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Using accelerometer data to identify movement patterns in an older adult: Innovative strategy for physical activity promotion

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Abstract

Evidence suggests a physically active lifestyle increases proportion of life lived free of disability. Unfortunately, physical activity participation in older adults is low, suggesting innovative strategies are needed. This case-report (1) examined daily activity routines from accelerometer data; and (2) utilized the movement patterns to "infuse" physical activity withinthe participant's normal routine.

Case-Report: A 60 year old wore an Actigraph GT3X+ accelerometer, on 2 separate days and weeks. Movement patterns, from "raw" accelerometer data, were presented to the participant to identify areas of high and low activity, with suggestions how to increase overall activity. Results indicated activity patterns were reproducible. Physical activity infusions increased movement counts by 34%, and Moderate-Vigorous Physical Activity (MVPA) by ~82minutes.

Discussion: Examination of"raw" accelerometer data identified distinct movement routines. Understanding these routines allowed for health provider/participant interaction that led to physical activity "infusions" which contributed to a large increase in MVPA, without major alterations to the individual's day.

Keywords

Physical activity patterns; health promotion; accelerometer; older adults.

Introduction

The proportion of people over 60 is estimated to grow from 9% in 2019 to 16% by 2050 [1]. Although it is clear people are living longer, the quality of life during those extra years is not evident [2]. Recent evidence suggests healthy lifestyle factors, affect the proportion of future life lived free of disability [3]. Given years of disability contribute substantially to healthcare costs [4], contraction of the disabled period through promotion of healthy lifestyles [3], may reduce healthcare costs and encourage continued societal contributions.

Physically active older adults, typically experience healthier ageing trajectories [5]. In fact, risk of losing independence is significantly lower for fitter older individuals [6]. Importantly, prospective studies indicate that engaging in exercise programs reduces the risks of functional limitations and disability [7-9]. As a result, scientific evidence-based recommendations have been developed to guide clinicians and other professionals in the promotion of physical activity for older adults. The current consensus recommendations of the 2009 American College of Sports Medicine and the 2008 Physical Activity Guidelines for older adults are 150 min/week of physical activity for health benefits. It is noted that additional benefits occur as the amount of physical activity increases through higher intensity, greater frequency, and/or longer duration.

Many older adults do not engage in adequate amounts of physical activity, and even fewer take advantage of programs designed to enhance physical fitness. Barriers to participation include physical limitations, lack of professional guidance, inadequate information on available and appropriate physical activity options and programs, feelings of intimidation, and no interest in organized activities [10].

Consequently, additional strategies are needed to assist older adults in increasing physical activity. With the advent of portable sensors (e.g. accelerometers), opportunities exist to examine movement throughout the day. Typically, accelerometer data are summarized using proprietary algorithms and provide information about the amount of time a person engages in low, moderate, and high-intensity activity [11]. Interestingly, few studies have explored daily patterns of physical activity. Such data may provide additional insight and allow clinicians and health professionals the opportunity to strategize with patients to increase the total volume of activity within the day, but perhaps, more importantly, how, when and where activities could be increased. Such strategies may, initially, be built within a person's daily routine, rather than presenting an additional burden.

The objective of this case-report was 3-fold: (1) to examine the presence of daily physical activity routines; (2) to determine the consistency of such physical activity routines and volumes of activity between days/weeks; and (3) to utilize the movement patterns to guide physical activity "infusions" within an older adults normal routine. The overall goal of the report is to stimulate the use of "raw" accelerometer data during a provider-patient exchange, aimed at increasing volume and intensity of physical activitywithin a patient's usual routine.

Case Presentation

This case-report provides an in-depth analysis of accelerometer data obtained from a 60-year-old individual. Although the analysis takes an idiographic approach, this report serves to stimulate the potential use for general application and an opportunity for advanced provider-patient interface. This case study was exempt by the IRB, but the report is in accordance with the requirements of the HIPAA privacy regulations.

Activity measurements: Physical activity was measured over two consecutive days, during two separate weeks, using the triaxial ActiGraph GT3X-BT accelerometer (ActiGraph, Pensacola, FL). The participant wore the device on the non-dominant wrist between the hours of 6:00 and 22:00.

