

## **Enabling better health for all: the role for digital technologies to help people move more and stay healthier for longer**

A response from the GetaMoveOn Network+ to *Advancing our Health: prevention in the 2020s*

*The GetaMoveOn Network+ supports an interdisciplinary network of researchers whose aim is to get people moving more with the help of digital technologies. It is funded by the EPSRC and led by Prof. Anna Cox of UCL.*

The recently published green paper *Advancing our Health: prevention in the 2020s<sup>3</sup>* sets out the government's strategy for putting health prevention and digitally-enabled services at the heart of healthcare.

#### In this briefing we:

Outline the central role played by physical activity in primary prevention of a wide range of chronic health conditions and as a tool for achieving the government's objective of 'better health for all'.

Demonstrate some of the ways in which technology can successfully support physical activity.

Identify the features and characteristics that make interventions effective and provide guidance for commissioners, service providers, clinicians and social prescribing link-workers.

### Executive summary

Physical activity is one of the key ingredients to better health for all. It not only reduces early deaths but decreases the risk of 35 chronic health conditions and improves mental well-being. However, many people find it difficult to become and stay physically active. The widespread adoption of digital technologies presents new opportunities: they can support active lifestyles for individuals and enable delivery of physical activity programmes cost-effectively, at scale, for target communities. However, a number of key elements need to be in place to make these effective.

### Recommendations



Physical activity should be considered a 'principal intervention' for primary prevention of chronic disease: those delivering primary healthcare should emphasise its importance and make more use of exercise 'prescriptions'.



Digital technology should be used to support physical activity and funding should be made available at the national and local level to develop effective technology-enabled physical activity support-tools and programmes.



These digital technologies should use behaviour change techniques including educating and giving feedback, motivating and rewarding activity, to enable people to sustain increased physical activity over time.



The digital technologies and programmes should be designed with the involvement of the target community to ensure that their needs are met.

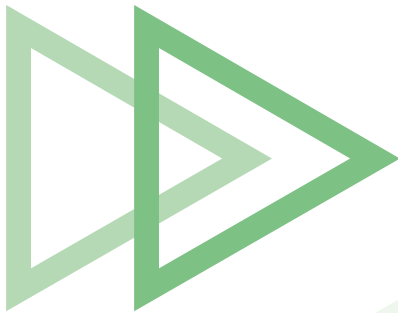


Commissioners, service providers, clinicians and social prescribing link-workers should be made aware of what to look for in physical activity technologies, how these can be used effectively with individuals, and what makes technology-enabled programmes successful.



# Introduction

The recently published government green paper, *Advancing our Health: prevention in the 2020s*, sets out the government's strategy for putting health prevention and digitally-enabled services at the heart of healthcare. There is significant untapped potential for technology to help people lead healthier lives, in particular to be more active. The potential benefits of this are considerable but the role for physical activity in primary prevention is often underestimated. This is important given that the cost of physical inactivity has been estimated at £1bn a year in direct costs to the NHS, rising to £7.4bn when the costs to wider society are included<sup>4</sup>. The cost for just five preventable diseases – ischaemic heart disease, cerebrovascular disease, breast cancer, colon cancer and type 2 diabetes – is £9.4m annually to each NHS CCG in England alone<sup>5</sup>.



## The benefits of physical activity for primary prevention and wellbeing

Physical activity has a significant impact on a person's health. The onset of chronic disease is becoming more prominent in younger adults, due in significant part to physical inactivity<sup>33</sup>. Regular physical activity has the potential to prevent 46% of deaths related to inactivity<sup>6</sup>. It has also been shown to strengthen our immune system as we age<sup>7</sup>, lower risk of heart disease, high blood pressure and diabetes<sup>8</sup>, as well as dementia, various cancers and stroke, while improving mental wellbeing and reducing anxiety and depression<sup>9</sup>. There is 'conclusive and overwhelming' scientific evidence for physical inactivity as a primary cause of 35 chronic diseases<sup>34</sup>. This underscores the potential for physical activity to play a much wider role in primary prevention than is often recognised.

'If physical activity were a drug, we would refer to it as a miracle cure, due to the great many illnesses it can prevent and help treat.'

