TITLE PAGE

Authors Names:

James P Sanders PhD[1,2], Stuart JH Biddle PhD [5], Kajal Gokal PhD [1,2], Lauren B Sherar PhD [1,2], Magdalena Skrybant PhD [3,4], Helen M Parretti PhD[6], Natalie Ives PhD [7], Thomas Yates PhD [8,9], Nanette Mutrie PhD [10] & Amanda J Daley PhD [1,2] on behalf of the Snacktivity Study Team*

Title

'Snacktivity™ ' to increase physical activity: Time to try something different?

Affiliations

[1] National Centre for Sport and Exercise Medicine, School of Sport, Exercise and Health Sciences, Loughborough University, Loughborough, Leicestershire, UK

[2] Centre for Lifestyle Medicine and Behaviour, School of Sport, Exercise and Health Sciences, Loughborough University, Loughborough, Leicestershire, UK

[3] Institute of Applied Health Research, University of Birmingham, Edgbaston, Birmingham, UK

[4] NIHR Applied Research Collaboration (ARC) West Midlands, University of Warwick, Coventry, UK

[5] Physically Active Lifestyles Research Group (USQ-PALs), Centre for Health Research, University of Southern Queensland, Springfield, QLD 4300, Australia

[6] Norwich Medical School, University of East Anglia, Norwich, UK

[7] Birmingham Clinical Trials Unit, Institute of Applied Health Research, University of Birmingham, Edgbaston, Birmingham, UK

[8] Diabetes Research Centre, University of Leicester, Leicester, UK

[9] NIHR Leicester Biomedical Research Centre, Leicester, UK

[10] Physical Activity for Health Research Centre, Institute for Sport, Physical Education and Health Sciences, University of Edinburgh, Edinburgh, UK

Corresponding Author

Professor Amanda Daley

The Centre for Lifestyle Medicine and Behaviour (CLiMB)

National Centre for Sport and Exercise Medicine

School of Sport, Exercise and Health Sciences,

Loughborough University

Loughborough

Leicestershire, LE11 3TU, UK

a.daley@lboro.ac.uk

Conflicts of interest/Competing interests (include appropriate disclosures)

AD is supported by a National Institute for Health Research (NIHR) Research Professorship award. The views expressed are those of the author(s) and not necessarily those of the NHS, the NIHR or the Department of Health and Social Care.

Financial Disclosures

No financial disclosures were reported by the authors of this paper

Word Count: 1999. Number of pages: 16, Tables: 0, Figures: 1

Introduction

Despite unequivocal evidence that physical activity (PA) reduces the risk of morbidity and mortality, a large proportion of the adult population do not meet the internationally accepted PA guidelines to perform at least 150 minutes of moderate-intensity PA (or 75 minutes of vigorous-intensity per week, or a combination of both)[1]. This guidance has historically been promoted as 30 minutes of moderate-to-vigorous intensity physical activity (MVPA) on at least five days/week. Alongside this, World Health Organisation (WHO) now advocates that 150-300 minutes of moderate-intensity, or 75-150 minutes of vigorous-intensity PA per week is required for optimal health. Furthermore, adults are also advised to undertake PA that improves muscle strength on at least two days per week. However, despite PA guidance having existed for many years, this has not led to an increase in population levels of PA. Based on accelerometer-measured PA, only 6% of men and 4% of women in England achieve 150 minutes per week[2], with similar results reported worldwide[3]. With the removal from the PA guidelines of the necessity to accumulate PA in bouts lasting 10 mins or more, a larger proportion (45-55%) of the population are now meeting PA guidelines; [4] however, this still means that approximately half of the population remains physically inactive. Of particular concern are data suggesting only 1% of adults participate in strength-based PA each week [5]. This suggests a need to consider more innovative, persuasive, and translational guidance messaging to encourage the population to regularly engage in PA and spend less time sedentary. Guidelines themselves do not change behaviour and improve health, it is having the means and motivation to achieve them that matters.

One of the most critical obstacles to meeting current guidance for PA is it requires inactive populations to make significant lifestyle changes to achieve at least 150 minutes of MVPA each week. Previous PA interventions have only had modest effects, at best, on initiation of

PA behaviour, and we know very little about successful behavioural maintenance[6]. There is also growing concern about the amount of time the public spend in sedentary behaviours (SB), with adults spending approximately 60-70% of waking hours sedentary[7]. For inactive adults, particularly those with low participation in MVPA, high levels of sedentary time have been associated with Type 2 diabetes, cardiovascular disease, and all-cause mortality[8]. Collectively, these data are of real concern and there is no reason to assume that this situation will improve unless effective strategies are put in place to address the problem; this includes the guidance and supporting implementation strategies given to the public to support behaviour change.

