Systematic review

1. * Review title.

Give the title of the review in English

The effect of fatigue on running biomechanics

2. Original language title.

For reviews in languages other than English, give the title in the original language. This will be displayed with the English language title.

3. * Anticipated or actual start date.

Give the date the systematic review started or is expected to start.

01/05/2020

4. * Anticipated completion date.

Give the date by which the review is expected to be completed.

01/05/2021

5. * Stage of review at time of this submission.

Tick the boxes to show which review tasks have been started and which have been completed. Update this field each time any amendments are made to a published record.

Reviews that have started data extraction (at the time of initial submission) are not eligible for inclusion in PROSPERO. If there is later evidence that incorrect status and/or completion date has been supplied, the published PROSPERO record will be marked as retracted.

This field uses answers to initial screening questions. It cannot be edited until after registration.

The review has not yet started: Yes

Review stage	Started	Completed
Preliminary searches	No	No
Piloting of the study selection process	No	No
Formal screening of search results against eligibility criteria	No	No
Data extraction	No	No
Risk of bias (quality) assessment	No	No
Data analysis	No	No

Provide any other relevant information about the stage of the review here.

6. * Named contact.

The named contact is the guarantor for the accuracy of the information in the register record. This may be any member of the review team.

Christopher Napier

Email salutation (e.g. "Dr Smith" or "Joanne") for correspondence:

Dr Napier

7. * Named contact email.

Give the electronic email address of the named contact.

chris.napier@ubc.ca

8. Named contact address

Give the full institutional/organisational postal address for the named contact.

212 Friedman Building

2177 Wesbrook Mall,

Vancouver, BC Canada V6T 1Z3

Canada

9. Named contact phone number.

Give the telephone number for the named contact, including international dialling code.

1-604-721-1310

10. * Organisational affiliation of the review.

Full title of the organisational affiliations for this review and website address if available. This field may be completed as 'None' if the review is not affiliated to any organisation.

University of British Columbia

Organisation web address:

https://physicaltherapy.med.ubc.ca

11. * Review team members and their organisational affiliations.

Give the personal details and the organisational affiliations of each member of the review team. Affiliation refers to groups or organisations to which review team members belong. **NOTE: email and country now**

MUST be entered for each person, unless you are amending a published record.

Dr Christopher Napier. School of Mechatronic Systems Engineering, Simon Fraser University, Metrro Vancouver, CANADA; Department of Physical Therapy, University of British Columbia, Vancouver, CANADA
Dr Christian Barton. La Trobe Sport and Exercise Medicine Research Centre, School of Allied Health, Human Services and Sport, La Trobe University, Bundoora, Victoria, Australia. Complete Sports Care, Hawthorn, Victoria Australia. Centre for Sport and Exercise Medicine, Queen Mary University of London, United Kingdom
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Ms Paula Pappalardo. La Trobe Sport and Exercise Medicine Research Centre, School of Allied Health, Human Services and Sport, La Trobe University, Bundoora, Victoria, Australia
Dr Bradley Neal. Sports & Exercise Medicine, William Harvey Research Institute, Barts and the London School of Medicine & Dentistry, Queen Mary University of London

12. * Funding sources/sponsors.

Details of the individuals, organizations, groups, companies or other legal entities who have funded or sponsored the review.

None

Grant number(s)

State the funder, grant or award number and the date of award

N/A

13. * Conflicts of interest.

List actual or perceived conflicts of interest (financial or academic).

None

14. Collaborators.

Give the name and affiliation of any individuals or organisations who are working on the review but who are not listed as review team members. **NOTE: email and country must be completed for each person, unless you are amending a published record.**

15. * Review question.

State the review question(s) clearly and precisely. It may be appropriate to break very broad questions down into a series of related more specific questions. Questions may be framed or refined using PI(E)COS or similar where relevant.

Do changes in running biomechanics occur with fatigue in healthy and injured runners?

16. * Searches.

State the sources that will be searched (e.g. Medline). Give the search dates, and any restrictions (e.g. language or publication date). Do NOT enter the full search strategy (it may be provided as a link or attachment below.)

