Association between physical fitness parameters and risk of in-season injury among adult male rugby players: a systematic review protocol

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ABSTRACT

Objective: The objective of this review is to assess whether pre-season physical fitness parameters are associated with in-season injury risk among adult male rugby players.

Introduction: Pre-season neuromusculoskeletal screening protocols (which include tests related to different physical fitness parameters) are injury prevention strategies employed to manage athletes' in-season injury risk. A systematic review exploring the association between in-season injury and specific physical fitness parameters may justify the inclusion or exclusion of these tests in official screening protocols.

Inclusion criteria: This review will consider prospective, observational cohort studies that investigate injury-free adult (aged 18 years or above) male rugby players, from all levels of participation (recreational, sub-elite and elite). Studies investigating physical fitness parameters and their association to rugby-related neuromusculoskeletal injury will be included.

Methods: The proposed systematic review will be conducted in accordance with the JBI methodology for systematic reviews of etiology and risk. Published and unpublished studies will be sourced from several databases and resources. Two independent researchers will screen, appraise and extract data from studies meeting the inclusion criteria using standardized critical appraisal and data extraction tools. Data synthesis will be conducted and a Summary of Findings constructed to summarize data and draw conclusions.

Systematic review registration number: PROSPERO 130240.

Keywords Injury; physical fitness; risk factors; rugby

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Introduction

Despite their collisional nature and related high injury incidence rates (IRs),[1] the sports of rugby union, rugby league and rugby sevens (collectively referred to as rugby) are among the most popular professional sports worldwide.[2] Several epidemiological studies[1,2] and a meta-analysis conducted by Williams *et al.*[3] concluded that most injuries occur during matches (IR = 81.0–91.0 injuries per 1000 player hours), and that these are related to a tackling incident. These studies concurred that the IRs were similar for forwards and backs position players, and that the most common sites of injury were the lower limbs (48.1–58.9%) and the upper limbs (15.6–25.6%).

Rugby-specific musculoskeletal screening protocols are developed by most international rugby unions in an attempt to limit in-season injury incidence. A screening protocol developed by the South African Rugby Union[4] contains a questionnaire related to previous injury and a series of physical screening tests assessing posture, flexibility, joint range of motion, neural mobility, strength, stability and proprioception. Although the reliability and mostly criterion-related validity of some of these tests have been established, studies related to their validity in terms of injury prediction among adult rugby players are scarce. Before inferences related to true causality (i.e. probability) can be made, studies

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investigating the association (i.e. possibility) of physical fitness parameters and injury incidences are warranted. Very few official injury risk screening protocols include tests typically designed to test athletes' physical fitness or athletic ability (e.g. muscular strength, cardiovascular respiratory fitness capacity, plyometric ability).

Gabbet *et al.* suggested that elite[5] and sub-elite[6] adult rugby players with superior athletic ability have a decreased risk of injury. Sub-elite players with slower 10 m and 40 m sprinting speeds as well as those with lower maximum aerobic power were found to be more injury-prone.[6] Heavier elite players, players with faster 10 m and 40 m speeds, players with reduced prolonged high-intensity intermittent running ability and those with poorly developed upper body strength, were also more prone to sustaining contact injuries.[5] The authors of a cohort study conducted by the New Zealand Rugby Injury and Performance Project[7] recognized that factors related to athletic performance might be associated with injury risk, and included tests related to players' aerobic and anaerobic endurance, sprint ability, vertical jump and push-up tests in their physical screening.[7]

This proposed systematic review aims to provide evidence for an association between physical fitness and in-season injury incidence. The authors hypothesize that there is an association between pre-season physical fitness parameters and in-season injury (both contact and non-contact) incidence among adult male rugby players. Should the findings of this review confirm this association, further investigations regarding the predictive validity and direct causal relationship of the confirmed fitness parameters should be conducted. From a clinical perspective, the findings of this review will provide scientific evidence for the fitness–injury relationship, thereby enabling recommendations for the inclusion or removal of certain physical fitness tests from official screening protocols. This will allow medical and strength-conditioning professionals to identify players who are at risk of sustaining in-season injuries and address some of the possible preventable causes in an attempt to minimize injury risk. Additionally, as these protocols might include conventional injury risk-screening tests (which may not be associated with the physical fitness state of an athlete) as well as physical fitness tests, the screening can be used to both identify injury risk factors and establish a baseline of athletes' physical fitness and related athletic ability. Professionals responsible for athletes' injury prevention and management (e.g. physiotherapists) and those responsible for conditioning of the athletes (e.g. sport scientists and strength-conditioning coaches) can therefore use the same independent test batteries. In a large team setting, this can save valuable time and provide all medical and fitness professionals with the same holistic profile regarding the state of each player's neuromusculoskeletal condition prior to the start of a season.

