Title: Pedometers, the frustrating motivators: A qualitative investigation of users' experiences of the Yamax SW-200 among people with multiple sclerosis

Running Head: Pedometer user experience among people with MS.

Article category: Research Paper

Abstract

Purpose: Self-monitoring may represent a mechanism to enhance physical activity among people with multiple sclerosis. To optimise activity monitoring as a behavioural tool to increase physical activity, user experience must be understood**.** This study evaluated user experience of the Yamax SW-200 Digi-walker pedometer in a group of people with MS.

Methods: Semi-structured interviews were conducted with 15 adults who participated in a 12-week pedometer-supported behavioural change intervention, the iStep-MS trial. Interviews were audio-recorded and transcribed verbatim. Data were analysed using the Framework Method.

Results: An overarching theme *Pedometers, the frustrating motivators* captures the complex and often contradictory experience of the pedometer. Sub-themes include: *Increasing activity awareness,* which describes the pedometer's utility in raising activity consciousness; *Numeric motivation* provides insight into dual motivating and demotivating experiences of using an objective feedback device*; (Un) usability* focuses on practical concerns encountered in the day-to-day use of the monitor.

Conclusion: The Yamax SW-200 Digi-walker raised awareness and enhanced participant motivation to engage in physical activity. Accuracy and usability concerns highlighted warrant consideration in the selection of this pedometer within a population with multiple sclerosis.

Keywords: Multiple sclerosis, pedometer, activity monitoring, qualitative, physical activity, step count, behaviour change

Trial registration: Changing physical activity behaviour in people with MS: the iStep-MS trial; https://doi.org/10.1186/ISRCTN15343862; ISRCTN15343862

Introduction

People with multiple sclerosis (MS) engage in substantially lower levels of physical activity compared with the general population and other groups with chronic illness [1]. Increasing physical activity is associated with improved fatigue [2], muscular strength and aerobic capacity [3] and health-related quality of life [2] and is a key therapeutic aim for people with MS [4]. Moreover, physical inactivity is associated with deconditioning and increased risk of secondary health conditions including cardiovascular disease [5, 6].

Effective strategies to promote physical activity are warranted. Walking is a safe and cost-effective method of increasing physical activity in sedentary populations [7] and is the most common activity undertaken by people with MS [8, 9]. Supporting people with MS to be active and engage in walking is appropriate but the optimal method to achieve this is unknown.

Interventions incorporating digital tools such as pedometers or accelerometers have gained popularity as a mechanism to increase physical activity among people with MS [10]. Pedometers measure step count and represent an objective and cost-effective method to quantify activity [11]. The objective feedback they provide motivates physical activity engagement in clinical [12] and non-clinical populations [13] with demonstrable increases in physical activity [14, 15]. Among people with MS, promising impacts on physical activity have been shown in theory-based interventions supported by a pedometer [16, 17]. Moreover health tracking and disease monitoring is associated with improved self-management and feelings of control [18] demonstrating the potential of these devices and the objective feedback they provide to support the initiation and maintenance of physical activity behaviour.

While these studies indicate the utility of pedometers to promote physical activity most studies are short term and the user experience is under-examined [16, 17]. To maximise acceptance and

long term adoption, self-monitoring devices must be valid, reliable, and integrate easily into daily life [19]. Exploration of how people with MS experience self-monitoring with a pedometer through qualitative enquiry can ascertain specific pedometer-based contributions to physical activity behaviour and lead to a better understanding of the motivational and practical device issues of using pedometers for physical activity promotion [18-20].

The iStep-MS trial, a behaviour-change intervention supported by the Yamax SW-200 Digi-walker pedometer, aimed to increase physical activity and reduce sedentary behaviour in people with MS [21]. This complex intervention was evaluated by feasibility randomised controlled trial and parallel embedded process evaluation [22]. One aim of the iStep-MS trial was to evaluate intervention outcomes and process in order to develop an in-depth understanding of the experience of trial participation [23]. While this covered all aspects of the trial, a dominant point raised was the usability and effectiveness of the pedometer. Consequently, this paper specifically draws on qualitative data from the process evaluation to describe the user experience of the Yamax SW-200 Digi-walker during home-based ambulatory monitoring in a group of people with MS.