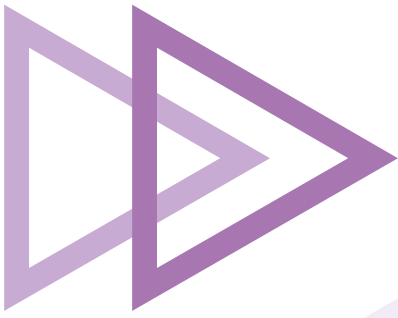
**UK Chief Medical Officers: Physical Activity Guidelines 2019**

Incorporating physical activity and exercise in everyday living is essential for primary disease prevention. Physical activity should be considered a 'principal intervention' for primary prevention of chronic disease<sup>33</sup>.

'Physical activity is an under-appreciated asset in our clinical arsenal. It is cheap and brings a long list of health benefits.'

**Prof. Dame Sally Davies, Chief Medical Officer for England**





## How physically (in)active are we?

Only 66% of men and 58% of women in England meet the recommended amount of physical activity <sup>10</sup>.

In England, 29% of people spend six or more hours a day sitting <sup>10</sup>. Due to the sedentary nature of the modern workplace, men in the UK on average spend 78 days a year sitting during the day; for women, it's 74 days a year <sup>11</sup>. Sitting for such extended periods during the day has severe negative effects on health outcomes, even for otherwise active people <sup>12</sup>.

There is clearly a need to increase the amount of physical activity and exercise people do.



**29%**

Of the population spend 6 or more hours a day being sedentary

That's an average of

**78 days**

a year sitting for men

And...

**74 days**

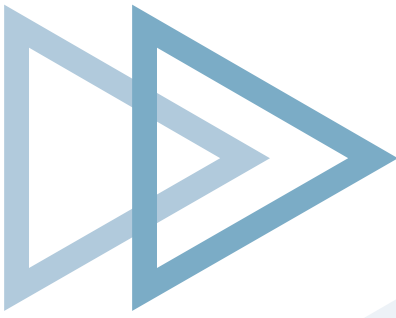
a year sitting for women



**66% 58%**

Meet the recommended amount of physical activity





# How can digital technology support physical activity on an individual level and at scale?

The widespread adoption of digital technologies like smartphones, even amongst older adults and lower-income groups, means there is potential to make better support for physical activity affordable and accessible.

## Technology can make physical activity more affordable and accessible

Technology has the potential to support a broad range of people to be more physically active. With the wide adoption of smartphones and internet technologies, there is potential to make support for physical activity more affordable and accessible. 79% of adults in the UK use a smartphone<sup>13</sup>, with usage numbers increasing year on year. Even for older adults, mobile phone use is above 96% for people aged 55 to 64, 92% for people aged 65 to 74 and 81% for people aged over 75<sup>13</sup>. In addition, mobile and smartphone use is increasing across socio-economic groups<sup>13</sup>.



96% aged 55 to 64  
92% aged 65 to 74  
81% aged 75+

## Combining technology with additional support for maximum impact

While activity trackers have risen in popularity and are effective at measuring activity levels, they offer little support to help maintain, improve or encourage physical activity and are often abandoned when used in isolation<sup>14</sup>.

However, when used in conjunction with mobile-based exercise programs, they can be successful in helping people to increase their activity levels<sup>15</sup>.

Similarly, using a physical activity education app alongside brief in-person counselling has been shown to increase activity levels, both short- and long-term, in physically inactive women<sup>16</sup>.

Simply 'prescribing' an activity tracker is unlikely to lead to any sustained increase in someone's physical activity. However, an initiative where people receive even a brief exercise counselling session with a personal trainer or coach, and are encouraged to use a tracker in conjunction with an online exercise programme or app, is more likely to see positive results.

Using an app in combination with a brief in-person activity counselling session can help people to stick with their physical activity programme and increase their activity in the short and longer term.