A preliminary search for previous systematic reviews on the topic was conducted. Databases searched included: *JBI Database of Systematic Reviews and Implementation Reports*, Cochrane Library, PubMed, PROSPERO and CINAHL. The authors found individual studies that investigated the association between in-season injury risk and players perceived pre-season fitness, physiological performance (bench press test, deadlift, lower body power and maximal higher aerobic capacity)[8] and rugby-specific skills (such as contact technique)[9]; however, a systematic review summarizing and comparing the results of these individual studies is yet to be published. The objective of this proposed review is to evaluate any association between physical fitness parameters (measured prior to the start of the competitive season) and in-season injury risk among adult male rugby players.

Review question

What is the association between pre-season measured physical fitness parameters and in-season injury risk among adult male rugby players?

Inclusion criteria

Participants

This review will consider studies that include adult (aged 18 years or above) male rugby players (without mental or physical disabilities), from all levels of participation, who were injury-free at the start of their respective competitive seasons. Levels of participation will include recreational (amateur players participating in matches in a social capacity), sub-elite (players that are part of an official club or university/college team that participates in structured tournaments) and elite (players playing for a team that participate in inter-provincial or national tournaments).

This review will investigate rugby specifically, as the rules of the different contact sports dictate the nature (in terms of manner and timing) of contact and the degree to which a player is exposed to contact (for example, by wearing the required protective gear during participation). Additionally, variations between sports (e.g. the duration of games, periods of broken play and the speed at which games are played) mean that different fitness parameters are challenged to varying degrees. Only male players were included, to account for confounding variables related to possible sex-specific intrinsic risk factors. For example, females have been found to have a higher risk of anterior cruciate ligament injury due to hormonal and structural anatomical differences.[10]

Exposure of interest

This review will consider studies that investigate physical fitness-related parameters (independent variable). These parameters typically provide an indication of athletes' physical fitness and athletic ability including muscular strength, cardio-respiratory fitness (aerobic, anaerobic and endurance capacity), plyometric ability, speed, agility, and force production. Non-modifiable physical fitness aspects (e.g. generalized joint hypermobility) will not be considered in this review.

Outcomes

The dependent variable of interest will be injury incidence due to participation in activities (training or match play) related to rugby. The review will consider studies where neuromusculoskeletal injury incidence is investigated prospectively over a predetermined period of time. Injuries can be self-reported by participants or clinically diagnosed and recorded by a healthcare provider.

The definition of injury varies among etiological studies that investigate the relationship between injury and one or more of the above-mentioned screening aspects. While some authors only include contact[5] or non-contact injuries or isolate injuries to a specific body part or structure,[11,12] others include any musculoskeletal injury[6,13] sustained. This is not unique to research related to rugby. In a study investigating musculoskeletal predictors among cricketers, Olivier *et al.*[14] only considered non-contact injuries while Martin *et al.*[15,16] considered both contact and non-contact injuries. Kiesel *et al.*[17] also considered any musculoskeletal injury among American football (NFL) players. Considering the collisional nature of rugby, some might reason that contact injuries are unavoidable and due to bad luck. The authors of this proposed review reason that superior athletic ability might allow a player to avoid contact (for example, by evading an opposing player on attack), or enable a player to better position himself at optimal biomechanical angles prior to contact, thereby redirecting or lessening the impact of opposing forces. Modifiable physical fitness-related risk factors for non-contact injuries, such as hamstring strains, include lack of flexibility and muscle imbalances.[11] This review will therefore consider studies that included contact and/or non-contact musculoskeletal injuries.