It is clear that guidance setting large behavioural goals for PA has not been successful in supporting those who are inactive, to become sufficiently physically active, and current approaches to PA guidelines may therefore not be optimal. The approaches that have been tried to date appear have been ineffective for people who are inactive and a shift in emphasis in facilitating PA behaviour to prevent disease is now required. It is time to try something different.

Every minute counts: Snacktivity™ to promote physical activity

Updated guidelines on the volume and intensity of PA from health agencies in 2019 and the WHO in 2020, has removed the need to complete PA in bouts of 10 mins or more[1,9,10]. Although revised guidance now recognises the importance of making small changes to PA behaviour and that any PA is better than none [1,9,10], guidance still focuses on the public needing to achieve a considerable behavioural goal of at least 150 mins of MVPA per week, which can be a daunting task for the most inactive populations[1,10]. Additional or

complementary strategies are likely to be needed to assist the public in overcoming their often, hypokinetic environment and become more physically active.

A complimentary 'whole day' approach to PA promotion that seeks to engage, support and motivate individuals to be more physically active throughout the day, is a concept we refer to as 'Snacktivity™. Rather than broadly encouraging at least 150 minutes/week of MVPA, Snacktivity™ focuses on promoting small (e.g., 2-5 minutes), but frequent, bouts of MVPA throughout each day, to accumulate at least 150 minutes of MVPA per week. For example six 'activity snacks' lasting five minutes each day would be required to meet the current PA recommendations. Examples of Snacktivity™ include walk-talk conversations, using stairs rather than the lift/elevator, pacing whilst using the telephone, squats while waiting for the kettle to boil, and leg raises whilst watching television (see Figure 1 for examples of Snacktivity™ in different contexts and settings).

What is the evidence that Snacktivity™ might improve population health?

Evidence demonstrates an inverse dose-response relationship exists between PA and all-cause mortality. This means that for people who are inactive, any increase in PA is important for health[11]. The relationship is also characterised by a steep early slope meaning the greatest gains in health are experienced inactive people doing a little more activity per week (e.g. 2-3 MET/hrs per/week), rather than by encouraging those who are already physically active to do marginally more[12]. Improved cardio-metabolic health and aerobic fitness have been reported following brief bouts of PA[13], such as stair climbing, which is a good example of Snacktivity™. Most studies reported no difference in improvement in cardiovascular fitness between accumulated and continuous bouts of exercise of the same total duration[14]. This suggests that achieving short(er) bouts of Snacktivity™ throughout the day may achieve

similar health benefits to long(er) bouts. Moreover, whilst the idea that small bouts of physical activity may improved health oututcomes is not new, as is shown in laboratory and experimental studies [14,15] it is not a message that has been prominent in public guidance, in part, due to a lack of high quality, "real world" evidence to support the approch.

How might Snacktivity™ work to improve population health?

The most commonly reported barrier to PA is a perceived lack of time, even though, on average, the population has more leisure time than in previous decades. For adults who are inactive, long(er) bouts of MVPA may seem too daunting and difficult to achieve and it may be that many people believe that achieving 150 mins of MVPA/week requires too much cognitive effort, planning and physical exertion to be worthwhile. In contrast, Snacktivity™ may be perceived as more achievable because each 'snack' only requires a small-time commitment, and it involves less planning and effort (physical and cognitive). Snacktivity™ does not require skills, equipment, or a change of clothing, thereby addressing both convenience and health inequalities[16]. Snacktivity™ requires little or no preparation, can be performed in several settings (home, work, indoors and outdoors), can be adapted for the environment, as well as for physical, social and cultural contexts, and easily incorporated into a day, allowing for greater population reach.

Simple actions may become more habitual than complex ones. This suggests that the integration of Snacktivity™ into usual routines may be a more feasible and appealing approach to sustaining PA behaviour than trying to achieve larger changes[17]. Moreover, small changes are easier to initiate, and maintain, than large changes. Snacktivity™ is consistent with the small change approach that argues behaviour change is best achieved through celebrating small successes to make behaviours become habitual[18].

How people feel about PA is an important predictor of whether they continue to engage and adhere to the behaviour. Snacktivity™ may help to develop confidence among those who are most physically inactive by encouraging them to 'start small' and try to be more physically active regularly. Psychological theory acknowledges that achieving small changes is important for individuals' task and self-regulatory self-efficacy and habit formation[19]. If individuals complete activity snacks, this should increase their self-efficacy for engagement, making them more likely to continue. Snacktivity™ might then be the gateway for more sustained participation in physical activity. Snacktivity™ may be particularly appropriate for specific populations, such as the elderly, pregnant women, and people with chronic diseases and disabilities, who may find it difficult or be reluctant to engage in PA because of lack of confidence, fear of injury, or exacerbating health conditions (see Figure 1).