Methods

Trial design and setting

Comprehensive details of the design and outcomes of the iStep-MS trial are described elsewhere [21, 24]. Briefly, sixty people with MS were recruited from a single MS Therapy Centre in southeast England and the MS Society UK website and randomly allocated to the intervention or usual care group following baseline assessment in a 1:1 ratio. Participants allocated to the usual care group received ongoing care which ranged from intensive physiotherapy to no treatment [21].

Eligibility criteria were a self-reported diagnosis of MS, ability to independently walk at a minimum within the home with or without a walking aid, relapse-free for the past 3 months, and free of unstable medical conditions (e.g., unstable angina) that would make participation in physical activity unsafe. Participants had to be able to travel to the centre, converse in English and have sufficient cognition to complete assessments and participate in the intervention. Exclusion criteria were pregnancy and ongoing participation in other trials. The trial consisted of four face-to-face sessions with a physiotherapist delivered at intervals of between 2 and 4 weeks over a three month period. Intervention sessions were supported by a handbook and a Yamax SW-200 Digi-walker (Yamax Corporation, Tokyo, Japan) pedometer. The Yamax SW-200 Digi-walker provides quantifiable and objective indicators of activity through measurement of the total number of steps. It has established accuracy [25], reliability [26], and validity [27] in people with MS. Participants were requested to wear the pedometer during waking hours and record their daily step count in their handbook for a minimum of one week in between each of the four intervention sessions. Recording step count beyond this seven-day timeframe was at the discretion of the participants.

Participants

A sampling frame was created and participants (n=15) were purposively sampled based on features that the literature suggests are relevant to engagement with physical activity and experiences of living with MS which we believed could potentially influence the experience of the programme [28]. Criteria included gender [29], type of MS (relapsing-remitting (RR) or any other)[30], age (older or younger than 60) to capture participants with different life commitments (e.g. employment) [31] and low and high physical activity engagement (above or below 5000 steps per day) to capture the experiences of active and sedentary participants [32]. People with MS identified as potential participants for interview were approached face-to-face by a member of the research team following their 12-week appointment. Participants provided explicit written

consent to participate in interview separate to the consent given to take part in the main iStep-MS trial.

Ethical approval was obtained from the College of Health and Life Sciences Research Ethics Committee (REC) in Brunel University London (6181-NHS-Apr/2017-7016-2).

Data collection

One-to-one semi-structured interviews (mean duration: 66.9 min; range: 51.6 min - 88.6 min) were conducted in a location and time of the participants' choosing. This included their own homes and a private room in the MS Centre. All interviews were conducted by an experienced qualitative researcher (MN), who was part of the research team and therefore aware of study content, but unknown to participants. This was deemed important to reduce any potential undue influence on the participants' response.

The semi-structured format of the questions allowed for flexibility in response to the interviewee and the interview context [33]. The topic guide was informed by the literature and developed in consultation with the wider research team. Interviews began with broad questions on the individual's history with MS and exploration of past and current engagement with physical activity followed by more focused questions related to the acceptability and usefulness of the intervention, and participants' perspective on being part of the research study. Overarching exploratory topics included: 'likes and dislikes of the intervention', 'changes as a result of the intervention', 'experience of being monitored' and 'experience of monitoring tools and questionnaires'. The topic guide was not explicitly designed to investigate pedometer experience. The complexity and frequency of discussions which occurred across topic areas regarding the pedometer highlighted the need for specific analytical focus.

Data management and Analytic Strategy

All interviews were audio-recorded, transcribed verbatim and imported into qualitative data management software (Nvivo version 12: QSR International). Pseudonyms are used in the presentation of findings, and specific details omitted to preserve participant anonymity. Transcripts were analysed using the Framework Method [34]. The Framework Method is a transparent process of analysing qualitative data which provides a clear audit trail of the iterative, analytical process from original transcripts to final themes, including the illustrative quotes [35]. The framework method was selected as an appropriate analysis approach as it allowed for the development of deductive codes from topics identified apriori (i.e. intervention feasibility, acceptability and safety) as well as inductive codes related to the experiential aspects of participation. The results presented here focus on the user experience of the Yamax SW-200 Digi-walker which were all inductive in development. The five iterative stages of the Framework method (familiarisation; thematic framework identification; indexing; charting; mapping and interpretation) were followed in the examination of the data presented [36, 37].

