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The potential impact of wearables on physical activity guidelines and interventions: opportunities and challenges

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9 T. Katzmarzyk⁸, Karen Milton⁹, Marie H. Murphy¹⁰, Emmanuel Stamatakis¹¹
10 5

11 6
12 6
13 7 ¹School of Cardiovascular and Metabolic Health, University of Glasgow, Glasgow, UK

14 8 ²Department of Infection, Immunity and Cardiovascular Disease, The Medical School, The University
15 of Sheffield, Sheffield, UK
16 9

17 10 ³The British Heart Foundation Data Science Centre, Health Data Research UK, London, UK.

18 11 ⁴Big Data Institute, Nuffield Department of Population Health, University of Oxford, Oxford, UK

19 12 ⁵Department of Biomedical Engineering, Duke University, Durham, NC, USA

20 13 ⁶Department of Sports Medicine, Norwegian School of Sports Sciences, Oslo, Norway

21 14 ⁷Department of Chronic Diseases, Norwegian Public Health Institute, Oslo, Norway

22 15 ⁸Pennington Biomedical Research Center, Baton Rouge, LA, USA

23 16 ⁹Norwich Medical School, University of East Anglia, Norwich, UK

24 17 ¹⁰Physical Activity for Health Research Centre, University of Edinburgh, Edinburgh, UK

25 18 ¹¹Charles Perkins Centre, Faculty of Medicine and Health, The University of Sydney, Sydney, New
26 South Wales, Australia.
27 19

28 20
29 21 *Correspondence to:

30 22 Professor Jason Gill

31 23 BHF Glasgow Cardiovascular Research Centre

32 24 School of Cardiovascular and Metabolic Health

33 25 College of Medical, Veterinary and Life Sciences

34 26 University of Glasgow

35 27 Glasgow

36 28 G12 8TA

37 29 United Kingdom

38 30
39 31 Tel: + 44 141 3302916

40 32 Email: Jason.Gill@glasgow.ac.uk
41 33

42 34 914 words, 8 references, 1 figure
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23 119 substantial contributions to refining and shaping the initial ideas. JMRG wrote the first draft; all
24 120 authors contributed to revisions in subsequent drafts. All authors approved the final version and are
25 121 accountable for all aspects of the work.

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158 **Figure Legend**

159 Physical activity captured by self-report questionnaire (top panels) and wearable device (bottom
160 panels) in 2 different scenarios: a session in the gym (left) and during intermittent activities of daily
161 living (right panel). Questionnaires overestimate physical activity in the former but underestimate
162 physical activity in the latter.

163 N.B. Simplified examples to illustrate the central point. VPA: vigorous physical activity.

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3 166 **Equity, diversity, and inclusion statement**
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5 167 The author team includes six men and three women, who are all from high-income countries: United
6 168 Kingdom, United States, Norway and Australia. One author is mixed-race, the others are white. The
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8 169 research cited in this editorial is largely from high-income countries which reflects the available data
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10 170 on device-based physical activity measurement and health outcomes. The need to ensure that
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12 171 changes to both guidelines and adherence monitoring methods are made through an equity lens,
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14 172 and the need for studies in more diverse populations are mentioned as important considerations in
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16 173 the editorial. We acknowledge that more data are required from diverse populations, particularly in
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18 174 low-and-middle income countries, and hope that this editorial can help highlight this need.
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14

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17

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36
37 *Correspondence to:

38 Professor Jason Gill

39 BHF Glasgow Cardiovascular Research Centre

40 School of Cardiovascular and Metabolic Health

41 College of Medical, Veterinary and Life Sciences

42 University of Glasgow

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44 G12 8TA

45 United Kingdom
46
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48 Tel: + 44 141 3302916

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31 120 authors contributed to revisions in subsequent drafts. All authors approved the final version and are
32 121 accountable for all aspects of the work.
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3 158 **Figure Legend**
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5 159 Physical activity captured by self-report questionnaire (top panels) and wearable device (bottom
6 160 panels) in 2 different scenarios: a session in the gym (left) and during intermittent activities of daily
7 161 living (right panel). Questionnaires overestimate physical activity in the former but underestimate
8 162 physical activity in the latter.
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10 163 N.B. Simplified examples to illustrate the central point. VPA: vigorous physical activity.
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Confidential: For Review Only