An important component of the PA guidance is that adults should undertake muscle-strengthening activity on at least two days per week. It is particularly important that people perform strength-based activities, especially older adults, given that strength is directly related to the risk of falls, fractures and osteoporosis[10]. Snacktivity™ provides an opportunity to promote this message since many muscle-strengthening activities lend themselves to activity snacks as they are traditionally shorter and stationery (so do not need space) and do not necessarily need special equipment or clothing. Examples of Snacktivity for muscle strength include press-ups against furniture and squats whilst brushing your teeth (Figure 1)..

Whilst Snacktivity™ is primarily focused on promoting MVPA, we should not be prescriptive over which activity snacks we wish the public to do, given all PA is important for health[1,10]. A further benefit of Snacktivity™ is that it encourages PA while

simultaneously breaking up time spent sedentary throughout the whole day. Snacktivity™ may therefore provide two health outcomes in a 'buy one, get one free' scenario, increasing the probability of cost-effectiveness.Snacktivity™ may also increase time spent in light-intensity PA because it may encourage a mindset of simply moving more and sitting less. To support this hypothesis, experimental trials have shown that breaking up prolonged time sedentary with periods of light activity provides favourable changes in individuals' cardio-metabolic risk profile[20]. PA does not need to be 'no pain, no gain', or prolonged, for it to benefit health and this is an important message to convey to the public through the Snacktivity™ message.

Issues to consider in promoting Snacktivity™

While there may be advantages to Snacktivity™, there are also some potential constraints to consider. Snacktivity™ may be disruptive to the day and easily forgotten. It might be difficult for the public to achieve MVPA in 'bite sizes', or too difficult to think of ways in which to implement Snacktivity™ into daily life whether at home or work. Indeed, incorporating activity snacks into the home or work life, may require a change in social norms (e.g. making it socially acceptable to leave one's desk to perform an activity snack).

Simply giving people information does not lead to sustained health behaviour change. Additional strategies to encourage the public to engage in Snacktivity™ will be required, and a wide range of technologies available are now available facilitate this process (e.g., mHealth) Consideration needs to be given to whether an accumulated Snacktivity™ approach requires the public to consider PA too many times in a day/week, and whether this then requires too much cognitive energy to continually enact and implement. Given this, Snacktivity™ may not be flexible enough and/or convenient to the public. Whilst all PA is

important for health, greater intensity PA provides more benefit for the same amount of time, particularly for non-communicable diseases[1]. However, Snacktivity™ may encourage participation in predominately light-intensity PA, without progressing towards sufficient PA within the MVPA range leading to Snacktivity™ having a smaller impact on health. Research needs to explore these issues and how potential barriers to Snacktivity™ might be resolved. Whilst evidence suggests that short bouts might be useful in increasing population levels of PA, no randomised controlled trials has directly tested if Snacktivity™ derives the same health benefits as current guidelines for PA; we are currently gathering such evidence (https://fundingawards.nihr.ac.uk/award/RP-PG-0618-20008).

Conclusion – time to add to the menu

Given the lack of success in encouraging people who are inactive to achieve large(r) bouts of PA. Snacktivity™ may be a complementary public health message that offers a method of implementing this guidance. It is not suggested that current PA guidance should be abandoned, but current approaches may not be ideal. Snacktivity™ should be achievable by most of the population and therefore addresses health inequalities maing it accessible to all of those who might benefit. Snacking is a common behaviour and for the first time, the public could be encouraged to snack as much as they can every day, just not with unhealthy foods, but with Snacktivity™.

Author contributions

AD developed the original Snacktivity idea and JS conceived the idea for this report. AD and JS wrote the initial draft for this report and SJHB, LS, KJ, MS, HMP, NI, TY, NM and Snacktivity Investigators contributed at a later stage.

*Snacktivity study team includes Stuart Biddle, Amanda J Daley, Dale Esliger, Charlotte Edwardson, Emma Frew, Kajal Gokal, Colin Greaves Sheila M Greenfield Natalie Ives, Kate Jolly, Ralph Maddison, Nanette Mutrie, Helen M Parretti, James Sanders, Lauren Sherar, Magdalena Skrybant, and Tom Yates.