A brief session with a personal trainer or coach, in conjunction with online exercise programme/app is likely to see positive results





### CASE STUDY: ENGAGING OLDER ADULTS

Dr Max Western from the University of Bath is developing methods for engaging older adults to use new physical activity technologies. His research explores how these can be used to reduce sitting time and encourage daily activity. It highlights the need to engage with target users in both the design and evaluation of technology. [www.GetAMoveOn.ac.uk/videos](http://www.GetAMoveOn.ac.uk/videos)

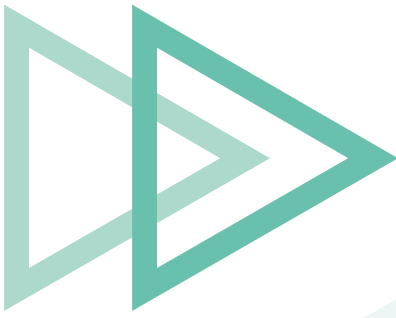
### Starting with the least active: the benefits of just sitting less

As well as considering physical activity in terms of exercise, there is a need to address people's daily activity levels. Interventions that focus on being more active during the day<sup>31</sup>, or even just on encouraging breaks from sitting<sup>32</sup>, especially at work and for older people, have been shown to be effective at making people more active and reducing health risks.



**Frequent breaks  
make people more active  
and reduce health risks**





# What features make technology effective in helping people increase their physical activity?



## CASE STUDY: REWARDING ACTIVITY

Dr Kirk Plangger at Kings College London is investigating how “gamification” can be used to reward physical activity. His work shows how a combination of real rewards and motivational nudges can be used to keep people engaged with a physical activity programme. [www.GetAMoveOn.ac.uk/videos](http://www.GetAMoveOn.ac.uk/videos)

Digital technologies such as trackers, apps and online programmes which incorporate proven behaviour change techniques are more likely to lead to sustained increases in activity over time.

## Gamification

‘Gamification’ is a buzz word in technology circles. Its intention is to make otherwise unappealing activities more engaging, and the gamification of exercise is a big area of research. Activity-based games, known as ‘exergames’ have been shown to benefit physical activity<sup>17</sup>, both on consoles such as the Wii and on mobile, but setting the context is important: without a focus on the health benefits of such activities, engagement is limited - people don’t continue to use them over time<sup>18</sup>. So active games should be positioned and described in terms of their health benefits. We need to be ‘focusing on “healthifying” exergames’ - highlighting an exergame’s dual purpose as both a game and exercise – not just “gamifying” health behaviors<sup>18</sup>.

## Including behaviour change techniques.

In order to make meaningful changes to people’s lifestyles, digital technologies need to incorporate ‘behaviour change techniques’<sup>19</sup> which prompt and support people to make lasting changes over time, rather than focusing on short-term changes<sup>20</sup>. Some of the key features that should be included in the design of technology for physical activity are information, encouragement and routine building<sup>21</sup>.

## Gamification

makes unappealing activities more engaging



Activity-based games, known as ‘exergames’ benefit physical activity on consoles such as the Wii and on mobile



But people don’t continue to use them over time



Emphasising health benefits of exergames promotes longer term use





### CASE STUDY: SMART SPEAKERS FOR ACTIVITY

Dr Angela Carlin at the University of Ulster is exploring how smart speakers like Alexa and Google Home Hub can be used to give advice and encouragement on physical activity and healthy eating. These devices offer the potential to support families in their own homes. Dr Carlin and her team have found that they are a promising method for providing educational material and helping people to develop healthier routines. [www.GetAMoveOn.ac.uk/videos](http://www.GetAMoveOn.ac.uk/videos)

### Information & feedback

Providing information and feedback helps people to learn how to exercise safely and avoid injury. It is also an important aspect of encouraging long-term lifestyle changes. Through the use of technologies like wearables and smartphone-based activity tracking, people are able to monitor and get feedback on their physical activity. This helps them to maintain an active lifestyle<sup>22</sup>. They can also set and track goals, which can help with continued progress and motivation<sup>23</sup>. Enabling them to reflect on their current achievements and how they are progressing helps them to build belief in their own ability, an important factor in maintaining physical activity<sup>24</sup>.

However, it may take some time for people to see noticeable effects on their health, so providing educational materials that help people to understand the context of the feedback they get from their device or apps is important<sup>16 18</sup>. It helps them to understand more about the unseen impact increased physical activity may have.

### Encouragement

Including methods for extrinsic (external) encouragement can support people to continue bring more physically active. This can come from motivational messaging to encourage people to go for their daily walk<sup>25</sup>, virtual or real-life rewards for reaching milestones<sup>23,26</sup>, or through the use of social networking and community building to help people encourage one another<sup>27,28</sup>.

