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Activity levels across the intensity spectrum in athletes: a systematic review protocol

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ABSTRACT

Physical activity (PA) promotes better cardiometabolic health, physical function, brain health and longevity. In contrast, prolonged sedentary behaviour (SB) is a risk factor for many chronic diseases and poor health. Limited research has evaluated or synthesised how competitive sports participation influences PA across the lifespan. Some evidence suggests, ironically, that former competitive athletes may be insufficiently active and current athletes may be highly sedentary away from sport. This study describes the protocol for a systematic review and meta-analysis on activity levels across the intensity spectrum in athletes, addressing the primary research question: is sports participation significantly associated with PA and/or SB among current and former competitive athletes? PubMed, Embase, Cochrane Database of Systematic Reviews, Web of Science and SPORTDiscus databases will be searched. Two reviewers will independently screen titles/abstracts and full texts of selected abstracts. Data will be extracted regarding the study population, sport played, PA measures and protocols, outcomes of interest and findings. Primary outcomes will include step counts, daily activity across the intensity spectrum (ie, sedentary, light, moderate and vigorous PA), metabolic equivalent of task and whole-day energy expenditure. Secondary outcomes will include additional accelerometry measures of PA, activity patterns and self-reported PA. The risk of bias will be assessed using the National Institutes of Health Study Quality Assessment Tools. Extracted data will be presented using narrative synthesis and tabular presentation. Meta-analyses will be conducted to determine outcomes with sufficient data.**PROSPERO registration number:** CRD42024469267.

INTRODUCTION

Physical activity (PA) is a modifiable lifestyle behaviour strongly and consistently linked to health. Greater PA levels reduce the risk for chronic conditions such as cardiovascular disease and type 2 diabetes, improve physical fitness levels, enhance functional capability, improve brain health and extend healthspans and lifespans.[1 2] Sedentary behaviour (SB), in contrast, is a risk factor for numerous chronic conditions.[3] Prolonged SB (sitting time) may be especially harmful to cardiometabolic

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ Physical activity (PA) is strongly associated with many health benefits, including reduced risk of early all-cause mortality and reduced risk for chronic conditions like cardiovascular disease, stroke, cancer, type 2 diabetes, obesity, hypertension and osteoporosis; improved physical fitness levels; enhanced functional capability; and improved brain health and cognition. Despite these benefits, knowledge of and adherence to national guidelines for PA remains low. Sports are often proposed and sometimes funded as a means to enhance PA. However, some research suggests, ironically, that current athletes may be highly sedentary away from sport, and former competitive athletes may be insufficiently active. Transitioning away from a sports career may be difficult for athletes as they face unique challenges such as injury management, reduced training, fewer resources and changing energy needs.

WHAT THIS STUDY ADDS

⇒ This study describes the protocol for a systematic review and meta-analysis on activity levels across the intensity spectrum in athletes: is sports participation significantly associated with PA and/or sedentary behaviour among current and former competitive athletes? This systematic review will provide a comprehensive scientific resource, including a narrative synthesis and tabular presentation of data from published studies describing activity levels across the intensity spectrum in current and former athletes. Secondary research questions will synthesise literature regarding how competition level, athletic status (ie, current vs former athlete), sex, age and sport type influence activity levels. Meta-analyses will be conducted on outcomes with sufficient data.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ Quantifying activity levels across the intensity spectrum in current and former athletes will inform healthcare providers, coaches and athletes about the risks and benefits of sports participation on PA levels. This systematic review and meta-analysis will be the critical first step towards creating targeted strategies and interventions that may help athletes lead healthier lives.

outcomes, including adiposity, lipid and plasma glucose levels, as well as cardiovascular morbidity and mortality.[3 4] Despite the profound benefits of PA and detriments of prolonged SB, knowledge of and adherence to national activity guidelines remain low.[1]