Databases: MEDLINE (OVID), SPORTDiscus, CINAHL, PubMed, PEDro

Literature: Articles published in English and involving humans.

Study design: Prospective or retrospective studies, case studies, case controlled studies,

Participants: Human male and female distance runners (healthy and injured) that perform a run to fatigue

Outcome measures: Three-dimensional (3D) biomechanical variables – kinematics, kinetics, spatiotemporal,

lower limb muscle function (e.g. EMG, muscle/tendon forces, etc.)

Exclusion criteria:

Articles not published in English

Studies assessing running biomechanics where protocol is not to a fatigue state

Studies failing to supply enough information for evaluation

Studies using only 2D analysis

In addition, the reference lists from included papers and previous systematic reviews on running biomechanics and fatigue will be hand searched to ensure no further relevant articles are missed.

17. URL to search strategy.

Upload a file with your search strategy, or an example of a search strategy for a specific database, (including the keywords) in pdf or word format. In doing so you are consenting to the file being made publicly accessible. Or provide a URL or link to the strategy. Do NOT provide links to your search **results**.

Alternatively, upload your search strategy to CRD in pdf format. Please note that by doing so you are consenting to the file being made publicly accessible.

Do not make this file publicly available until the review is complete

18. * Condition or domain being studied.

Give a short description of the disease, condition or healthcare domain being studied in your systematic review.

Running biomechanics are known to change during the course of a prolonged run due to fatigue. However, the consistent patterns of these changing mechanics are unknown. A recent systematic review (https://PubMed.ncbi.nlm.nih.gov/27074435/) investigated the effect of fatigue on kinematics and kinetics, but only included overground running studies (n=12). The majority of the literature investigating the effects of a fatiguing run has taken place on a treadmill and these studies were not included in this systematic review. The aim of this systematic review is to identify if biomechanics changes due to fatigue in healthy and injured runners. Identifying changes in biomechanics related to fatigue is critical to the improvement of performance and prevention of injuries in runners. For this purpose, we will summarize and evaluate the evidence on this topic and provide recommendations for future research.

19. * Participants/population.

Specify the participants or populations being studied in the review. The preferred format includes details of both inclusion and exclusion criteria.

Inclusion: Human distance runners (males and females), injured or uninjured at the time of testing that performed studies in which the testing protocol involved running.

Exclusion: Studies in which the testing protocol involved any activity or sport other than sub-maximal running. Studies with a sprinting/maximal running protocol. Protocols that did not perform a run to fatigue. Studies in

which 3D biomechanical variables were not collected.

20. * Intervention(s), exposure(s).

Give full and clear descriptions or definitions of the interventions or the exposures to be reviewed. The preferred format includes details of both inclusion and exclusion criteria.

Measurements of biomechanical kinematics, kinetics, spatiotemporal, or lower limb muscle function variables.

A fatiguing protocol is defined as one in which a runner reaches a predetermined heart rate or rating of perceived exertion, or uses an alternative fatiguing protocol (e.g. follows a protocol based on previous performance that is designed to fatigue the individual).

21. * Comparator(s)/control.

Where relevant, give details of the alternatives against which the intervention/exposure will be compared (e.g. another intervention or a non-exposed control group). The preferred format includes details of both inclusion and exclusion criteria.

Runners in a non-fatigued state (within-subject designs).

22. * Types of study to be included.

Give details of the study designs (e.g. RCT) that are eligible for inclusion in the review. The preferred format includes both inclusion and exclusion criteria. If there are no restrictions on the types of study, this should be stated.

Prospective or retrospective studies, case studies, case controlled studies.

23. Context.

Give summary details of the setting or other relevant characteristics, which help define the inclusion or exclusion criteria.

Running fatiguing protocol performed on a treadmill or overground.

24. * Main outcome(s).

Give the pre-specified main (most important) outcomes of the review, including details of how the outcome is defined and measured and when these measurement are made, if these are part of the review inclusion criteria.

Biomechanical factors, categorized into kinematic, kinetic, spatiotemporal, and lower limb muscle function variables.