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3 166 **Equity, diversity, and inclusion statement**
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5 167 The author team includes six men and three women, who are all from high-income countries: United
6 168 Kingdom, United States, Norway and Australia. One author is mixed-race, the others are white. The
7
8 169 research cited in this editorial is largely from high-income countries which reflects the available data
9
10 170 on device-based physical activity measurement and health outcomes. The need to ensure that
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12 171 changes to both guidelines and adherence monitoring methods are made through an equity lens,
13
14 172 and the need for studies in more diverse populations are mentioned as important considerations in
15
16 173 the editorial. We acknowledge that more data are required from diverse populations, particularly in
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18 174 low-and-middle income countries, and hope that this editorial can help highlight this need.
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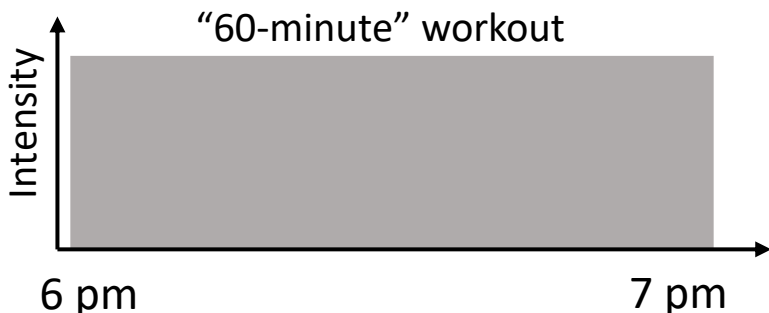
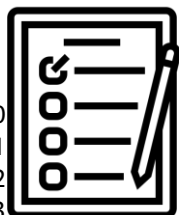
Example 1: A "60-minute" gym session

Example 2: Activities of daily living

Q: How much time did you spend exercising yesterday?

A: I went to the gym for 60 minutes

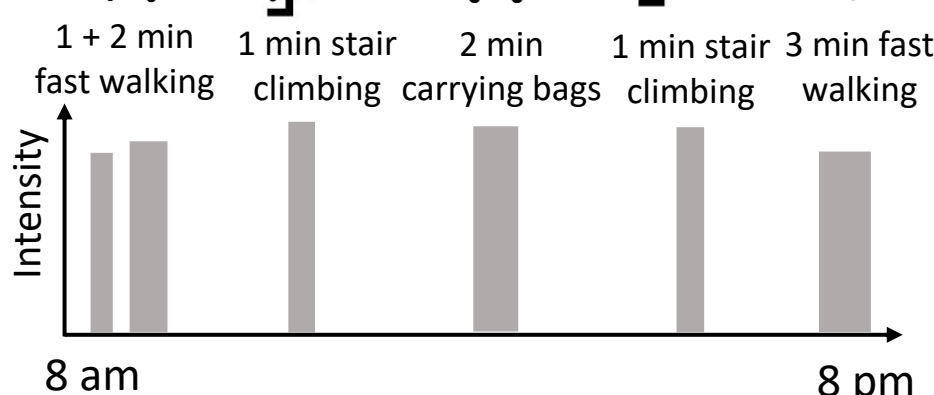
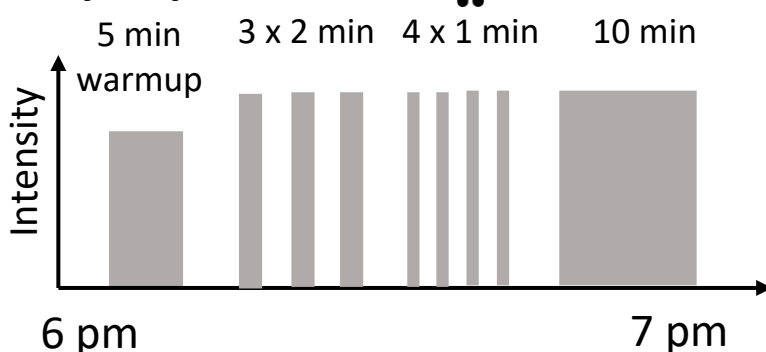
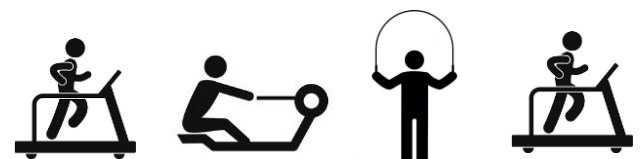
Q: How much vigorous physical activity did you do yesterday?