From the grassroots level upwards, sports participation is often proposed to enhance PA levels.[5 6] While current competitive athletes engage in high moderate to vigorous-intensity PA (MVPA), they may also ironically be highly sedentary outside of scheduled practices and competitions.[7] Moreover, while many former athletes adopt healthier and more active lifestyles than their non-athlete counterparts,[8–11] others do not.[8–10 12–15] A study by Sorenson and colleagues found that current college athletes report significantly greater PA levels than non-athletes but found no differences between alumni and non-athletes, indicating a significant post-athletic career decline in PA levels among athletes.[15] The transition away from a sports career may be a difficult yet critical time for developing new lifestyle behaviours as athletes often face unique challenges like managing prior injuries, reduced training, fewer resources and changing energy needs.[16] Many former athletes, particularly those involved in collision and contact sports,[12 14 17] may be hampered by prior injuries that limit their ability to participate in sport and recreational activities as they age. A recent scoping review of long-term health in middle-aged former athletes indicated that a history of previous participation in high levels of exercise, even at an elite level, may not be enough to offer lifelong protective benefits for cardiometabolic health, function or body composition.[18] These findings[18] emphasise the importance of maintaining sufficient levels of exercise or MVPA and minimising prolonged SB across the lifespan, which may also help manage some of the issues relating to previous injuries.

Research evidence on activity levels among current and former athletes is conflicting and challenging to synthesise. For example, one study found that individuals previously active in sports were likelier to accumulate high amounts of SB[19] in their leisure time than their non-athlete peers. At the same time, another study indicated that former male elite athletes engage in more leisure-time PA than healthy controls.[20] A systematic review of randomised control trials investigating the effect of sport on health-related outcomes in older adults found no significant effect of sport on overall PA participation (ie, those who participated in sports were no more active overall than those who did not).[21] Perhaps individuals who engage in sports are at risk for the occupational activity paradox,[22] though likely for different reasons. Furthermore, studies are often conducted in small, homogeneous groups (eg, male professional athletes in a single sport),[7 23] limiting generalisability.

Why is it important to do this review?
Synthesising activity levels across the intensity spectrum (ie, from sedentary to very vigorous-intensity PA levels) in current and former athletes will inform healthcare providers, coaches and athletes of the risks and benefits of sports participation on PA levels. This systematic review and meta-analysis will be a critical step towards creating targeted strategies and interventions that may help athletes lead healthier lives in the long term.

Primary and second review questions
This study aims to systematically review and meta-analyse existing literature on activity levels across the intensity spectrum in current and former competitive athletes. This primary research question is: is sports participation significantly associated with activity levels across the intensity spectrum (including PA and SB) among current and former competitive athletes?

The secondary research questions are: does the association between competitive sports participation and activity levels differ by sex (male vs female), age (youth (<18 years) vs adults (≥18 years)), athletic status (current vs former), competition level of sport (ie, tier 2 (trained/developmental athletes) vs tier 3 and above (ie, national, international, world-class athletes)),[24] type of sport (eg, contact vs non-contact) and assessment method (self-reported vs device-measured (eg, accelerometer))?

METHODS AND ANALYSIS
This protocol for a systematic review follows the Preferred Reporting Items for Systematic Reviews and Meta-Analysis Protocols statement.[25] The research question was formulated according to the population, exposure, comparison, outcome and study design framework (table 1).[26] The initial preliminary search was conducted on 15 December 2023. The protocol was submitted for registration in the International Prospective Register of Systematic Reviews (PROSPERO) on 23 January 2024 and registered on 3 February 2024. During the development of this manuscript, minor changes were made and updated in PROSPERO; any additional changes or updates to the protocol will be documented in PROSPERO.

Patient and public involvement
Neither patients nor the public were involved in this research's design, conduct, reporting, or dissemination.

Eligibility criteria
Inclusion criteria
► All studies involving human sport competitive athletes (ie, tier 2 and above)[24] were published until the search was performed. Athletes can be any sex, from the start of adolescence onwards (ie, age 10 and older), any athletic status, any competition level of the sport (tier 2 and above)[24] or any type of sport.

► Studies including any measure of PA or SB (eg, activity intensity (light, moderate, vigorous), type (PA or SB), frequency, volume) using devices (eg, accelerometers) or self-reported measures (eg, questionnaires).

► Study designs eligible for inclusion are published peer-reviewed journal articles that are cross-sectional, longitudinal, case-control, case series or clinical trials.