Familiarity with the data was established by reading transcripts several times. Identifying the thematic framework involved the identification of initial deductive and inductive codes and different levels of code abstraction to develop key ideas for subsequent phases. Independent dual analysis and coding of the first three transcripts by two researchers (JF, MN) enhanced the rigour of this stage [38]. Indexing was achieved by applying the initial framework developed to the entire data set to ensure full coverage [39]. The initial framework was reviewed and refined iteratively if new areas were identified [40]. During charting, data were summarized using a thematic matrix for interpretation and development of explanatory themes [40]. Finally, during mapping and interpretation, relationships and interactions were described supported by the use of a schematic diagram [38]. To ensure themes were comprehensive and enhance the depth of analysis the research team (MN, JR, AS and CK) engaged in critical discussion of the findings [41]. Inconsistencies were discussed and resolved iteratively through peer-debriefing. Preliminary results and interpretations were shared with the trial advisory group composed of people with MS

and therapists who were given the opportunity to reflect on the findings. No changes were made as a consequence of this process.

Acknowledging MN and JF's background in physiotherapy and role in the intervention development, several strategies including consideration of negative case analysis to identify elements of the data that did not support or appeared contradictory to identified patterns and the maintenance of a reflexive diary were put in place to ensure the trustworthiness of the analytical process.

Results

A summary of participant characteristics is shown in table 1. The desired sample was achieved demonstrating a range in all variables of interest.

Table 1 Participant demographic and clinical data

An overarching theme *Pedometers, the frustrating motivators* was identified from the data, which describes the conflicting benefits and difficulties that participants experienced in using the pedometer. Three subthemes elucidate this theme further. *Increasing activity awareness* describes the utility of the pedometer as an awareness-raising tool and the impact of this enhanced awareness on activity modification. *Numeric motivation* focuses on the value of objective, tangible feedback on motivation to engage in physical activity, but also highlights concerns and consequences of the perceived inaccuracy of the device. Our third sub-theme *(Un)usability* considers the practical implications of pedometer attachment and operation and alternative activity tracking strategies implemented by participants to overcome these issues.

Increasing activity awareness

Self-monitoring through continuous activity feedback on the pedometer's digital display raised participant consciousness regarding current activity levels. Insight into the variability of activity prompted the evaluation of the step count value of daily tasks. For William, quantifying activity

through step count not only facilitated efficient planning of activities with regard to their known effect on step count gain;

> *Oh yes, if I hadn't planned the village walks, I'd probably be just pottering round the garden and you don't do too many steps going round the garden. (William)*

It also unlocked understanding of wider health promotion messages. Step count was no longer abstract and conceptualising activity through this medium enhanced awareness of recommended daily activity requirements.

> *the NHS came out with the fact that you should do 7,500, a day. Now if I'd hadn't been on this [iStep-MS intervention] that wouldn't have meant anything to me at all, but at least I can know what 7,500 is, because on quite a few days I do do that, plus, 8,000. So I do learn now what steps are and what I can do. (William)*

Awareness of the number of steps completed during usual routines and activities also enhanced understanding of, and reflections upon diurnal and weekly patterns of activity and inactivity.

> *And you know what it is like when you are off [work]? And on days off with this as well it has been absolutely key because you do hardly any steps and do hardly any movement. Because it is your day off you don't do anything basically (Harry)*

This enhanced awareness of activity patterns allowed participants to identify sedentary periods and mobilised them to purposefully modify their behaviour to compensate.

> *Because some days it was like four thousand and it was like, "Yes, okay, well, you've been at work for the morning and you've been sat down and you've done this. You've*

not done anything this afternoon." So the next day you'd be like, "Come on, we're going to do a bit more." So that did make me be a bit more active. (Emma)

Although respondents acknowledged that increased activity awareness resulted in beneficial activity modifications, in situations where activity could not be adapted awareness became a reminder of inactivity and a source of worry as highlighted by Ella:

The step count, I was, I would fret a bit if I feel as if I hadn't done it sort of thing so particularly if I wasn't, if I wasn't feeling very energetic, I'd kind of just worry a bit basically about oh, I'm not going to do that, I'm not going to be able to do that or I can't do it. (Ella)

Numeric motivation

The objective numeric feedback provided by the pedometer was a powerful motivational tool for ten participants. The visual display served as a concrete reminder of the participant's desired number of steps and appeared to act as a catalyst to activity engagement. Visualizing daily step count progress and comparing it with individualized goals gave participants a focus to work towards. Through the pedometers' immediate feedback participants could regularly review their progress and titrate their activity in order to reach their daily target.