Kinematic factors describe the motion of an object (body) or a group of objects (body parts), without regard to the forces or torques that may produce the motion, e.g. joint or angular position, displacement, velocity or acceleration.

Kinetic factors describe forces that cause movement, e.g. ground reaction forces.

Spatiotemporal characteristics: global characteristics of the running cycle related to time or space, e.g. stance time, flight time, step length, step frequency or running velocity.

Lower limb muscle function includes variables that provide information about muscle/tendon activity/loading in the lower limbs: e.g. EMG, muscle/tendon forces, etc.

* Measures of effect

Please specify the effect measure(s) for you main outcome(s) e.g. relative risks, odds ratios, risk difference, and/or 'number needed to treat.

N/A

25. * Additional outcome(s).

List the pre-specified additional outcomes of the review, with a similar level of detail to that required for main outcomes. Where there are no additional outcomes please state ‘None’ or ‘Not applicable’ as appropriate to the review

None

* Measures of effect

Please specify the effect measure(s) for you additional outcome(s) e.g. relative risks, odds ratios, risk difference, and/or 'number needed to treat.

N/A

26. * Data extraction (selection and coding).

Describe how studies will be selected for inclusion. State what data will be extracted or obtained. State how this will be done and recorded.

Titles and/or abstracts of studies retrieved using the search strategy will be independently screened by two review team members for potential eligible studies following the application of inclusion and exclusion criteria. The selection of eligible studies will be discussed in a team meeting and discrepancies will be resolved by consulting a third reviewer. The full texts of the potential eligible studies will be retrieved and Data pertaining to study characteristics will be extracted from all included papers. Two review team members will independently assess the two reviews will be extracted. will independently extract all data independently. Discrepancies will be identified and resolved through discussion (with a third reviewer where necessary). This data extraction will include publication details (author and year), general information regarding fatigue protocol used, specific running population, sample size, data collection method, running speed during testing, and biomechanical outcome variables. Data relating to subject characteristics (e.g. age, gender, body height, body mass index) and running mileage will also be recorded. Missing data will be requested from study authors.

27. * Risk of bias (quality) assessment.

State which characteristics of the studies will be assessed and/or any formal risk of bias/quality assessment tools that will be used.

First, selected components from the ‘Quality Index’ developed by Downs and Black (Downs & Black, 1998) will be used. The original 26-question scale consists of four subscales (reporting, external validity, internal validity: bias, internal validity: confounding) with scoring criteria described for each question. When evaluating the subscales separately, items relating to external validity showed poor reliability, with both poor

internal consistency and test-retest reliability. Due to this apparent weakness in assessing external validity, we will use a modified 'Quality Index' including 15 selected components from the "Quality Index" developed by Downs and Black, and previously used in other systematic reviews of running biomechanics (Neal et al., 2016; Barton et al., 2009). On this scale, each study can score a maximum of 16. Studies scoring 11 or more will be considered high quality, 6–10 considered moderate quality, and ? 5 considered low quality (Neal et al., 2016). Two independent reviewers will evaluate all included studies. Outcomes will be discussed in a team meeting and discrepancies will be resolved by consulting a third reviewer.

28. * Strategy for data synthesis.

Describe the methods you plan to use to synthesise data. This **must not be generic text** but should be **specific to your review** and describe how the proposed approach will be applied to your data. If meta-analysis is planned, describe the models to be used, methods to explore statistical heterogeneity, and software package to be used.

In order to draw conclusions from the results across studies, various levels of evidence will be defined based on previous work of van Tulder, Furlan, Bombardier, and Bouter (2003). We will use the following definitions to classify the levels of evidence:

- Strong evidence: consistent findings among three or more studies, including a minimum of two high quality studies.

- Moderate evidence: consistent findings among two or more studies, including at least one high quality study.

- Limited evidence: findings from at least one high quality study or two low or moderate quality studies. - Very limited evidence: findings from one low or moderate quality study.

- Conflicting evidence: inconsistent findings among multiple studies.

- No evidence: results are insignificant and derived from multiple studies regardless of quality.

We anticipate that there will be limited scope for meta-analysis because of the range of different outcomes measured across the small number of existing trials.