### Routine-building

Technologies that include features to support routine-building can help people to continue past perceived barriers and promote continued engagement<sup>21,29</sup>. While learning and seeing progress is important, this can only be achieved over time. Giving people encouragement is important in helping them to get to the point where they start to develop habits and to feel improvements in their capability.

When using technology all these factors should be considered together in order to actively support changes in behaviour<sup>21</sup>.



Using technologies like wearables and smartphone-based activity tracking, people are able to monitor and get feedback on their physical activity



This helps to maintain an active lifestyle

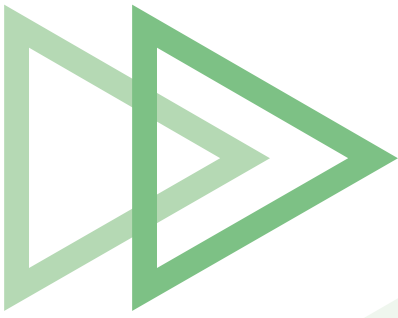


Digital technologies should aim to inform and educate people on both technique and the benefits of activity, as well as providing feedback to help people track and understand their progress

Digital technologies should aim to encourage physical activity through motivational messaging, rewarding activity and using social motivators to encourage continued engagement.

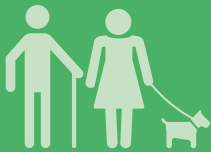






## Tailoring programmes

Specific communities may be more receptive to particular motivators. For example, it was found that older adults were more motivated by the social and environmental aspects of a physical activity intervention, i.e. seeing others from their community while doing exercise or using local walking routes<sup>28</sup>. Others may be more receptive to more novel approaches to giving feedback. For example, more 'playful' feedback using music to support progress while also informing people about their movement<sup>30</sup>. In addition, there are many other motivators for physical activity apart from health or social benefits, such as improved sleep and reduced stress. When planning a programme or intervention, or when promoting it, it is important to understand what really motivates your target community, and to consider the specific needs of those the technology or programme is being designed for.



**Older adults are...**

**more motivated by seeing others from their community while doing exercises or using local walking routes**



**Others maybe more receptive to novel approaches, e.g. using music to support progress**



**Many other motivators for physical activity...**



### **CASE STUDY: GETTING FOOTBALL FANS ACTIVE**

Dr John Rooksby from Northumbria University worked with football fans to develop an application to promote activity. Their work demonstrates that important insights into how best to engage a target community can be gained by involving those communities in the design of technology, especially those who are hardest to engage in physical activity programmes. [www.GetAMoveOn.ac.uk/videos](http://www.GetAMoveOn.ac.uk/videos)

**It's important to know your target community and make sure that your plans will meet their wants and needs, and address their motivations**



# Recommendations



Physical activity should be considered a 'principal intervention' for primary prevention of chronic disease: those delivering primary healthcare should emphasise its importance and make more use of exercise 'prescriptions'.



Digital technology should be used to support physical activity and funding should be made available at the national and local level to develop effective technology-enabled physical activity support-tools and programmes.



These digital technologies should use behaviour change techniques including educating and giving feedback, motivating and rewarding activity, to enable people to sustain increased physical activity over time.



The digital technologies and programmes should be designed with the involvement of the target community to ensure that their needs are met.



Commissioners, service providers, clinicians and social prescribing link-workers should be made aware of what to look for in physical activity technologies, how these can be used effectively with individuals, and what makes technology-enabled programmes successful.



# Guidance for commissioners, service providers, clinicians and social prescribing link-workers

The following guidance is designed to assist those involved in making decisions and recommendations, both to individuals and organisations, on the use of technologies to support physical activity. It sets out a number of key considerations and questions to ask about technologies or technology-enabled programmes and services to help ensure they are targeted, acceptable to users and effective in promoting and sustaining increased physical activity.

## Understand the nature of activity and inactivity in your area

Understanding patterns of inactivity is the foundation for developing tailored programmes:

- Who is completely inactive?
- Who is not doing enough?
- Who is active but only at light intensity?
- What specific groups or communities have particular needs?

## Target those who are least active

Those who are least active have the greatest health risks, and it only takes a small increase in activity to deliver significant benefits, especially in those who are least active. The least active may benefit from using technologies aimed at reducing sitting time.

## Partner with workplaces

The workplace is a key site for reaching people, given how long people spend there and the extent of sedentary behaviour at work. Working in partnership with local employers to help them design programmes that lead to sustained increases in physical activity could be a cost-effective strategy.