I think, once you get into the habit of looking at it regularly, you can set yourself goals, even goals throughout the day, never mind the goal at the end of the day. You can look at it at lunchtime, and think, "Well, actually, I've only done 1,000 steps this morning. That's not good enough. I need to do something, (Anna)

Achievement of numeric goals was associated with positive reinforcement, created feelings of satisfaction and a sense of achievement. Participants described seeing their quantified step count at the end of the day as rewarding and motivating.

> *That was good. I got really chuffed with myself when I got over ten thousand. It was quite a positive re-enhancement. (Emma)*

Others utilised the pedometers' tracking ability to measure their progress. Contrasting current activity levels with those at programme initiation created an index of achievement. Over time measurable feedback provided longitudinal objective evidence of progress and served as a motivating device for maintaining physical activity changes as participants reflected upon past successes.

> *it has been really useful because looking back, I can say do you know what, that was a really good day, I'm going to try and do that. (Emily)*

While reaching a numeric goal created positive reinforcement and was motivational, the value of measurable feedback was closely reliant on the accuracy of the monitoring tool. While three participants described close approximation of the step count with their activities, eight others reported variable accuracy. The pedometer was described as "temperamental" with poor step measurement reliability. On occasions where step count did register it was often viewed as inaccurate by the participant and unrepresentative of the individual's estimation of the volume of activity that had been completed. While issues with accuracy were more commonly reported by participants with severe impairment (6/8 participants) who mobilised with a walking aid (6/8 participants) this was not universal as shown in the following quote from Julia who mobilised independently:

Definitely, like you get a bit through the day, like about 10 o'clock or something and then you have a look at it and you think, bloody hell, I've done no steps but I've been upstairs ten times (Julia)

Multiple accuracy issues cast doubt on the value of the pedometer as a monitoring device. Setting goals and targets to increase activity based on a device, which participants perceived to be inaccurate was demoralising and negatively affected the participants' motivation in continuing with its use.

Well, when it worked, it was great because you'd say, "Oh, oh, now tomorrow, tomorrow, I'm going to do a little bit more because I want to beat that." So, it was a great motivator, so that's how it was motivating, but it was awful when you got to lunchtime and you looked at it and it said zero and you think no, I did more than that, or six steps and you think -- so, that's when it was a bit of a demotivator (Emily)

(Un) usability

Ten participants described usability considerations which impacted on the functionality of the Yamax SW-200. Participants reported a broad range of issues related to pedometer attachment at the advised hip position. Step count accuracy was influenced by wear position and orientation of the device, which varied depending on which item of clothing the monitor was attached to. Female participants reported issues with accuracy related to attaching the pedometer to dresses, undergarments, loose-fitting clothing or apparel with varying waist height. Placement difficulties affected user confidence in the accuracy of the pedometer reducing its value as a monitoring device.

you know, because obviously we've gone through the summer and if you had a different pair of shorts on or something and I don't know, if it [the pedometer] was lower down or whatever, it didn't … sometimes you think, well I've just walked around the house and it's done two steps and it was a bit temperamental. (Julia)

While attachment to waist belts was favourable, one participant highlighted the space and compatibility considerations with other hip-based devices used in ongoing treatment (e.g. functional electrical stimulation (FES)).

> *"I say the fact that I normally have the FES on, I mean there's a limit to how many more things I could have on my belt" (Olivia)*

Where attachment at hip level was possible, mixed success was reported. Pedometers frequently became detached during strenuous activity

> *Well, the first one died a death, because it dropped off when I was coming down a steep walk somewhere when we were out walking and it dropped on the ground and it never worked again (Maisie)*

Detachment when using the toilet was a particular issue for female participants with bladder urgency issues. Limited durability of the unit resulted in breakage due to frequent detachment. The perceived fragility of the devices limited their use as participants were resistant to ask for a replacement monitor.

> *It kept falling off. Because you're going to the loo all the time, and more often if you've got MS, it kept falling off onto the tiled floor in the bathroom. (Anna)*

Additional to attachment problems, five participants highlighted issues with opening and closing the pedometer. Step count is presented via an on-instrument digital display which may be viewed and reset daily by opening the device cover and viewing the display screen. Difficulties presented in participants with and without self-reported dexterity problems. Inability to easily view step count on the digital display reduced motivation as participants were unable to monitor their steps throughout the day and "check-up" on how they were progressing.