29. * Analysis of subgroups or subsets.

State any planned investigation of 'subgroups'. Be clear and specific about which type of study or participant will be included in each group or covariate investigated. State the planned analytic approach.

We anticipate that there will be limited scope for making subgroups because of the range of different outcomes measured across the small number of existing trials.

30. * Type and method of review.

Select the type of review, review method and health area from the lists below.

Type of review

Cost effectiveness

No

Diagnostic
No

Epidemiologic
Yes

Individual patient data (IPD) meta-analysis
No

Intervention
No

Meta-analysis
No

Methodology
No

Narrative synthesis
No

Network meta-analysis
No

Pre-clinical
No

Prevention
No

Prognostic
No

Prospective meta-analysis (PMA)
No

Review of reviews
No

Service delivery
No

Synthesis of qualitative studies
No

Systematic review
Yes

Other
No

Health area of the review

Alcohol/substance misuse/abuse
No

Blood and immune system
No

Cancer
No

Cardiovascular
No

Care of the elderly
No

Child health
No

Complementary therapies
No

COVID-19
No

Crime and justice
No

Dental
No

Digestive system
No

Ear, nose and throat
No

Education
No

Endocrine and metabolic disorders
No

Eye disorders
No

General interest
No

Genetics
No

Health inequalities/health equity
No

Infections and infestations
No

International development
No

Mental health and behavioural conditions
No

Musculoskeletal
Yes

Neurological
No

Nursing
No

Obstetrics and gynaecology

No

Oral health
No

Palliative care
No

Perioperative care
No

Physiotherapy
Yes

Pregnancy and childbirth
No

Public health (including social determinants of health)
No

Rehabilitation
No

Respiratory disorders
No

Service delivery
No

Skin disorders
No

Social care
No

Surgery
No

Tropical Medicine
No

Urological
No

Wounds, injuries and accidents
No

Violence and abuse
No

31. Language.

Select each language individually to add it to the list below, use the bin icon to remove any added in error.
English

There is not an English language summary

32. * Country.

Select the country in which the review is being carried out. For multi-national collaborations select all the countries involved.

Australia

Canada
England

33. Other registration details.

Name any other organisation where the systematic review title or protocol is registered (e.g. Campbell, or The Joanna Briggs Institute) together with any unique identification number assigned by them. If extracted data will be stored and made available through a repository such as the Systematic Review Data Repository (SRDR), details and a link should be included here. If none, leave blank.

34. Reference and/or URL for published protocol.

If the protocol for this review is published provide details (authors, title and journal details, preferably in Vancouver format)

Add web link to the published protocol.

Or, upload your published protocol here in pdf format. Note that the upload will be publicly accessible.

No I do not make this file publicly available until the review is complete

Please note that the information required in the PROSPERO registration form must be completed in full even if access to a protocol is given.

35. Dissemination plans.

Do you intend to publish the review on completion?

Yes

Give brief details of plans for communicating review findings.?

We plan to submit a paper to a leading journal in this field (sport medicine/science). We also plan to disseminate the information from this review to clinicians, researchers, and the general public via infographics and conference presentations.

36. Keywords.

Give words or phrases that best describe the review. Separate keywords with a semicolon or new line. Keywords help PROSPERO users find your review (keywords do not appear in the public record but are included in searches). Be as specific and precise as possible. Avoid acronyms and abbreviations unless these are in wide use.

Running; biomechanics; fatigue

37. Details of any existing review of the same topic by the same authors.

If you are registering an update of an existing review give details of the earlier versions and include a full bibliographic reference, if available.

38. * Current review status.

Update review status when the review is completed and when it is published.New registrations must be ongoing so this field is not editable for initial submission.
Please provide anticipated publication date

Review_Ongoing

39. Any additional information.

Provide any other information relevant to the registration of this review.

40. Details of final report/publication(s) or preprints if available.

Leave empty until publication details are available OR you have a link to a preprint (NOTE: this field is not editable for initial submission). List authors, title and journal details preferably in Vancouver format.

Give the link to the published review or preprint.