Data from the accelerometers were downloaded and converted using ActiLife software, version 6.13 (ActiGraph). Acceleration data were collected in raw mode and transformed into g-units. For each time point, the resultant acceleration (ri), or vector magnitude, was calculated as follows [12]:

$$ri = \sqrt{x^2 i + y^2 i + z^2 i},$$

where x_i, y_i, and z_i are the i^{th} measurement sample of the raw acceleration signal in the x-, y-, and z-directions. The vector magnitude (r) was calculated at each time point (i), followed by the mean vector magnitude for 10 second epochs.

Intensity thresholds were calculated using previously reported regression equations for non-dominant arm wrist placement of the device [13]:

VO_2=0.0320 (mg) + 7.28

and converted to Metabolic Equivalents (METs) by dividing the VO_2 value by 3.5. This approach allowed estimation of minutes spent in light (1-3 METs), moderate (>3-≤6 METs), and vigorous (≥6 METs) activities [14].

Also, Moderate to Vigorous Physical Activities (MVPA) were estimated, as frequently done in other studies [15]. Data were then graphed from the onset to end of the wear period to allow for visual inspection of physical activity patterns and matched with an activity log.

Consistency of the data between weeks was determined from the total vector magnitude counts, the minutes spent in light, moderate and vigorous activities, and the observed patterns of activity across the wear time during the "low" and "high" activity days.

Activity Intervention: The participant was asked to engage in regular activity on the first day of each week. Regular activity was defined as activity "typically" conducted by the participant within their day. The activity patterns were subsequently reviewed and opportunities for physical activity "infusions" discussed. Based on the evaluation of the physical activity patterns during the "typical" day, three "infusion" opportunities were presented, 1. "Interruption"of sitting, 2. "Creation" of activity, and 3. "Enhancement" of existing activity. Interruption of sitting was made possible through provision of a cycle ergometer in the work space. Creation of additional activities included information about parking further away from the office, and the use of stairs. Enhancing existing activity included information about how to increase duration and intensity of existing physical activity bouts (such as activities in and around the home). The "infusion" opportunities were encouraged for the second day within each week.

Discussion

The vector magnitude counts across the "Typical" and "Infused" activity days, for both weeks are presented in Figure 1. The percent difference between the counts for the "Typical" activity days was 16%, and 12% for the "Infused" activity days. The percent difference between the "Typical" and "Infused" activity days was 34%.

Minutes of light, moderate and vigorous activity are presented in Figure 2. On the "Typical" activity days, minutes of light, moderate, and vigorous activity averaged 760.25 minutes, 162.75 minutes, and 37 minutes, respectively, and 678.50, 201.25, and 80.25 minutes, on the "Infused" activity days. This suggests the participant does meet the physical activity requirements, given they exceed 200 min of MVPA within each day, as indicated in Figure 2. The difference in minutes in moderate and vigorous activity was 19% and 53% between the "Typical" and "Infused" activity days. This difference represents 81.75 minutes of additional MVPA (i.e., physical activity above 3 METs). Arguably this person could still benefit from the added physical activity based on evidence that the health benefits of physical activity are dose dependent [16], and the fact that prolonged sitting is a risk factor for all-cause mortality independent of physical activity levels [17].

The activity patterns, for the "Typical" versus "Infused" activity days, for week 1, are presented in Figure 3a and b. The activity patterns for the "Typical" versus "Infused" activity days, for week 2 are depicted in Figure 4a and b. Activities within the day are highlighted to indicate the types of activities.

The unique contribution of this case-report is the use of "raw" accelerometer data to identify patterns of physical activity within the day. Indeed, distinct routines of activity and inactivity were observed. Recognition of these patterns allows providers to engage with patients in developing simple strategies to increase the overall volume of physical activity. Without the burden of creating an organized "exercise" session, the present findings suggest the "infusion" of physical activity within the existing daily routine, contributed to a large increase in physical activities above the critical intensity-threshold, for health benefits to occur.