## Understand people's wants and needs

- What is important to them and will help motivate them to be more active? What are the right 'hooks'?
- What are the barriers?
- These insights can inform not only what services you commission but how you communicate and promote them.

## Involve people to ensure technology and technology-enabled programmes meet their needs

- Has this technology or programme been designed with the involvement of the target users, considering their needs and goals?
- Has it been designed with the involvement of clinicians and/or physical activity practitioners?
- Does the technology or programme incorporate behaviour change techniques e.g. how does it give people feedback about their activity? How does it give them encouragement?

## The role of face-to-face support

For target groups that want or need ongoing support from a real person, consider how this can be made cost-effective through programmes that combine an element of face-to-face support with remote delivery and/or remote contact with a real person, such as a physiotherapist or personal trainer in a local gym.

## Provide appropriate training for those involved in delivery

Ensure that clinicians, social prescribing link-workers and those delivering prescribed activities (e.g. fitness trainers in a local gym) are suitably trained and informed about the evidence for how technologies can be used effectively to support increased activity and habit-formation, how best to combine personal support with the use of technologies, and how to select technologies that are suited to a particular individual's needs.

## Tailor your messaging

Tailor messaging to the motivations of different groups. Do they want to be healthier, happier, or sleep better? Does 'doing more sport' appeal, or 'being more active', or just 'moving more' rather than 'exercising'?



## Authors

Joe Newbold, UCL, GetaMoveOn Network+

Clare Casson, UCL, GetaMoveOn Network+

Anna Cox, UCL, GetaMoveOn Network+

## Acknowledgements

Thank you to the GetaMoveOn fellows and feasibility grant researchers for their help in compiling the evidence for this publication.

This publication was funded by UCL Public Policy through EPSRC Impact Acceleration Account award EP/R511638/1