I think they should be able to be opened by somebody with just one good hand. And even with two good hands my wife struggles every day to do it. And it needs an easy flick or something just so you can look at it, glance at it during the day to see how you're doing and I couldn't do that and I've no idea what I've done so far today (William)

Although these issues were a clear source of frustration for many participants, it did not dampen commitment. Participant's problem solved around the pedometer and developed alternative self-monitoring strategies. Some purchased an alternative monitor while others reverted to a paper-based format to record their active days or used an application or calendar on their phone to record their movements.

...because of the pedometer issue…, I took a notion, and this was my way of dealing with it really, I suppose of keeping a diary, only on scrap paper, so I wrote every day the steps and what I'd done because the pedometer was not actually accurately recording the amount I was doing. (Olivia)

Discussion

To our knowledge, this is the first qualitative evaluation of the Yamax SW-200 Digi-walker, a pedometer with established reliability [26], and validity [27] for people with MS. Our results reveal conflicting positive and negative user experiences and provide considerations for integrating self-monitoring devices as a strategy to promote physical activity for people with MS.

In line with previous research, the present findings demonstrate that pedometers serve as a motivational tool to promote physical activity [14]. Objective feedback provided a barometer of personal activity gains, served as a motivational device for physical activity initiation and as a reflective tool for measurement of personal progress. Access to objective feedback provided participants with an accurate understanding of their true activity levels [19]. This conscious awareness of physical activity facilitated flexible tailoring of their daily activity patterns to meet personal goals.

Despite the clearly articulated impact of objective feedback on self-management, pedometer acceptability was mixed. User satisfaction depended on accurate data which correlated with the participant's own activity estimation. Inaccurate or questionable feedback impacted on their motivation for, and engagement with self-monitoring. Pedometer inaccuracies have been reported previously [42, 43] and are a known barrier to engagement during activity tracking [44-46]. To date, studies examining the validity of the Yamax SW-200 Digi-walker have examined step count at varying [25] or self-selected walking speeds [47] against the criterion observed steps, under controlled laboratory conditions in homogenous groups of people with relapsing-remitting MS, who are ambulatory without an aid [25, 47]. Abnormal gait patterns are prevalent among people with MS. Issues, including slower speed and cadence and shorter stride length are present even when there is minimal impairment [48] and may negatively impact pedometer accuracy [25, 47]. In the present study, inaccuracies were more frequently reported among individuals with more severe disability and who mobilised with an aid. Hip worn Yamax SW-200 pedometers have shown poor step count validity among people with stroke walking with aids in free-living conditions [49] and suggests that consideration may be needed for device type and positioning among those who mobilise with assistance. For people with MS whose disease course and symptoms may vary incorporation of an activity monitor which can accommodate variances in walking speed, pattern and aid use may be required to enhance accuracy.

While the establishment of validity is vital, the present findings indicate that acceptability and critically usability are equally important to maximise the benefit of self-monitoring devices. In line with previous research, wearability issues including the practicality of waist attachment to different clothing [12, 50] and security of device placement impacted on perceived ease of use and decision to persist with monitoring [50, 51]. Issues with opening and closing and attachment and detachment suggest consideration may be needed to ensure the suitability of this pedometer for participants with dexterity and bladder issues respectively. The acceptability of

wrist-worn monitors which avoid the issues of opening, closing and attachment warrant exploration as an alternative.

To best support participants to initiate and continue physical activity behaviour change, activity monitors must reach minimum acceptability for use. Initial engagement with the device was positive, however, inaccuracies and usability problems were disappointing and demotivating. Issues experienced by many participants led to a mistrust of the pedometer and a loss of relevance as participants incorporated alternative measurement options. While the pedometers proved unsuitable for some participants, the continued value derived from activity tracking and progress quantification through alternative measurement devices reaffirms the value attributed to objective monitoring [18] and underlines the need for accurate and acceptable measurement tools for people with MS.

Pedometers as self-monitoring devices have the potential to support increases in physical activity however initiation of their use depends on the device quality. To maximise adoption and promote sustained use, users' needs and preferences regarding specifications of effective devices must be considered.

Conclusion

This qualitative investigation supplements existing quantitative literature which has shown the validity of the Yamax SW-200 in people with MS and highlights the importance of consideration of both psychometric properties and user experience in the selection of activity monitors. Participants' experiences in the present study provide valuable information regarding usability concerns, which may assist in the design of future activity monitor supported interventions. Determining a practical and easy to use method for assessing free-living physical activity among people with MS has the potential to enhance activity engagement but requires further examination. Future research should consider the pedometer's reliability, validity and

acceptability in diverse groups with varying disease course and mobility impairments and explore alternative devices.