Tri-axial accelerometers continue to gain in popularity for the objective monitoring and assessment of physical movements. A major advantage of accelerometers is the objective measures of physical activity behaviors free of the random and systematic errors associated with self-report [18]. However, accelerometers also pose significant challenges [11], to providers interested in helping patients increase the volume of activity. Consequently, accelerometers are mainly used in research settings, and strategies are needed to bridge to clinical practice. Even in the research setting, accelerometer data are typically summarized into minutes spent in light, moderate, and vigorous intensity. Little time is given to examining the patterns of physical (in) activity to understand how physical activity behavior can be modified.

Visual inspection of the data, for this case-report, allowed for identification of daily activities, which were verifiable through recall. Importantly, physical activity patterns were relatively consistent between the same days, on different weeks, suggesting the presence of a daily "physical" routine. These "routines" were identifiable on both "Typical" and "Infusion" activity days. Of particular relevance to this case was the significant period of low physical activity during the workday, secondary to sitting behavior whilst working. Placement of a cycle ergometer in the participant's office allowed for successful interruption of sitting. Other successful and visible examples of physical activity "infusions" included increasing the distance from the parked car to the office, the use of stairs, instead of elevators, and "walking" the dog. These "infusions" collectively increased MVPA by 81.75 minutes on the "Infusion" activity days. Epidemiological data support that such an increase of additional MVPA would significantly impact health outcomes [16].

This case-report is valuable for several reasons. First, activity "infusions" did not significantly alter the participant's daily routine. The participant did not have to make "exercise" time for additional activities outside of their routine. Second, the appearance that daily routines are consistent within the same days, across different weeks, may provide opportunities that physical activity "infusions," on those days, may lead to meaningful changes. Third, visualization of an individual's physical activity pattern may promote self-directed behavior change. Consequently, the individual may feel in control of their choices and behaviors, which gives them more reason to sustain healthy behaviors [19]. When individuals become more involved in their care, they are typically more compliant and committed, allowing the change in behavior to become permanent.

Finally, this report serves to encourage healthcare providers to use and share objective physical activity measures with their patients. This provider-patient interaction may promote autonomous motivation for change by personalizing current behaviors and potential areas for change [20]. Such interaction may increase perceived competence by identifying specific areas in the day where physical activity can be added or increased. These strategies are particularly important for individuals who may not be "ready" to engage in "organized" exercise programs.

We recognize the limitations of case-reports, and the on-going debate regarding the use of accelerometers. We appreciate that physical activity counts may have been different if the device would have been worn on the hip rather than the wrist, even though previous research has shown modest correlations in older populations [21]. We also acknowledge the lack of sensitivity of accelerometers to differentiate between sedentary and light-intensity activities [22]. As such "true" periods of inactivity versus light activity may be partially masked. In addition, difficulties in detecting non-ambulatory activities, such as cycling, may have underestimated the true activity in this case. Finally, the use of algorithms to quantify and estimate intensity thresholds from accelerometer data is a known limitation, as different algorithms may provide different physical activity outcomes [23]. Given this limitation, pattern recognition techniques as explored in this report may circumvent such problems.

This study used “raw” accelerometer data for the purpose of identifying patterns of physical activity within the day. Distinct patterns of activity and inactivity were observed and through health provider/ participant interaction allowed for simple “infusions” of physical activity within the daily routine. These physical activity infusions did not alter the person’s daily routine or create an additional burden of physical activity time. The physical activity infusions also contributed to a large increase in physical activities above the critical threshold needed for health benefits to occur.

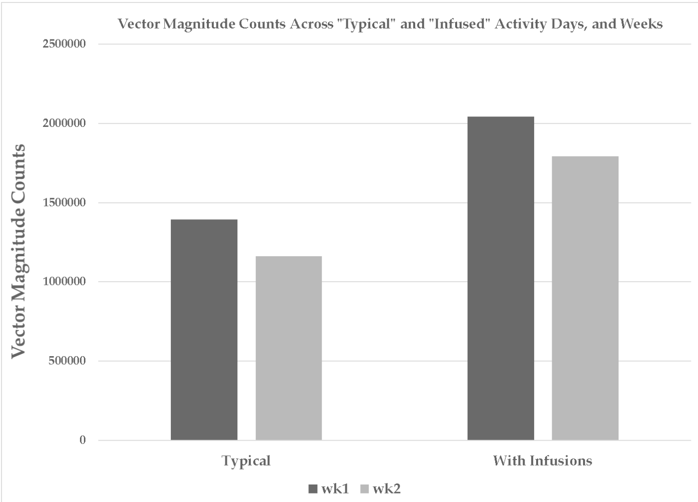

Figure 1: Vector Magnitude Counts across the “Typical” and “Infusion” activity days, for both weeks.