The GetaMoveOn Network+ is funded by the EPSRC grant number EP/N027299/1

## References

1. Department of Health and Social Care. Prevention is better than cure: our vision to help you live well for longer - GOV.UK [Internet]. 2018 [cited 2019 Aug 21]. Available from: <https://www.gov.uk/government/publications/prevention-is-better-than-cure-our-vision-to-help-you-live-well-for-longer>
2. Department of Health and Social Care. NHS Long Term Plan launched - GOV.UK [Internet]. 2019 [cited 2019 Aug 21]. Available from: <https://www.gov.uk/government/news/nhs-long-term-plan-launched>
3. Cabinet Office and Department of Health and Social Care. Advancing our health: prevention in the 2020s - GOV.UK [Internet]. 2019 [cited 2019 Aug 21]. Available from: <https://www.gov.uk/government/consultations/advancing-our-health-prevention-in-the-2020s>
4. NICE. Physical activity and the environment [Internet]. NICE; 2018 [cited 2019 Aug 21]. Available from: <https://www.nice.org.uk/guidance/ng90/chapter/Context>
5. Michael Brannan. Increasing physical activity in every level of society - Public health matters [Internet]. 2018 [cited 2019 Aug 21]. Available from: <https://publichealthmatters.blog.gov.uk/2018/10/10/increasing-physical-activity-in-every-level-of-society/>
6. Mok A, Khaw K-T, Luben R, Wareham N, Brage S. Physical activity trajectories and mortality: population based cohort study. *BMJ* [Internet]. 2019 Jun 26 [cited 2019 Aug 8];365:l2323. Available from: <https://www.bmj.com/content/365/bmj.l2323>
7. Nieman DC, Wentz LM. The compelling link between physical activity and the body's defense system. *J Sport Heal Sci* [Internet]. 2019 May 1 [cited 2019 Aug 8];8(3):201–17. Available from: <https://www.sciencedirect.com/science/article/pii/S2095254618301005>
8. Allender S, Foster C, Scarborough P, Rayner M. The burden of physical activity-related ill health in the UK. *J Epidemiol Community Health* [Internet]. 2007 Apr 1 [cited 2015 Dec 30];61(4):344–8. Available from: <http://jech.bmj.com/content/61/4/344.full>
9. Knapen J, Vancampfort D, Moriën Y, Marchal Y. Exercise therapy improves both mental and physical health in patients with major depression. *Disabil Rehabil* [Internet]. 2015 Jul 31 [cited 2019 Aug 8];37(16):1490–5. Available from: <http://www.tandfonline.com/doi/full/10.3109/09638288.2014.972579>
10. NHS Digital. Health Survey for England, 2016. 2016.
11. British Heart Foundation. Physical Inactivity Report 2017 - [Internet]. 2017 [cited 2019 Aug 30]. Available from: <https://www.bhf.org.uk/informationsupport/publications/statistics/physical-inactivity-report-2017>
12. Parry S, Straker L. The contribution of office work to sedentary behaviour associated risk. *BMC Public Health* [Internet]. 2013 Dec 4 [cited 2018 Dec 4];13(1):296. Available from: <http://bmcpublichealth.biomedcentral.com/articles/10.1186/1471-2458-13-296>
13. OfCom. Adults: Media use and attitudes report 2019 [Internet]. 2019 [cited 2019 Aug 19]. Available from: [https://www.ofcom.org.uk/\\_\\_data/assets/pdf\\_file/0021/149124/adults-media-use-and-attitudes-report.pdf](https://www.ofcom.org.uk/__data/assets/pdf_file/0021/149124/adults-media-use-and-attitudes-report.pdf)
14. Harrison D, Marshall P, Bianchi-Berthouze N, Bird J. Activity tracking: barriers, workarounds and customisation. 2015 Sep 7 [cited 2016 Feb 5];617–21. Available from: <http://dl.acm.org/citation.cfm?id=2750858.2805832>
15. Hurling R, Catt M, De Boni M, Fairley B, Hurst T, Murray P, et al. Using internet and mobile phone technology to deliver an automated physical activity program: randomized controlled trial. *J Med Internet Res*. 2007;9(2):e7.
16. Fukuoka Y, Haskell W, Lin F, Vittinghoff E. Short- and Long-term Effects of a Mobile Phone App in Conjunction With Brief In-Person Counseling on Physical Activity Among Physically Inactive Women. *JAMA Netw Open* [Internet]. 2019 May 24 [cited 2019 Aug 8];2(5):e194281. Available from: <http://jamanetworkopen.jamanetwork.com/article.aspx?doi=10.1001/jamanetworkopen.2019.4281>
17. Biddiss E, Irwin J. Active video games to promote physical activity in children and youth: a systematic review. *Arch Pediatr Adolesc Med* [Internet]. 2010 Jul 5 [cited 2016 Feb 20];164(7):664–72. Available from: <http://archpedi.jamanetwork.com/article.aspx?articleid=383491>
18. Chen FX, King AC, Hekler EB, Chen FX, King AC, Hekler EB. "healthifying" exergames. In: Proceedings of the 32nd annual ACM conference on Human factors in computing systems - CHI '14 [Internet]. New York, New York, USA: ACM Press; 2014 [cited 2019 Aug 8]. p. 1855–64. Available from: <http://dl.acm.org/citation.cfm?doid=2556288.2557246>