Strengths and limitations

Strengths of the present study include a balanced, purposive group of participants. However, it should be noted that the present study focused on the views of community-dwelling people with MS and are reflective of this population only. Participants were recruited through their local MS Therapy Centre. Due to their engagement with the centre, it is possible that the present group may be more aware of exercise and physical activity than the general population of people with MS living in the community. The lack of ethnic diversity within the participant group is also noted.

Acknowledgements

This work was supported by a project grant from the MS Society UK.

Declaration of Interest

The authors report no conflicts of interest

References:

1. Motl, R.W., E. McAuley, and E.M. Snook, *Physical activity and multiple sclerosis: a meta-analysis.* Mult Scler, 2005. **11**(4): p. 459-63.
2. Canning, K.L. and A.L. Hicks, *Benefits of Adhering to the Canadian Physical Activity Guidelines for Adults with Multiple Sclerosis Beyond Aerobic Fitness and Strength.* Int J MS Care, 2020. **22**(1): p. 15-21.
3. Charron, S., K.A. McKay, and H. Tremlett, *Physical activity and disability outcomes in multiple sclerosis: A systematic review (2011-2016).* Mult Scler Relat Disord, 2018. **20**: p. 169-177.
4. Stennett, A., L. De Souza, and M. Norris, *The meaning of exercise and physical activity in community dwelling people with multiple sclerosis.* Disabil Rehabil, 2020. **42**(3): p. 317-323.
5. Keytsman, C., et al., *Elevated cardiovascular risk factors in multiple sclerosis.* Mult Scler Relat Disord, 2017. **17**: p. 220-223.

6. Manouchehrinia, A., et al., *Mortality in multiple sclerosis: meta-analysis of standardised mortality ratios.* J Neurol Neurosurg Psychiatry, 2016. **87**(3): p. 324-31.
7. Siegel, P.Z., R.M. Brackbill, and G.W. Heath, *The epidemiology of walking for exercise: implications for promoting activity among sedentary groups.* Am J Public Health, 1995. **85**(5): p. 706-10.
8. Weikert, M., et al., *Most common types of physical activity self-selected by people with multiple sclerosis.* Int J MS Care, 2011. **13**(1): p. 16-20.
9. Asano, M., et al., *Exercise barriers and preferences among women and men with multiple sclerosis.* Disability and Rehabilitation, 2013. **35**(5): p. 353-361.
10. Rintala, A., et al., *Effectiveness of technology-based distance physical rehabilitation interventions on physical activity and walking in multiple sclerosis: a systematic review and meta-analysis of randomized controlled trials.* Disabil Rehabil, 2018. **40**(4): p. 373-387.
11. Laine, J., et al., *Cost-effectiveness of population-level physical activity interventions: a systematic review.* Am J Health Promot, 2014. **29**(2): p. 71-80.
12. Houle, J., et al., *Acceptability of a computer-tailored and pedometer-based socio-cognitive intervention in a secondary coronary heart disease prevention program: A qualitative study.* Digital health, 2020. **6**: p. 2055207619899840-2055207619899840.
13. Lindgren, T., J. Hooper, and Y. Fukuoka, *Perceptions and Experiences of Women Participating in a Digital Technology-Based Physical Activity Intervention (the mPED Trial): Qualitative Study.* JMIR public health and surveillance, 2019. **5**(4): p. e13570-e13570.
14. Bravata, D.M., et al., *Using pedometers to increase physical activity and improve health: a systematic review.* Jama, 2007. **298**(19): p. 2296-304.
15. Chan, C.B., D.A. Ryan, and C. Tudor-Locke, *Health benefits of a pedometer-based physical activity intervention in sedentary workers.* Prev Med, 2004. **39**(6): p. 1215-22.
16. Dlugonski, D., et al., *Internet-delivered behavioral intervention to increase physical activity in persons with multiple sclerosis: sustainability and secondary outcomes.* Psychol Health Med, 2012. **17**(6): p. 636-51.
17. Motl, R.W., et al., *Internet intervention for increasing physical activity in persons with multiple sclerosis.* Mult Scler, 2011. **17**(1): p. 116-28.
18. Ayobi, A., et al., *Quantifying the Body and Caring for the Mind: Self-Tracking in Multiple Sclerosis*, in *Proceedings of the 2017 CHI Conference on Human Factors in Computing Systems*. 2017, Association for Computing Machinery: Denver, Colorado, USA. p. 6889–6901.
19. Wendrich, K., et al., *Toward Digital Self-monitoring of Multiple Sclerosis: Investigating First Experiences, Needs, and Wishes of People with MS.* Int J MS Care, 2019. **21**(6): p. 282-291.
20. Croteau, K.A., et al., *Effect of a pedometer-based intervention on daily step counts of community-dwelling older adults.* Res Q Exerc Sport, 2007. **78**(5): p. 401-6.
21. Ryan, J.M., et al., *Safety, feasibility, acceptability and effects of a behaviour-change intervention to change physical activity behaviour among people with multiple sclerosis: Results from the iStep-MS randomised controlled trial.* Mult Scler, 2019: p. 1352458519886231.