SELF-REPORT

Questionnaire: 60 mins VPA

Questionnaire: 0 mins VPA



DEVICE

Device-measured: 25 mins VPA

<https://mc.manuscriptcentral.com/bjsm>

Device-measured: 10 mins VPA

Dear Dr Kemp and reviewers

We would like to thank you for your comprehensive and thoughtful evaluation of this editorial. We have carefully considered all of the comments and have revised our manuscript accordingly. Our point-by-point responses are highlighted in red below and specific changes to the manuscript are highlighted in yellow. To fully address the reviewers' comments, the word count has increased slightly to 914 words. We hope that this is acceptable. Thank you for considering this work for publication in BJSM and we look forward to hearing your decision this revised version in due course.

Kind regards

Jason Gill on behalf of all authors

Formatting Amendments (where applicable):

Please make sure the following statements are included in the main document file, which should match the details given in the submission pages:

Competing interests

Contributorship

Acknowledgements

Funding and grant/award info, name and number Ethical approval information, name and number

Data sharing statement If there is no information to add, please include: none or not applicable.

Authors' response: Thank you. We have made these changes.

The figure should be supplied in 300dpi TIFF, JPEG, EPS or PDF format.

Authors' response: Thank you. We have converted the figure to pdf.

Reviewer(s)' Comments to Author (if any):

Reviewer: 1

Comments to the Author

Thank you for taking the time to put together this interesting Editorial that presents a perspective of current and future interplay between physical activity guidelines and the use of wearable devices. It was enjoyable to read. I am sure it will be of interest to the BJSM readership and generate some conversation and debate in this arena

Authors' response: Thank you for your kind comments.

Page 2 – paragraph one (starting line 35) and paragraph 2 (starting line 46) Paragraph one presents MPA and VPA guidelines as separate entities. The doses associated with device-measured recommendations in paragraph 2 are presented as a single MVPA figure. Consistency between the

two paragraphs would be helpful to facilitate an understanding of the impact on guidelines/expectations.

Authors' response: Thank you for this thoughtful comment and we appreciate your concern. We presented in this way to represent the way that physical activity guidelines are expressed in paragraph one (MPA and VPA considered separately) and how the device-measured data are reported in the epidemiological studies cited in paragraph two (i.e. as MVPA). Thus, it is not possible to use the exact same terminology in both paragraphs while also being accurate in what we say. To make things clearer we have removed the second mention of MVPA on line 51. We hope this satisfies the reviewer's concern.

Device-based activity monitoring (starting line 62) How adaptable commercial device outputs are to population monitoring of guideline adherence is also of relevance here. Few commercial devices present outputs in the format of "MPA" and "VPA". In the same way that these definitions are often unhelpful to a public unclear about this terminology, the output of commercial devices (such as number of 'very active' minutes) can be difficult to correlate to research defined MPA/VPA cut points.

Author response: Thank you for this very helpful comment. We agree. In order to respond to all the reviewer comments while retaining a good logical flow of the points made, we have moved the order of the three paragraphs describing the opportunities and challenges that wearables provide, so we now first discuss development of physical activity intervention approaches, then research-grade vs consumer wearables, and finally device-based monitoring.

In the revised manuscript, we have added a new sentence in the section on research grade vs consumer wearables (lines 76-77) stating:

"For example, it is unclear how a metric such as 'very active' minutes on a consumer-device relates to definitions of MPA and VPA used in research."

Page 3 "Research-grade vs consumer wearables"

Line 89/90 – In addition to the relationship between commercial and research grade devices, the relationship between different commercial devices (with variable algorithms) is also something that requires better understanding if they are going to be used to underpin guidelines and monitor adherence.

The least complex algorithms (e.g. step count) are established as having the least variability across the range of commercial devices and research grade devices. We know that studies using a 'more comprehensive range of metrics' will, by their nature, reveal greater variability.

Author response: Thank you. We have expanded our point about greater understanding being needed of how activity metrics from consumer-based wearables related to outputs from research-grade devices to also include how they relate to outputs from other models of consumer device (line 79). We agree that studies with a more comprehensive range of metrics will reveal greater variability between devices. However other metrics than steps captured from consumer-wearables, particularly those which contain an intensity component, may have a different (potentially stronger) relationship with health outcomes than simply measuring steps which provide a measure of total activity independent of intensity. This is why we highlighted this as a research need here.

Figure 1

I understand that you are trying to simplify here to make a point, but it doesn't quite hold together.

