Wearable technology in sport: Protocol for a scoping review

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Abstract

Introduction: Wearable technology has grown rapidly over the last decade and exists within sport in many forms such as smart jewellery (e.g., watches, wristbands, and rings), body-mounted sensors and smart clothing. Technologies placed on the skin can measure physiological variables such as heart rate, breathing rate, and blood glucose. With the exponential expansion of wearable technology, there remains a large degree of uncertainty regarding the breadth and depth of available technologies with applications to sporting activities. The objective of the scoping review is to investigate which wearable technologies placed on the skin have been developed or are in development for use in sporting activities to measure physiological variables.

Methods: The review will be conducted in accordance with the Joanna Briggs Institute and reported according to Preferred Reporting Items for Systematic Review and Meta-analysis (PRISMA) extension for scoping reviews known as the PRISMA-ScR. Four databases (i.e., Pub-Med, Scopus, SPORTDiscus and Web of Science), two grey literature databases (i.e., Open Grey and EthOS) and conference proceedings (i.e., IEEE International Workshop on Wearable and Implantable Body Sensor Networks) will be searched. Two independent reviewers will initially screen the title and abstracts, before then assessing the full text of the remaining articles. The relevant data will be extracted and presented in tabular form with a narrative summary.

Dissemination: The scoping review will summarise the available literature that utilises wearable technology applicable for sport, with the findings used to direct future sensors and research. The authors aim to publish the review in a peer-reviewed journal and present the findings at a relevant conference.

1.0 Introduction

1.1 Background

Wearable technology is defined as an electronic device worn on the user's body and can transmit real-time data back to the user or a remote system (Godfrey et al., 2018). The development and use of wearable technology has grown rapidly over the last decade and their capabilities now have applications spanning various industries (International Data Corporation, 2023). Sport is one such industry where wearable technology can be employed to quantify individuals' movements or physiological responses.

Wearable technology within sport exists in many forms such as smart jewellery (e.g., watches, wristbands, and rings), body-mounted sensors and smart clothing (Godfrey et al., 2018). These devices can measure performance variables such as acceleration, speed, step count and sleep patterns (Cardinale and Varley, 2017; Burnham et al., 2018). Wearable technologies placed on the skin can also measure physiological variables such as heart rate, breathing rate, blood glucose, etc. (Dias and Cunha, 2018). Therefore, these types of sensors which monitor variables during different types of exercise are of interest and use to consumers, athletes, performance analysts and scientists.

The monitoring of physiological variables during sporting activities has become increasingly prevalent within the world of sports performance (Foster et al., 2017). These data can be analysed and used to provide insights which can potentially help with reducing injury, assisting with rehabilitation, and optimising training load (Halson, 2014).

With the exponential expansion in the field of wearable technology, there remains a large degree of uncertainty regarding the breadth and depth of available technologies with applications to sporting activities. Given the drive to develop technologies that collect physiological variables for implementation within sport, there is a need to ensure the current range of available technologies is mapped systematically (Khalil et al., 2022). Therefore, there is a strong rationale for a comprehensive scoping review of technologies worn on the skin which collect physiological variables and have been developed for use or are currently in use within sporting activities.

1.2 Objective

The objective of the scoping review is to identify which wearable technologies placed on the skin have been developed or are in development for use in sporting activities to measure physiological variables.

1.3 Review question

Which wearable technologies placed on the skin have been developed or are in development for use in sporting activities to measure physiological variables?

2.0 Methods

The scoping review will be conducted in accordance with the Joanna Briggs Institute (JBI) manual for scoping reviews (Peters et al., 2020) and reported according to the Preferred Reporting Items for Systematic Review and Meta-analysis (PRISMA) extension for scoping reviews known as the PRISMA-ScR (Tricco et al., 2018).

2.1 Inclusion criteria

The population, concept, context (PCC) framework will direct the inclusion criteria, as it is recommended for scoping reviews by the JBI (Peters et al., 2020).

2.1.1 Population

The population of interest is any human participant(s).