22. Ryan, J.M., et al., *Changing physical activity behaviour for people with multiple sclerosis: protocol of a randomised controlled feasibility trial (iStep-MS).* BMJ Open, 2017. **7**(11): p. e018875.
23. Craig, P., et al., *Developing and evaluating complex interventions: the new Medical Research Council guidance.* BMJ, 2008. **337**: p. a1655.
24. Fortune, J., et al., *'I can do this': a qualitative exploration of acceptability and experiences of a physical activity behaviour change intervention in people with multiple sclerosis in the UK.* BMJ Open, 2020. **10**(3): p. e029831.
25. Motl, R.W., et al., *Accuracy of two electronic pedometers for measuring steps taken under controlled conditions among ambulatory individuals with multiple sclerosis.* Mult Scler, 2005. **11**(3): p. 343-5.
26. Motl, R.W., et al., *Reliability of scores from physical activity monitors in adults with multiple sclerosis.* Adapt Phys Activ Q, 2007. **24**(3): p. 245-53.
27. Gosney, J.L., et al., *Physical activity and multiple sclerosis: validity of self-report and objective measures.* Fam Community Health, 2007. **30**(2): p. 144-50.
28. Ritchie J, L.J., Elam, G, Tennant R, Rahim N, *Qualitative Research Practice: A Guide for Social Science Students and Researchers*. 2nd ed. Designing and selecting samples. 2014, London: Sage.
29. Anens, E., et al., *Physical activity in subjects with multiple sclerosis with focus on gender differences: a survey*. BMC neurology, 2014. **14**: p. 47-47.
30. Motl, R.W., et al., *Does the effect of a physical activity behavioral intervention vary by characteristics of people with multiple sclerosis?* International journal of MS care, 2015. **17**(2): p. 65-72.
31. Streber, R., S. Peters, and K. Pfeifer, *Systematic Review of Correlates and Determinants of Physical Activity in Persons With Multiple Sclerosis.* Arch Phys Med Rehabil, 2016. **97**(4): p. 633-645.e29.
32. Tudor-Locke, C., et al., *A step-defined sedentary lifestyle index: <5000 steps/day.* Appl Physiol Nutr Metab, 2013. **38**(2): p. 100-14.
33. Miles J, G., P, *A Handbook of Research Methods for Clinical and Health Psychology*. 2005: Oxford University Press.
34. Ritchie J, L.J., *Qualitative Research Practice: A Guide for Social Science Students and*

Researchers. . 2009, London: SAGE Publishers.

35. Gale, N.K., et al., *Using the framework method for the analysis of qualitative data in multi-disciplinary health research.* BMC Medical Research Methodology, 2013. **13**(1): p. 117.
36. Holloway I, W.S., *Qualitative Research in Nursing and Healthcare*. 3rd Edition ed ed. 2010, United Kingdom: Wiley-Blackwell.
37. Ritchie, J. and L. Spencer, *Chapter 9: Qualitative data analysis for applied policy research*, in *Analyzing qualitative data*, R.G. Burgess and A. Bryman, Editors. 1994, Routledge: London ; New York. p. 173-194.
38. Srivastava, A.T., SB, *Framework analysis: A qualitative methodology for applied policy research.* Journal of Administration and Governance, 2009. **4**(2): p. 72-79.
39. Parkinson, S., et al., *Framework analysis: a worked example of a study exploring young people's experiences of depression.* Qualitative Research in Psychology, 2016. **13**(2): p. 109-129.
40. Ward, D.J., et al., *Using Framework Analysis in nursing research: a worked example.* J Adv Nurs, 2013. **69**(11): p. 2423-31.