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3 I am assuming that the 5 min MPA (Example 1, device measured) correlates with the 5 minute warm-
4 up, however in example 2, brisk walking, or walking carrying bags are classed as VPA.
5 Perhaps consider taking moderate and vigorous out of the equation (for both examples) and using the
6 figure just to demonstrate the concept of potential differences between self-report and device
7 measured PA data?
8

9
10 **Author response: Thank you. We have now termed the warmup as VPA and have the total device-**
11 **measured activity as 25 mins VPA.**
12

13 Example 2 – the questionnaire and device measured sections are showing 2 different things. The
14 questionnaire asks for ‘continuous activity’, for which the answer is zero – the device example is
15 showing cumulative activity (the answer would still be zero in regard to 10 mins continuous activity).
16 To be comparable, the question needs to be about cumulative activity. The same illustrations would
17 work as it demonstrates the point that people forget about incidental activity undertaken.
18

19
20 **Author response: Thank you. We have now removed mention of continuous activity in the question.**
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23 **Reviewer: 2**

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27 Comments to the Author

28 Thank you for the opportunity to review this editorial about the use of wearable physical activity
29 monitors. I believe the authors use the available word count well to explore their topic. I did not
30 identify and spelling or grammar errors and think the writing is presented in a logical sequence.

31 I only have one small comment to slightly improve the clarity of your supporting Figure: I would
32 recommend reversing the order of the time provided by the device to read "5 min MPA + 20 mins
33 VPA" as this is the order the activity would be completed in your illustration. The formatting may have
34 shrunk the image at my end but the lines seem to cross over with some of the bold titles.
35
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37 **Authors’ response: Thank you for your kind comments. In response to your comment and the**
38 **comment from Reviewer 1, we have now revised the Figure so that the warm-up is classified as VPA**
39 **to increase consistency with Example 2, so we now have the total device-measured activity as 25 mins**
40 **VPA.**
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45 **Reviewer: 3**

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49 Comments to the Author

50 I’d like to commend the authors on an excellent, important and clearly written editorial. I offer the
51 following thoughts to consider:
52

53 **Authors’ response: Thank you for your kind comments.**
54
55

56 One aspect not touched upon here is privacy. Many (understandably) don’t want data to be accessed
57 by third party servers in other countries. The word ‘surveillance’ can have negative connotations. The
58 question becomes, ‘who owns the data’? Could you comment?
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3 Authors' response: Thank you. This is a very important point. We have now added further text to the
4 consumer wearables paragraph to highlight that important challenges remain in relation to consumer
5 devices with respect to data ownership and privacy (as well as representativeness, and alignment of
6 metrics between devices) (lines 84-89). We have also replaced the term surveillance with monitoring
7 (line 97 and 104).
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11 While objective data via accelerometry may be more accurate at capturing 'true' physical activity
12 levels, I also wonder about the accuracy in research given the length of time that participants may
13 wear the device and if this changes over time (ie the novelty wears off) – could you comment /
14 reference anything specific to sustainability/long-term results?
15

16 Authors' response: Thank you. This is an interesting point. We feel that there are two issues here.
17 Firstly, using devices to monitor physical activity. Here we don't know how long people would be
18 prepared to wear devices for, which is likely to depend on whether data are being captured from their
19 own consumer-device or a research-grade device supplied by researchers. The evidence (at least from
20 the All of Us Research Program) is that a selected group of people are prepared to provide data from
21 their own devices for several years. The second issue relates to how long people are prepared to
22 engage with and use their device as a self-monitoring tool to support them in increasing their physical
23 activity level. This is more uncertain. We have made an addition to line 67 to state that studies are
24 needed to test the long-term effectiveness of novel device-monitored intervention approaches.
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29 Very glad to see mention of equity– what about those who will never be able to afford even simple
30 wearables? Wouldn't a change in guidelines, even if concurrent, potentially further deter those who
31 can't afford to access the "right" (eg relatively wealthy person) guidelines?
32

33 Authors' response: Thank you. This is a very important point and is why we have emphasised that any
34 changes to guidelines and monitoring would need to be made through as equity lens. Any changes to
35 guidelines would need to be made with sensitivity to the concern that many, particularly in LMIC
36 countries, will never be able to access a wearable device. This is why we have also emphasised the
37 need for concurrent measurements with devices and self-report in surveillance and cohort studies to
38 better understand how align self-report and device-based data.
39
40

41 It may also be of value to mention that a first step is to ensure research be undertaken in historically
42 underrepresented / marginalized groups given the cost of these wearables – or do we have this data
43 already?
44

45 Authors' response: Thank you. We have now mentioned the need for further research in historically
46 underrepresented and marginalised groups on line 83.
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49 Thanks -an enjoyable read.
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