Types of studies

Both published and unpublished prospective, observational, longitudinal cohort studies in any language will be considered for inclusion in this review. Studies published from database inception to present will be included. Experimental studies will not be included, as this review aims to establish the association of physical fitness or athletic performance parameters and will not evaluate the effect of training modalities on injury prevention. Considering the types of studies included, the aim of this systematic review is not to determine causality or the predictive validity of the investigated physical fitness tests, but merely ascertain any possible association between different physical fitness parameters and injury.

Methods

This review will be performed in compliance with the JBI guidelines for systematic reviews of association[18] as well as the COSMOS-E (Conducting Systematic Reviews and Meta-Analyses of Observational Studies of Etiology).[19]

Search strategy

The search strategy will aim to locate both published and unpublished studies from inception of the database to present. The search will be conducted in three sequential steps. Firstly, a restricted search of MEDLINE and CINAHL databases will be conducted to identify articles whose titles, abstracts or MeSH Major Topics contain the following keywords: rugby, injury, physical fitness test, risk factors. A second search will be conducted, using all recognized keywords and index terms for the articles identified in the first search. The keywords and index terms will be entered into the databases mentioned below to search for more studies. A full search strategy for the PubMed database is detailed in Appendix I. Finally, the reference lists of all identified studies will be screened to identify any other relevant studies. Should the researchers require additional information or clarity, the authors of the specific identified studies will be contacted.

Information sources

Databases to be searched include PubMed, CINAHL, the Cochrane Central Register of Controlled Trials, PEDro, ProQuest 5000 International, ProQuest Health and Medical Complete, EBSCO MegaFile Premier, Science Direct, SPORTDiscus with Full Text, and Embase. Sources of unpublished and gray literature to be searched include conference proceedings and papers, and gray literature databases (including SCOPUS, ProQuest Dissertations and Theses, OpenGrey, Gray Matters, GreyNet).

Study selection

Following the search, all identified citations will be collated and uploaded into Zotero version 5.0.72 (Corporation for Digital Scholarship and Roy Rosenzweig Center for History and New Media, VA, USA) and duplicates removed. Titles and abstracts will then be screened by two independent reviewers for assessment against the inclusion criteria for the review. Potentially relevant studies will be retrieved in full and their citation details imported into the JBI System for the Unified Management, Assessment and Review of Information (JBI SUMARI; Joanna Briggs Institute, Adelaide, Australia). The full text of selected citations will be assessed in detail against the inclusion criteria by two independent reviewers. Reasons for exclusion of full text studies that do not meet the inclusion criteria will be recorded and reported in the systematic review. Any disagreements that arise between the reviewers at each stage of the study selection process will be resolved through discussion, or with a third reviewer. The results of the search will be reported in full in the final systematic review and presented in a Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA) flow diagram.[20]

Assessment of methodological quality

Two independent reviewers will independently assess eligible studies for methodological validity using the JBI instrument for comparable cohort studies,[21] a standardized critical appraisal tool. Authors of papers will be contacted to request missing or additional data for clarification, where required. Disagreements between reviewers will be discussed, and a third reviewer will be consulted should there be any unresolved issues. All studies, irrespective of methodological quality, will be included. Methodological quality will be considered when conclusions are drawn. The results of critical appraisal will be reported in narrative form and in a table.

Data extraction

The standardized JBI SUMARI data extraction tool[21] will be used to extract data from the eligible studies. To minimize error, two reviewers will independently extract data and compare the outcome. A third reviewer will be consulted to resolve any disagreements. The data extracted will include specific details about the exposure of interest, including different exposure categories (if applicable), populations, study methods and outcomes, or dependent variables of significance to the review question and any specific objectives. Confounding factors reported by the included studies will also be extracted to provide context to findings. Authors of papers will be contacted to request missing or additional data where required.