41. Shaw, R., *Embedding Reflexivity Within Experiential Qualitative Psychology.* Qualitative Research in Psychology, 2010. **7**(3): p. 233-243.
42. Wahlich, C., et al., *'You started something ... then I continued by myself': a qualitative study of physical activity maintenance.* Prim Health Care Res Dev, 2017. **18**(6): p. 574-590.
43. Vetrovsky, T., et al., *A pedometer-based walking intervention with and without email counseling in general practice: a pilot randomized controlled trial.* BMC public health, 2018. **18**(1): p. 635-635.
44. Blake, H. and M.E. Batt, *Employee perceptions of a pedometer walking intervention in a hospital workplace.* International Journal of Health Promotion and Education, 2015. **53**(5): p. 257-270.
45. Hawkins, J., et al., *Acceptability and Feasibility of Implementing Accelorometry-Based Activity Monitors and a Linked Web Portal in an Exercise Referral Scheme: Feasibility Randomized Controlled Trial.* J Med Internet Res, 2019. **21**(3): p. e12374.
46. Fausset, C.B., et al., *Older Adults' Use of and Attitudes toward Activity Monitoring Technologies.* Proc Hum Factors Ergon Soc Annu Meet, 2013. **57**(1): p. 1683-1687.
47. Balto, J.M., D.L. Kinnett-Hopkins, and R.W. Motl, *Accuracy and precision of smartphone applications and commercially available motion sensors in multiple sclerosis.* Mult Scler J Exp Transl Clin, 2016. **2**: p. 2055217316634754.
48. Martin, C.L., et al., *Gait and balance impairment in early multiple sclerosis in the absence of clinical disability.* Mult Scler, 2006. **12**(5): p. 620-8.
49. Vanroy, C., et al., *Physical activity monitoring in stroke: SenseWear Pro2 Activity accelerometer versus Yamax Digi-Walker SW-200 Pedometer.* Disability and Rehabilitation, 2014. **36**(20): p. 1695-1703.
50. Shingler, E., et al., *The feasibility of the Prostate cancer: Evidence of Exercise and Nutrition Trial (PrEvENT) dietary and physical activity modifications: a qualitative study.* Trials, 2017. **18**(1): p. 106-106.
51. Mitchell, F., et al., *A qualitative exploration of participants' experiences of taking part in a walking programme: Perceived benefits, barriers, choices and use of intervention resources.* J Appl Res Intellect Disabil, 2018. **31 Suppl 1**: p. 110-121.

Table 1 Participant demographic and clinical data

ID	Age (years)	Sex	Clinical course	Time since diagnosis (years)	EDSS	Functional walking level	Physical activity engagement (above or below 5000 steps)	Treating therapist
Harry	47	Male	SPMS	12	4.5 - 6.5	Independent with walking aid	<5000	Therapist A
Julia	60	Female	PPMS	7	1.0 -4.5	Independent	<5000	Therapist C
Anna	59	Female	SPMS	27	4.5 - 6.5	Independent with walking aid	<5000	Therapist D
William	71	Male	SPMS	23	4.5 - 6.5	Independent with walking aid	<5000	Therapist A
Rose	62	Female	SPMS	21	4.5 - 6.5	Independent with walking aid	<5000	Therapist A
Adam	54	Male	PPMS	5	4.5 - 6.5	Independent with walking aid	<5000	Therapist D
Ella	52	Female	RRMS	10	1.0 -4.5	independent	>5000	Therapist A
Hannah	41	Female	RRMS	4	1.0 -4.5	Independent	>5000	Therapist D
Maisie	55	Female	RRMS	20	1.0 -4.5	Independent	>5000	Therapist B
Joe	67	Male	RRMS	42	4.5 - 6.5	Independent with walking aid	<5000	Therapist C
Sophie	52	Female	RRMS	12	1.0 -4.5	Independent	>5000	Therapist C

Emma	39	Female	RRMS	5	4.5 - 6.5	Independent	>5000	Therapist D
Olivia	62	Female	SPMS	12	4.5 - 6.5	Independent with walking aid	<5000	Therapist B
Emily	61	Female	RRMS	8	4.5 - 6.5	Independent with walking aid	>5000	Therapist C
Mark	63	Male	PPMS	8	4.5 - 6.5	Independent with walking aid	<5000	Therapist A
	SPMS: Secondary progressive multiple sclerosis; PPMS: Primary progressive multiple sclerosis; RRMS: Relapsing remitting multiple sclerosis.							