2.1.2 Concept

The concept of interest is wearable technology that is placed on the skin and capable of measuring physiological variables, such as, but not limited to, heart rate, breathing rate, blood glucose, etc. Only wearable technology that has been developed or is in development for use in sporting activity will be included. Only technology which is shown to be at technology readiness level 3 (i.e., analytical, and experimental critical function or characteristic proof of concept) or above will be included (UKRI, 2022).

2.1.3 Context

The context of interest is sporting activities, including: Olympic sports, additional popular sports (e.g., American Football, Australian Rules Football, Baseball, Cricket, Formula One, Gaelic Football, Horse racing, Lacrosse, Martial Arts, Motorsports, Netball, Powerlifting) or forms of non-competitive activity (e.g., cycling, running, sprinting). Activities that take place in any environment (e.g., indoor or outdoor) and during any situation (e.g., competitions, training, research) are of interest.

2.2 Search strategy

A scoping search of PubMed was undertaken to identify relevant articles which included the use of wearable technology to monitor physiological variables in sporting contexts. The key terminology used within the titles, abstracts, keywords, and main text of the articles formed the framework used to develop the search terms shown in Table 1. For the scoping review, the search terms will be searched in Pub-Med, Scopus, SPORTDiscus and Web of Science databases. The search for grey literature will be undertaken in the Open Grey and EThOS databases. The search terms will be adapted for each database to reflect local syntax. The date range in these databases will be set from the inception of the database until the present day. The conference proceedings from the last five annual editions of the IEEE International Workshop on Wearable and Implantable Body Sensor Networks will also be searched using the term "wearable". Only studies published in the English language will be included. The reference list of all eligible sources of evidence will be screened for additional studies.

Table 1. Search terms

Population	*"Adolescen*" OR "Adult*" OR "Athlet*" OR "Boy" OR "Child*" OR "Competit*" OR "Elderly" OR "Female*" OR "Girl*" OR "Human*" OR "Junior" OR "Male*" OR "Man" OR "Master" OR "Men" OR "Mens" OR "People" OR "Person" OR "Player*" OR "Senior" OR "Veteran" OR "Woman" OR "Women*" OR "Youth" TITLE-ABS-KEY*
Concept	*("Wearable*) AND ("Detect*" OR "Device*" OR "Electr*" OR "Monitor*" OR "Sens*" OR "Smart*" OR "Technolog*" OR "Track*") AND ("Epiderm*" OR "Band*" OR "Bracelet*" OR "Chain*" OR "Cloth*" OR "E-skin*" OR "Ear" OR "Ears" OR "Earb*" OR "Earr*" OR "Flexible*" OR "Garment*" OR "Glove*" OR "Head*" OR "Helmet*" OR "Insole*" OR "Jewel*" OR "Mouthguard*" OR*