Table 1 Population, exposure, comparison, outcome and study design framework

Item	Specification
Participants, population of interest	Human competitive athletes (from the start of adolescence onwards (ie, age 10 and older as per the WHO) of any sex, athletic status, competition level or type of sport)
Exposure(s)	Sports participation at any competition level (eg, trained/developmental, highly trained/national level, elite/international level, world-class (ie, tier 2 and above)[24])
Comparison(s), control	Individuals who did not participate in sports or athletic activities
Outcome(s) of interest	Primary: step counts, daily activity across the intensity spectrum (ie, sedentary, light, moderate and vigorous PA), METs, whole-day EE Secondary: additional accelerometry measures of PA levels and activity patterns (eg, median bout duration of SB or PA, timing of activity accumulation), self-reported PA, adherence to PA guidelines, exercise frequency/volume
Study designs	Cross-sectional, longitudinal, case-control, case series or clinical trials

EE, energy expenditure; METs, metabolic equivalents of task; PA, physical activity; SB, sedentary behaviour.

Exclusion criteria

► Studies involving only non-athlete populations, animals, cadavers, humans younger than 10 years, pregnant women, tactical athletes (eg, firefighters, military personnel) or e-athletes/video-gaming athletes.
► Studies that do not define sports participation or competitive standard attained.[24]
► Studies that do not provide any measure of PA or SB.
► Studies that quantify training load only during practices and/or competitions but do not assess PA or SB outside of sports participation.
► All other publication types (eg, editorials, letters, reviews (systematic, scoping, narrative)), meta-analyses, conference proceedings, abstracts, posters and case reports.

Methodological considerations

To be classified as a competitive athlete, participants must engage or have engaged regularly in sport at the world-class (ie, Olympic, World Championship contenders), elite (eg, international, professional, National Collegiate Athletic Association (NCAA) Division I athletics) or sub-elite (ie, tier 2 (trained/developmental) athletes and above including NCAA Division II and III athletics, high school varsity and competitive club sports).[24] Engaging in recreational or unstructured sports activities (eg, jogging, recreational adult league) alone (ie, tier 1 or recreationally active participants)[24] is insufficient for

inclusion, given that the research question aims to study activity levels in competitive athletes.

Studies that measured game-time or training activity alone, without measuring activity levels outside of sport, will also be excluded, as the research question aims to evaluate activity levels across the intensity spectrum and throughout the day.

Activity classified as occupational PA (eg, job duties performed by firefighters, law enforcement and military personnel) has different health effects compared with leisure-time PA, as occupational PA is associated with increased risk for cardiovascular events and type 2 diabetes.[22] Studies that investigate tactical athletes (eg, firefighters, military personnel), who engage in occupational PA, will thus be excluded.

Information sources and search strategy

The search strategy was developed with a research librarian (AF). PubMed, Embase, Cochrane Database of Systematic Reviews, Web of Science and SPORTDiscus will be searched. Text word synonyms related to activity and athletes will be used. Search results will be de-duplicated and exported to Covidence (Melbourne, Australia). The search strategy can be found in PROSPERO and online supplemental file 1.

Study records: data management, selection process and data collection process

Title and abstract screening will take place in Covidence, where investigators will vote 'yes' or 'no' for each record per the predetermined eligibility criteria described above. The titles and abstracts of retrieved records will be screened independently by at least two reviewers. Any conflicts in screening will be resolved by the senior author (JJC) or discussion among the investigative team when warranted (eg, when the resolving author is part of the conflicting vote). For articles that pass the initial screening, the full text will be retrieved and independently reviewed for eligibility by two authors. Relevant systematic reviews and meta-analyses will be retained during title screening for reference lists to be manually searched for relevant studies. Data will be extracted from the full texts or corresponding supplementary material. One author will extract the data, and a second will independently verify the extractions. A third party will resolve discrepancies in the extracted data if necessary. Corresponding authors of the primary research articles will be contacted via email in case of unclear or missing data. If a response is not received or data cannot be provided, those publications will be excluded from the meta-analysis. Data to be extracted from the studies included in the review can be found in table 2. Means/medians, SD, IQRs and effect sizes will be extracted as appropriate and recorded in a summary table.

