensation, motivation, injuries, and biomechanics in competitive sport. *Br J Sports Med* 2005;39:2–3.
- 27 Finch C. A new framework for research leading to sports injury prevention. *J Sci Med Sport* 2006;9:3–9.
- 28 Finch CF, Donaldson A. A sports setting matrix for understanding the implementation context for community sport. *Br J Sports Med* 2010;44:973–8.
- 29 Johnson U, Ivarsson A. Psychological predictors of sport injuries among junior soccer players. *Scand J Med Sci Sports* 2011;21:129–36.
- 30 Ivarsson A, Johnson U, Lindwall M, *et al.* Psychosocial stress as a predictor of injury in elite junior soccer: a latent growth curve analysis. *J Sci Med Sport* 2014;17:366–70.
- 31 Ivarsson A, Johnson U, Karlsson J. Elite female footballers' stories of sociocultural factors, emotions, and behaviours prior to anterior cruciate ligament injury. *Int J Sport Exerc Psychol* 2018;1–17.
- 32 Steffen K, Pensgaard AM, Bahr R. Self-reported psychological characteristics as risk factors for injuries in female youth football. *Scand J Med Sci Sports* 2009;19:442–51.
- 33 Gledhill A, Forsdyke D, Murray E. Psychological interventions used to reduce sports injuries: a systematic review of real-world effectiveness. *Br J Sports Med* 2018;52:967–71.
- 34 Ivarsson A, Johnson U, Andersen MB, *et al.* Psychosocial factors and sport injuries: meta-analyses for prediction and prevention. *Sports Med* 2017;47:353–65.
- 35 Johnson U, Ekengren J, Andersen MB. Injury prevention in Sweden: helping soccer players at risk. *J Sport Exerc Psychol* 2005;27:32–8.
- 36 Andersen MB, Williams JM. A model of stress and athletic injury: prediction and prevention. *J Sport Exer Psychol* 1988;10:294–306.
- 37 Williams JM, Andersen MB. Psychosocial antecedents of sport injury: Review and critique of the stress and injury model'. *J Appl Sport Psychol* 1998;10:5–25.
- 38 Appaneal RN, Perna FM. Biopsychosocial model of injury. In: Eklund RC, Tenenbaum G, eds. *Encyclopedia of sport and exercise psychology*.
- 39 Wiese-Bjornstal DM. Psychology and socioculture affect injury risk, response, and recovery in high-intensity athletes: a consensus statement. *Scand J Med Sci Sports* 2010;20(Suppl 2):103–11.
- 40 Cavallerio F, Wadey R, Wagstaff CRD. Understanding overuse injuries in rhythmic gymnastics: a 12-month ethnographic study. *Psychol Sport Exerc* 2016;25:100–9.
- 41 Fenton LT, Pitter R. Keeping the body in play: pain, injury, and socialization in male rugby. *Res Q Exerc Sport* 2010;81:212–23.
- 42 Malcom NL. “Shaking it off” and “toughing it out”. Socialization to pain and injury in girls' softball. *J Contemp Ethnogr* 2006;35:495–525.
- 43 Markula P, Pringle R. *Foucault, sport and exercise: power, knowledge and transforming the self*. New York and Oxford: Routledge, 2006.
- 44 Roderick M, Waddington I, Parker G. Playing hurt. *Int Rev Sociol Sport* 2000;35:165–80.
- 45 Schubring A, Thiel A. Coping with growth in adolescent elite sport. *Sociol Sport J* 2014;31:304–26.
- 46 Schubring A, Barker-Ruchti N. Navigating sports medical practice in women's artistic gymnastics: a socio-cultural analysis. In: Kerr R, Barker-Ruchti N, Stewart C, *et al.*, eds. *Women's artistic gymnastics Socio-cultural perspectives*. Routledge, 2020: 216–30.
- 47 Kuhlín F, Barker-Ruchti N, Stewart C. Long-term impact of the coach-athlete relationship on development, health, and wellbeing: stories from a figure skater. *Sports Coaching Review* 2019:1–23.
- 48 Nixon HL. Accepting the risks of pain and injury in sport: mediated cultural influences on playing hurt. *Sociol Sport J* 1993;10:183–96.
- 49 Young K, White P, McTeer W. Body talk: male athletes reflect on sport, injury, and pain. *Sociol Sport J* 1994;11:175–94.
- 50 Morin E. Restricted complexity, general complexity. In: Gershenson C, Aerts D, Edmonds B, eds. *Worldviews, sciences and us. philosophy and complexity*. 1st edn. Liverpool: University of Liverpool, 2005: 5–29.
- 51 Hägerstrand T. Presence and absence: a look at conceptual choices and bodily necessities. *Reg Stud* 1984;18:373–9.
- 52 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.
- 53 Hanson D, Hanson J, Vardon P, *et al.* The injury iceberg: an ecological approach to planning sustainable community safety interventions. *Health Promot J Austr* 2005;16:5–10.
- 54 Jacobsson J, Bergin D, Timpka T, *et al.* Injuries in youth track and field are perceived to have multiple-level causes that call for ecological (holistic-developmental) interventions: a national sporting community perceptions and experiences. *Scand J Med Sci Sports* 2018;28:348–55.
- 55 Newell WH. A theory of interdisciplinary studies. *Issues in Integrative Studies* 2001;19:1–25.
- 56 Byrne D, Callaghan G. *Complexity theory and the social sciences. The state of the art*. London: Routledge, 2014: 312 p..
- 57 Klein JT, Newell WH. Advancing interdisciplinary studies. In: Gaff JG, Ratcliff JL, eds. *Handbook of the undergraduate curriculum: a comprehensive guide to purposes, structures, practices, and change*. San Francisco: Jossey-Bass Publishers, 1997: 393–415.
- 58 Buekers M, Ibáñez-Gijón J, Morice AHP, *et al.* Interdisciplinary research: a promising approach to investigate elite performance in sports. *Quest* 2017;69:65–79.
- 59 Nature. Time for the social sciences. *Nature* 2015;517.
- 60 Pringle R, Falcous M. Transformative research and epistemological hierarchies: Ruminating on how the sociology of the sport field could make more of a difference. *Int Rev Sociol Sport* 2018;53:261–77.
- 61 Campbell LM. Overcoming obstacles to interdisciplinary research. *Conservation Biology* 2005;19:574–7.
- 62 Bracken LJ, Oughton EA. 'What do you mean?' The importance of language in developing interdisciplinary research. *Trans Inst Br Geog* 2006;31:371–82.
- 63 Sparkes AC. Toward understanding, dialogue, and polyvocality in the research community: extending the boundaries of the paradigms debate. *Journal of Teaching in Physical Education* 1991;10:103–33.
- 64 Repko AF, Szostak R. *Interdisciplinary research: process and theory*. 3rd. Thousand Oaks: Sage, 2016.
- 65 Welch J. The impact of Newell's “a theory of interdisciplinary studies”: reflection and analysis. *Issues in interdisciplinary studies* 2018;36:193–211.