Data synthesis

Where appropriate, studies for which the exposure variables or outcomes are sufficiently similar will be pooled in a statistical meta-analysis using JBI SUMARI. Effect sizes will be expressed as either odds ratios (binary data) or standardized mean differences (continuous data) and their 95% confidence intervals calculated for analysis. Risk ratios, odds ratios, and/or hazard ratios will be pooled where appropriate. A random effects model, using the DerSimonian and Laird method, will be preferred over a fixed-effects model due to the likely heterogeneity in association studies.[19] To determine the level of heterogeneity, the I^2 test will be conducted as well visual inspection of the forest plots.[21]

Subgroup analysis will be considered if studies with sufficient data in a specific subgroup can be identified. The anticipated subgroups include level of performance (recreational, sub-elite or elite), types of injuries (acute, overuse, contact or non-contact), form of the game (rugby union, rugby league or rugby sevens) and types of physical fitness/athletic performance-related parameter. Quantitative data related to physical fitness parameters will be measured in the standard unit of the specific physical fitness parameter (for example, one repetition maximum for strength measurement). Should different studies report results in categories of exposure variables (e.g. quartiles), the association between exposure and outcome will be modeled (using dose-response modeling or other appropriate model as suggested by Hartemink *et al.*)[22] to estimate the change (increase or decrease) in risk associated, with one increment change in exposure (outcome).[19] Should different studies use different ratio metrics for the same exposure-outcome association, metrics will be combined, ignoring the difference, if the outcome under study is rare (<5%).[19] Otherwise, risk ratios will be transformed to other metrics such as standardized mean differences or correlation coefficients and subsequently combined in the meta-analysis.[19]

Sensitivity analysis will be conducted to explore the impact of excluding or including studies in the meta- analysis based on sample size, methodological quality or variance.[21] Where statistical pooling is not possible, the findings will be presented in narrative form including tables and figures to aid in data presentation. A funnel plot will be generated using JBI SUMARI to assess publication bias if there are 10 or more studies included in a meta-analysis. Where appropriate additional statistical tests for funnel plot asymmetry (Egger test, Begg test and/or Harbord test) will be performed. Appropriate strategies (sensitivity analysis, propensity score methods, or adjustment strategies etc.)[23,24] will be applied to address included studies which did not adjust for confounding variables.

Assessing certainty in the findings

The Grading of Recommendations, Assessment, Development and Evaluation (GRADE) approach for grading the certainty of evidence will be followed[25] and a Summary of Findings (SoF) will be created using GRADEpro (McMaster University, ON, Canada). The SoF will present the following information where appropriate: absolute risks for the treatment and control, estimates of relative risk, and a ranking of the quality of the evidence based on the risk of bias, directness, heterogeneity, precision and risk of publication bias of the review results. The outcomes reported in the SoF will include number of neuromusculoskeletal injuries for groups that attained or did not attain a specific fitness level respectively, site (body area) of injury, severity of injury (in terms of time-loss and or medical intervention required), anatomical structure (e.g. bone, tendon, muscle injured).

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Appendix I: Search strategy

Search conducted in PubMed database on 1 September 2018.

Search	Query	Records retrieved
1	Search (((Rugby[Title/Abstract]) OR Football[Title/Abstract]) OR collision sport[Title/Abstract]) OR contact sport[Title/Abstract]	10271
2	Search ((((((((Fitness[MeSH Major Topic]) OR Athletic ability[MeSH Major Topic]) OR Athletic performance[MeSH Major Topic]) OR Plyometric tests[MeSH Major Topic]) OR endurance[MeSH Major Topic]) OR Muscular strength[MeSH Major Topic]) OR Agility[MeSH Major Topic]) OR Flexibility[MeSH Major Topic]) OR Physical characteristics[MeSH Major Topic]) OR Physical attributes[MeSH Major Topic]	32,219
3	Search (Injury[MeSH Major Topic]) OR risk factors[MeSH Major Topic]	682,106
4	Search ((((Injury[MeSH Major Topic]) OR risk factors[MeSH Major Topic])) AND ((((((((((Fitness[MeSH Major Topic]) OR Athletic ability[-MeSH Major Topic]) OR Athletic performance[MeSH Major Topic]) OR Plyometric tests[MeSH Major Topic]) OR endurance[MeSH Major Topic]) OR Muscular strength[MeSH Major Topic]) OR Agility[MeSH Major Topic]) OR Flexibility[MeSH Major Topic]) OR Physical characteristics[-MeSH Major Topic]) OR Physical attributes[MeSH Major Topic])) AND ((((Rugby[Title/Abstract]) OR Football[Title/Abstract]) OR collision sport[-Title/Abstract]) OR contact sport[Title/Abstract])	60