	"Patch" OR "Ring*" OR "Shinpad*" OR "Shirt*" OR "Shorts" OR "Skin" OR "Sleeve*" OR "Sock*" OR "Strap*" OR "Tattoo*" OR "Textile*" OR "Vest*" OR "Watch*" OR "Wrist*") AND ("Capacitat*" OR "ECG" OR "Electrocardiogram" OR "Electrode*" OR "Microfluidic" OR "OECT*" OR "Organic Electrochemical Transistor*" OR "Photoplethysmography" OR "PPG" OR "Pulse Oxim*" OR "Strain" OR "Therm*" OR "Ultrasound" OR "Blood" OR "Breath*" OR "Frequency*" OR "Glucose" OR "Heart" OR "Lactate" OR "O2" OR "Oxygen" OR "Pressure*" OR "Pulse" OR "Rate*" OR "Respirat*" OR "Saturation" OR "SpO2" OR "Sugar*" OR "Sweat" OR "Temperature*" OR "Ventilation") AND ("Bio" OR "Biol*" OR "Biom*" OR "Bios*" OR "Bioc*" OR "Bioe*" OR "Cardi*" OR "Internal" OR "Physiolog*" OR "Analy*" OR "Data" OR "Indicator*" OR "Marker*" OR "Measure*" OR "Metric*" OR "Parameter*" OR "Sign*" OR "Variab*") TITLE-ABS-KEY*
Context	*"Archer*" OR "Athlet*" OR "Badminton" OR "Baseball*" OR "Basketball" OR "Biathlon" OR "Bobsled*" OR "Boxing" OR "Boxer" OR "Canoe*" OR "Climb*" OR "Cricket*" OR "Curl*" OR "Cycli*" OR "Diving" OR "Diver" OR "Equestrian" OR "Exercise*" OR "F1" OR "Fenc*" OR "Fitness" OR "Football*" OR "Formula one" OR "Futsal" OR "Golf*" OR "Gymnast*" OR "Handball*" OR "Hockey" OR "Horse r*" OR "Judo" OR "Karate" OR "Lacrosse" OR "Marathon" OR "Martial art*" OR "Motorsport" OR "Netball*" OR "Olympi*" OR "Paralympi*" OR "Pentathlon" OR "Physical activity" OR "Powerlift*" OR "Rowing" OR "Rower" OR "Rugby" OR "Run" OR "Runn*" OR "Sail*" OR "Shoot*" OR "Skat*" OR "Skeleton" OR "Skier" OR "Skiing" OR "Snowboard*" OR "Soccer" OR "Softball*" OR "Sport*" OR "Sprint*" OR "Squash" OR "Surf*" OR "Swim*" OR "Table tennis" OR "Taekwondo" OR "Tennis" OR "Triathlon" OR "Volleyball" OR "Water polo" OR "Weightlift*" OR "Wrestl*" TITLE-ABS-KEY*

* indicates a wildcard, that the search term can have any ending.
TITLE-ABS-KEY indicates a title, abstract and keyword search.

2.3 Study selection

The searches will be exported from the databases and imported into Covidence systematic review software (Veritas Health Innovation, Melbourne, Australia) with the duplicates removed. Primary scientific articles including original investigations, case reports and technical notes will be included. Whereas, secondary articles (e.g., review articles) and special articles (e.g., letters to the editor, editorials, commentaries) will not be included. Only scientific grey literature (e.g.,

conference abstracts, theses, etc) will be included in this review as it is important that the outcome variables have been verified using scientific approaches. The titles and abstracts will then be screened against the inclusion criteria independently by two reviewers (DR and NW). Following this stage, the full text of the remaining articles will be assessed in detail against the inclusion criteria independently by two reviewers (DR and NW). At this stage, the reason for exclusion will be recorded and reported in the PRIMSA flow diagram within the scoping review (Tricco et al., 2018). If any abstracts, including conference abstracts, are selected without the full text available, the authors of the abstract will be contacted with a request for the full text. If there is no response after two weeks, the authors will be reminded and given a further two weeks to respond. After this point, if there has been no contact from the authors, this abstract will be excluded, and the reason noted. If there are any disagreements between the two reviewers at either stage, this will be resolved by a third independent reviewer (AS).

2.4 Data extraction

The data will be extracted from the selected articles independently by two reviewers (DR and NW) and included in the scoping review. The data extracted from the selected studies are outlined in Table 2 below.

Table 2. Data extraction

Topic	Data extracted
General study information	Title Authors Year of publication Journal Type of publication
Methods	Participant characteristics Sample size Study design Study setting Task performed
Wearable Technology	Technology readiness level Efficacy of device Location on the body

	Material(s) used Technologies employed Variables collected Target sport(s)

2.5 Risk of bias analysis

As recommended for scoping reviews by the JBI and PRISMA-ScR, a risk of bias analysis will not be conducted (Peters et al., 2020; Tricco et al., 2018).

2.6 Data synthesis and presentation

The data will be synthesised using the topics from Table 2 into relevant sub-sections. The data will be presented in tabular form with a narrative summary.

Contributions

Contributed to conception and design: DR, NW, AS
Drafted and/or revised the article: DR, NW, AS
Approved the submitted version for publication: DR, NW, AS

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Conflicts of interest/Competing interests

All authors declare no conflict of interest/competing interests.

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