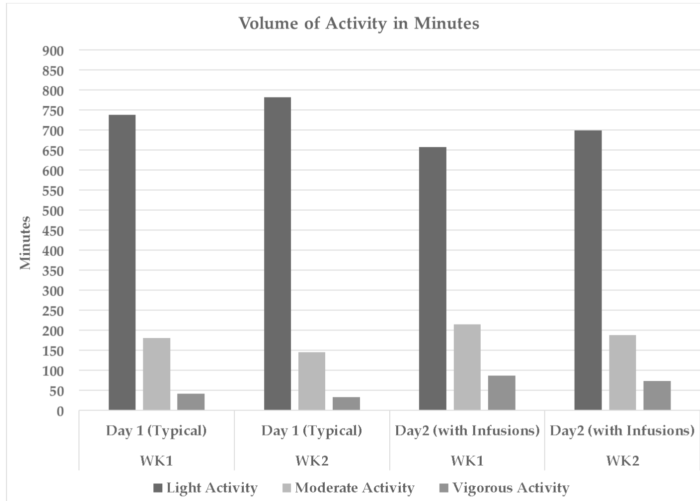

Figure 2: Volume of Activity in minutes for the “Typical” and “Infusion” activity days, for both weeks.

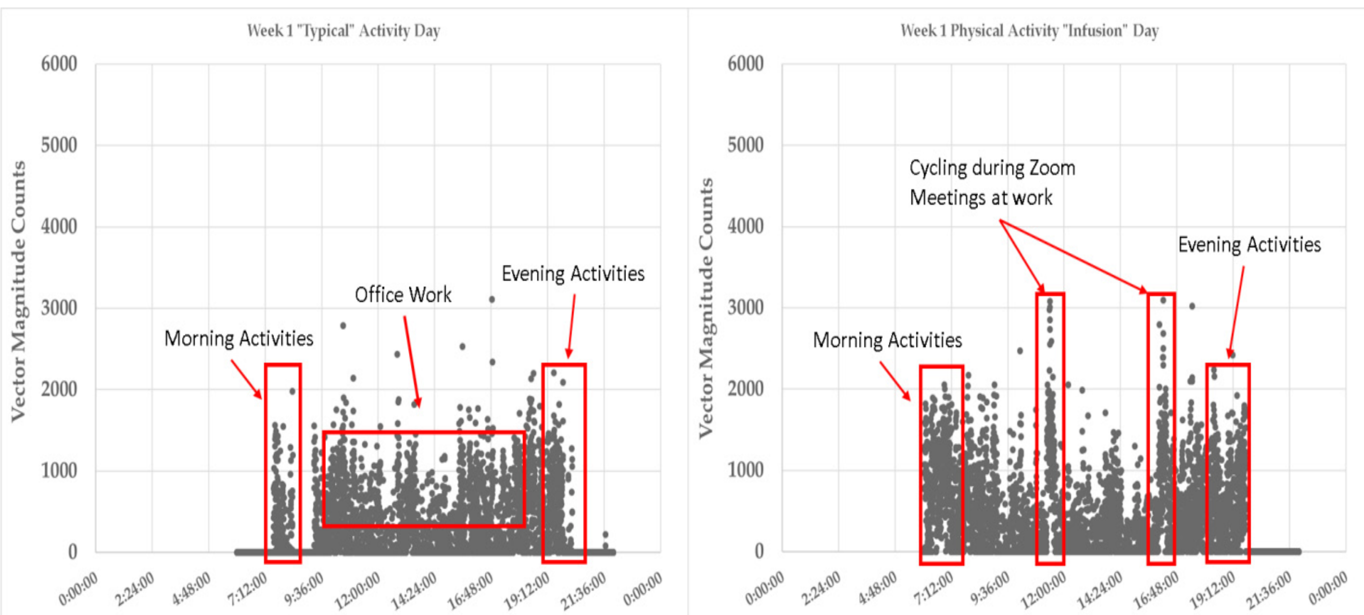

Figure 3: (a) Vector Magnitude Counts across a single day accelerometer wear period (16 hours), for week 1 and a “typical” activity day. (b)Vector Magnitude Counts across a single day accelerometer wear period (16 hours), for week 1 with physical activity “infusions”.

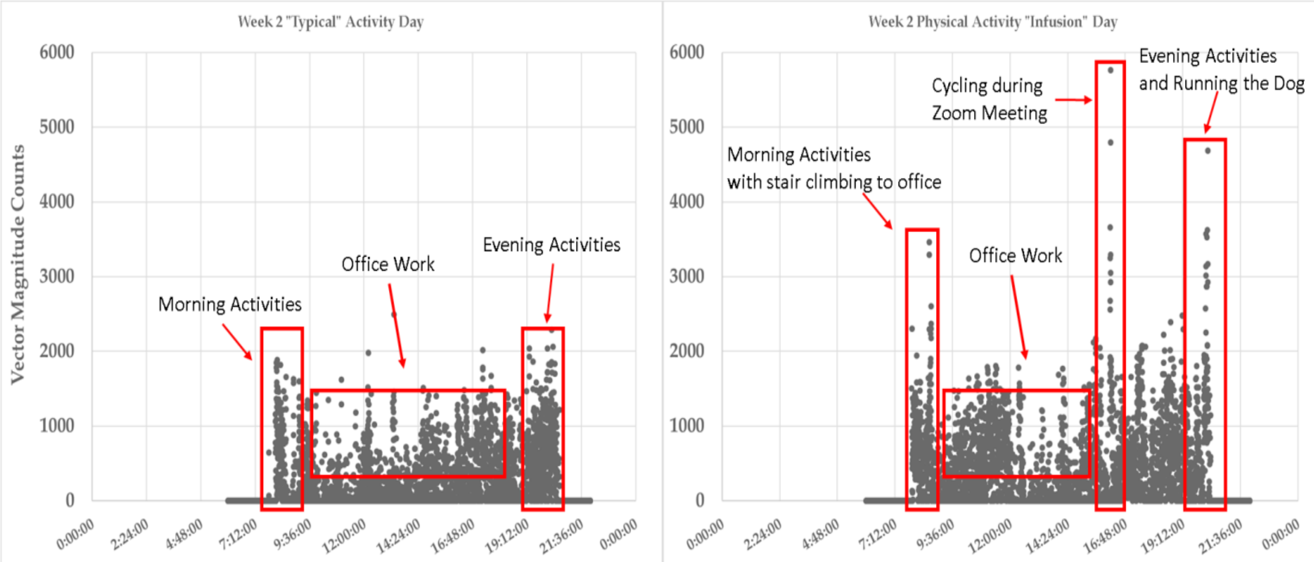

Figure 4: (a) Vector Magnitude Counts across a single day accelerometer wear period (16 hours), for week 2 and a "typical" activity day. (b) Vector Magnitude Counts across a single day accelerometer wear period (16 hours), for week 2 with physical activity "infusions".

References

1. United Nations, Department of Economic and Social Affairs, Population Division. World Population Prospects 2019: Highlights (ST/ESA/SER.A/423). 2019.

2. Crimmins EM, Beltrán-Sánchez H. Mortality and morbidity trends: is there compression of morbidity?. The journals of gerontology. Series B, Psychological sciences and social sciences. 2011; 66: 75-86.

3. Jacob ME, Yee LM, Diehr PH, Arnold AM, Thielke SM, Chaves PH, et al. Can a Healthy Lifestyle Compress the Disabled Period in Older Adults? Journal of the American Geriatrics Society. 2016; 64: 1952-1961.

4. Cai L. The cost of an additional disability-free life year for older Americans: 1992-2005. Health services research. 2013; 48: 218-235.