REFERENCES

1. UK Chief Medical Officer. UK Chief Medical Officers' Physical Activity Guidelines. Department of Health and Social Care. https://www.gov.uk/government/publications/physical-activity-guidelines-uk-chief-medical-officers-report. Published 2019. Accessed December 4, 2020.
2. Chaudhury M, Esliger DW. *Accelerometry in Adults*.; 2009. doi:10.1016/j.ridd.2011.01.017
3. Troiano R, Berrigan D, Dodd K, Masse L, Tilert T, McDowell M. Physical activity in the United States measured by accelerometer. *Med Sci Sport Exerc*. 2008;40(1):181-188.
4. Rowlands A V., Sherar LB, Fairclough SJ, et al. A data-driven, meaningful, easy to interpret, standardised accelerometer outcome variable for global surveillance. *J Sci Med Sport*. 2019;22(10):1132-1138. doi:10.1016/j.jsams.2019.06.016
5. NHS. Health Survey for England 2016 Physical activity in adults. NHS Digital. https://digital.nhs.uk/data-and-information/publications/statistical/health-survey-for-england/health-survey-for-england-2016. Published 2017. Accessed November 21, 2020.
6. King AC, Whitt-Glover MC, Marquez DX, et al. Physical Activity Promotion: Highlights from the 2018 Physical Activity Guidelines Advisory Committee Systematic Review. *Med Sci Sports Exerc*. 2019;51(6):1340-1353. doi:10.1249/MSS.0000000000001945
7. Biswas A, Oh PI, Faulkner GE, et al. Sedentary time and its association with risk for disease incidence, mortality, and hospitalization in adults. *Ann Intern Med*. 2015;162(2):123. doi:10.7326/M14-1651
8. Ekelund U, Brown WJ, Steene-Johannessen J, et al. Do the associations of sedentary

behaviour with cardiovascular disease mortality and cancer mortality differ by physical activity level? A systematic review and harmonised meta-analysis of data from 850 060 participants. *Br J Sports Med*. 2019;53(14):886-894. doi:10.1136/bjsports-2017-098963

9. Bull FC, Al-Ansari SS, Biddle S, et al. World Health Organization 2020 guidelines on physical activity and sedentary behaviour. *Br J Sports Med*. 2020;54(24):1451-1462.
10. 2018 Physical Activity Guidelines Advisory Committee. *2018 Physical Activity Guidelines Advisory Committee Scientific Report*.; 2018. doi:10.1115/1.802878.ch1
11. Arem H, Moore SC, Patel A, et al. Leisure time physical activity and mortality: a detailed pooled analysis of the dose-response relationship. *JAMA Intern Med*. 2015;175(6):959-967. doi:10.1001/jamainternmed.2015.0533
12. Ekelund U, Tarp J, Steene-Johannessen J, et al. Dose-response associations between accelerometry measured physical activity and sedentary time and all cause mortality: Systematic review and harmonised meta-analysis. *BMJ*. 2019;366. doi:10.1136/bmj.l4570
13. Hupin D, Roche F, Gremeaux V, et al. Even a low-dose of moderate-to-vigorous physical activity reduces mortality by 22% in adults aged ≥60 years: a systematic review and meta-analysis. *Br J Sports Med*. 2015;49(19):1262-1267. doi:10.1136/bjsports-2014-094306
14. Murphy MH, Lahart I, Carlin A, Murtagh E. The effects of continuous compared to accumulated exercise on health: A meta-analytic review. *Sport Med*. 2019;49:1585-1607. doi:10.1007/s40279-019-01145-2
15. Boreham CAG, Kennedy RA, Murphy MH, Tully M, Wallace WFM, Young I. Training effects of short bouts of stair climbing on cardiorespiratory fitness, blood lipids, and homocysteine in sedentary young women. *Br J Sports Med*.

2005;39(9):590-593. doi:10.1136/bjsm.2002.001131

16. Reichert FF, Barros AJD, Domingues MR, Hallal PC. The role of perceived personal barriers to engagement in leisure-time physical activity. *Am J Public Health*. 2007;97(3):515-519. doi:10.2105/AJPH.2005.070144

17. Hill JO. Can a small-changes approach help address the obesity epidemic? a report of the joint task force of the american society for nutrition, institute of food technologists, and international food information council. *Am J Clin Nutr*. 2009;89(2):477-484. doi:10.3945/ajcn.2008.26566

18. Fogg B. *Tiny Habits: The Small Changes That Change Everything*. Houghton Mifflin Harcourt; 2019.

19. Gardner B, Rebar A., Lally P. Habit Interventions. In: *The Handbook of Behavior Change*. Cambridge: Cambridge University Press; 2020:599-616.

20. Frith E, Loprinzi PD. Accelerometer-assessed light-intensity physical activity and mortality among those with mobility limitations. *Disabil Health J*. 2018;11(2):298-300. doi:10.1016/j.dhjo.2017.08.007

Figure 1 - Snacktivity ideas