19. Schoeppe S, Alley S, Van Lippevelde W, Bray NA, Williams SL, Duncan MJ, et al. Efficacy of interventions that use apps to improve diet, physical activity and sedentary behaviour: a systematic review. *Int J Behav Nutr Phys Act* [Internet]. 2016 Dec 7 [cited 2018 Dec 5];13(1):127. Available from: <http://ijbnpa.biomedcentral.com/articles/10.1186/s12966-016-0454-y>
20. McKay FH, Wright A, Shill J, Stephens H, Uccellini M. Using Health and Well-Being Apps for Behavior Change: A Systematic Search and Rating of Apps. *JMIR mHealth uHealth* [Internet]. 2019 Jul 4 [cited 2019 Aug 8];7(7):e11926. Available from: <https://mhealth.jmir.org/2019/7/e11926/>
21. Bondaronek P, Alkhalidi G, Slee A, Hamilton FL, Murray E. Quality of Publicly Available Physical Activity Apps: Review and Content Analysis. *JMIR mHealth uHealth* [Internet]. 2018 Mar 21 [cited 2019 Aug 8];6(3):e53. Available from: <http://mhealth.jmir.org/2018/3/e53/>
22. Kirwan M, Duncan MJ, Vandelanotte C, Mummery WK. Using smartphone technology to monitor physical activity in the 10,000 Steps program: a matched case-control trial. *J Med Internet Res* [Internet]. 2012 Apr 20 [cited 2019 Aug 13];14(2):e55. Available from: <http://www.jmir.org/2012/2/e55/>
23. Munson SA, Consolvo S. Exploring goal-setting, rewards, self-monitoring, and sharing to motivate physical activity. In: *Pervasive computing technologies for healthcare (PervasiveHealth), 2012 6th international conference on*. 2012. p. 25–32.
24. Shieh C, Weaver MT, Hanna KM, Newsome K, Mogos M. Association of self-efficacy and self-regulation with nutrition and exercise behaviors in a community sample of adults. *J Community Health Nurs*. 2015;32(4):199–211.
25. Notthoff N, Carstensen LL. Promoting walking in older adults: Perceived neighborhood walkability influences the effectiveness of motivational messages. *J Health Psychol* [Internet]. 2014; Available from: <http://dx.doi.org/10.1177/1359105315616470>
26. Khot RA, Lee J, Aggarwal D, Hjorth L, Mueller F. Tastybeats: Designing palatable representations of physical activity. In: *Proceedings of the 33rd Annual ACM Conference on Human Factors in Computing Systems*. 2015. p. 2933–42.
27. Cavallo DN, Tate DF, Ries A V., Brown JD, DeVellis RF, Ammerman AS. A Social Media–Based Physical Activity Intervention: A Randomized Controlled Trial. *Am J Prev Med* [Internet]. 2012 Nov 1 [cited 2019 Aug 13];43(5):527–32. Available from: <https://www.sciencedirect.com/science/article/pii/S074937971200520X>
28. Zubala A, MacGillivray S, Frost H, Kroll T, Skelton DA, Gavine A, et al. Promotion of physical activity interventions for community dwelling older adults: A systematic review of reviews. Zeeb H, editor. *PLoS One* [Internet]. 2017 Jul 10 [cited 2019 Aug 13];12(7):e0180902. Available from: <http://dx.plos.org/10.1371/journal.pone.0180902>
29. Patel M, O’Kane AA. Contextual Influences on the Use and Non-Use of Digital Technology While Exercising at the Gym. In: *Proceedings of the 33rd Annual ACM Conference on Human Factors in Computing Systems - CHI ’15* [Internet]. New York, New York, USA: ACM Press; 2015 [cited 2019 Aug 8]. p. 2923–32. Available from: <http://dl.acm.org/citation.cfm?doid=2702123.2702384>
30. Newbold JW, Bianchi-Berthouze N, Gold NE, Tajadura-Jiménez A, Williams AC. Musically Informed Sonification for Chronic Pain Rehabilitation: Facilitating Progress & Avoiding Over-Doing. In: *Proceedings of the 2016 CHI Conference on Human Factors in Computing Systems* [Internet]. New York, NY, USA: ACM; 2016. p. 5698–703. (CHI ’16). Available from: <http://doi.acm.org/10.1145/2858036.2858302>
31. Kazakos K, Bourlai T, Fujiki Y, Levine J, Pavlidis I. NEAT-o-Games. In: *Proceedings of the 10th international conference on Human computer interaction with mobile devices and services - MobileHCI ’08* [Internet]. New York, New York, USA: ACM Press; 2008 [cited 2019 Aug 13]. p. 515. Available from: <http://portal.acm.org/citation.cfm?doid=1409240.1409333>
32. Stephenson A, McDonough SM, Murphy MH, Nugent CD, Mair JL. Using computer, mobile and wearable technology enhanced interventions to reduce sedentary behaviour: a systematic review and meta-analysis. *Int J Behav Nutr Phys Act* [Internet]. 2017 Dec 11 [cited 2019 Mar 29];14(1):105. Available from: <http://ijbnpa.biomedcentral.com/articles/10.1186/s12966-017-0561-4>
33. Durstine JL, Gordon B, Wang Z, Luo X. Chronic Disease and the link to physical activity. *Journal of Sport and Health Science* 2013; 2(1): 3-11
34. Booth FW, Roberts CK, Laye MJ. Lack of exercise is a major cause of chronic diseases. *Compr Physiol* 2012; 2(2): 1143-1211

Funded by UCL Public Policy through EPSRC Impact Acceleration Account award EP/R511638/1