5. Cunningham, C., O' Sullivan, R., Caserotti, P., & Tully, M. A. Consequences of physical inactivity in older adults: A systematic review of reviews and meta-analyses. Scandinavian journal of medicine & science in sports. 2020; 30: 816-827.

6. Paterson DH, Govindasamy D, Vidmar M, Cunningham DA, Koval JJ. Longitudinal study of determinants of dependence in an elderly population. Journal of the American Geriatrics Society. 2004; 52: 1632–1638.

7. Pahor M, Guralnik JM, Ambrosius WT, Blair S, Bonds DE, Church TS, et al. Effect of structured physical activity on prevention of major mobility disability in older adults: the LIFE study randomized clinical trial. JAMA. 2014; 311: 2387–2396.

8. Paterson DH, Warburton DE. Physical activity and functional limitations in older adults: a systematic review related to Canada's Physical Activity Guidelines. The international journal of behavioral nutrition and physical activity. 2010; 7: 38.

9. Tak E, Kuiper R, Chorus A, Hopman-Rock M. Prevention of onset and progression of basic ADL disability by physical activity in community dwelling older adults: a meta-analysis. Ageing research reviews. 2013; 12: 329–338.

10. Bethancourt HJ, Rosenberg DE, Beatty T, Arterburn DE. Barriers to and facilitators of physical activity program use among older adults. Clinical medicine & research. 2014; 12: 10–20.

11. Lee IM, Shiroma EJ. Using accelerometers to measure physical activity in large-scale epidemiological studies: issues and challenges. British journal of sports medicine. 2014; 48: 197–201.

12. van Hees VT, Fang Z, Langford J, Assah F, Mohammad A, da Silva IC, et al. Autocalibration of accelerometer data for free-living physical activity assessment using local gravity and temperature: an evaluation on four continents. Journal of applied physiology

(Bethesda, Md. 2014; 117: 738–744.

13. Hildebrand M, Van Hees VT, Hansen BH, Ekelund U. Age group comparability of raw accelerometer output from wrist- and hip-worn monitors. Medicine and science in sports and exercise. 2014; 46: 1816–1824.

14. Freedson PS, Melanson E, Sirard J. Calibration of the Computer Science and Applications, Inc. accelerometer. Medicine and science in sports and exercise. 1998; 30: 777–781.

15. Kozey SL, Lyden K, Howe CA, Staudenmayer JW, Freedson P S. Accelerometer output and MET values of common physical activities. Medicine and science in sports and exercise. 2010; 42: 1776–1784.

16. Physical Activity Guidelines Advisory Committee. Physical Activity Guidelines Advisory Committee scientific report. U.S. Department of Health and Human Services. 2018.

17. van der Ploeg HP, Chey T, Korda RJ, Banks E, Bauman A. Sitting time and all-cause mortality risk in 222 497 Australian adults. Arch Intern Med. 2012; 172: 494-500.

18. Matthews CE, Moore SC, George SM, Sampson J, Bowles HR. Improving self-reports of active and sedentary behaviors in large epidemiologic studies. Exercise and sport sciences reviews. 2012; 40: 118–126.

19. Ng JY, Ntoumanis N, Thøgersen-Ntoumani C, Deci EL, Ryan RM, Duda JL, Williams GC. Self-Determination Theory Applied to Health Contexts: A Meta-Analysis. Perspectives on psychological science : a journal of the Association for Psychological Science. 2012; 7: 325–340.

20. Ryan RM, Deci EL. Self-determination theory: Basic psychological needs in motivation, development, and wellness. The Guilford Press. 2017.

21. Kamada M, Shiroma EJ, Harris TB, Lee IM. Comparison of physical activity assessed using hip- and wrist-worn accelerometers. Gait & posture. 2016; 44: 23–28.

22. Ainsworth B, Cahalin L, Buman M, Ross R. The current state of physical activity assessment tools. Progress in cardiovascular diseases. 2015; 57: 387–395.

23. Heil DP, Brage S, Rothney MP. Modeling physical activity outcomes from wearable monitors. Medicine and science in sports and exercise. 2012; 44: S50–S60.

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