Outcomes and prioritisation

The main outcomes of interest will be daily step counts, daily activity across the intensity spectrum (ie, sedentary,

Table 2 Data will be extracted from studies included in the review

No.	Description
1	Authors and publication year
2	Country of study
3	Study design
4	Descriptors of the investigative population (sample size, gender/sex, age, athletic status, competition level of sports, type of sport)
5	Control or comparison population (if applicable)
6	Sport participation reporting method (eg, self-report)
7	Physical activity measurement method(s) (eg, accelerometry or questionnaire)
8	Accelerometer wear time (ie, minutes per day and total number of days worn) (if applicable)
9	Primary outcomes
10	Secondary outcomes
11	Key findings

light, moderate and vigorous PA), metabolic equivalents of task and whole-day energy expenditure in human athletes of any status or competitive level. Secondary outcomes of interest include additional accelerometry-based measures of PA levels and patterns[27] (eg, median bout duration of SB, median bout duration of PA, transitions from sitting/sedentary time to non-sitting/sedentary time and timing of activity accumulation (eg, early, midday or late)). Secondary outcomes also include survey/questionnaire-based self-reported PA, such as adherence to PA or exercise guidelines (eg, as recommended by the WHO and American College of Sports Medicine), exercise frequency and exercise volume.

Risk of bias in individual studies
The quality of data reported in individual studies included in the systematic review will be assessed via activity measurement method (eg, accelerometry or questionnaire) and accelerometer wear time (ie, minutes per day and total number of days worn), if applicable and available. All included studies will be assessed for risk of bias using the NIH Study Quality Assessment Tools according to the study design type.[28] Two independent reviewers will assess each study and resolve conflicts via discussion. A third reviewer will resolve any conflicts if necessary.

Data synthesis
Data will be synthesised qualitatively, and descriptive statistics for outcomes of interest in athletes will be reported in the study. Athlete populations will be compared with non-athlete populations using measures of effect when warranted. Meta-analyses will be performed on primary and secondary outcomes when sufficient data are available.

Pooled effects will be estimated using random effects meta-analysis using standardised mean differences in cases where there are enough studies (at least two per outcome) to evaluate. Heterogeneity will be assessed using the I^2 test.

Additional analyses
Planned investigations of subgroups include sex, age (youth (<18 years) vs adults (≥18 years)), athletic status (current vs former), competition level of sport (ie, tier 2 (trained/developmental athletes)[24] vs tier 3 and above (ie, national, international, world-class athletes)),[24] type of sport (eg, contact vs non-contact) or assessment method (self-reported vs device-measured (eg, accelerometer)) of the participants included in all reviewed studies. Sub-analyses regarding COVID-19-related studies or studies investigating injured populations of athletes (eg, those undergoing anterior cruciate ligament reconstruction) will be conducted if there are sufficient data to report.

Meta-bias(es)
Possible publication bias will be assessed if a minimum of 10 studies are included using a visual examination of funnel plots displaying effect estimates against sample sizes.[29] Extreme values will be compared, and plot asymmetry will be assessed using Egger's test, where a regression intercept of zero indicates an absence of publication bias. A leave-one-out sensitivity analysis will also be considered if necessary.

Confidence in cumulative evidence
Certainty of evidence will be assessed using the Grading of Recommendations Assessment, Development and Evaluation approach, which classifies evidence into one of four categories ranging from low to high.[30]

CONCLUSION
How athletes engage in activity levels across the intensity spectrum during and after their sporting careers is not well synthesised. Conducting a systematic review and meta-analysis on the associations of competitive sports participation on PA and SB in current and former athletes will provide a comprehensive scientific resource for healthcare providers, coaches and athletes. This systematic review and meta-analysis will be a critical first step towards creating targeted strategies and interventions that may help athletes lead healthier lives.

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Competing interests None declared.

Patient and public involvement Patients and/or the public were not involved in the design, or conduct, or reporting, or dissemination plans of this research.

Patient consent for publication Not applicable.

Ethics approval Ethical approval is not needed because this work is a protocol for a systematic review and meta-analysis that will synthesise previously published data. The study is thus determined to not involve human subjects and is exempt (Marquette University IRB #4758).

Provenance and peer review Not commissioned; internally peer reviewed.

Data availability statement All data relevant to the study are included in the article or uploaded as supplementary information. Data sharing is not applicable as no new datasets were generated or analysed for this study. All data are from previously published works and are included in the article.

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