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Title Page

Title:

Compliance with physical activity guidelines in a group of UK based postal workers using an objective monitoring technique.

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Abstract (100-150 words)

Compliance with physical activity (PA) recommendations were assessed using objective PA monitoring of ambulatory activity, in two healthy groups of individuals with active and sedentary occupations. The study showed generally low compliance with the guidelines (53% with 10,000 steps a day; 10% with 30 minutes of moderate activity a day; and 1% with 30 minutes of moderate activity a day in bouts of at least 10 minutes (ACSM)). Adherence to guidelines decreased as more rigorous conditions were applied to the PA data. Use of an objective monitor revealed that health enhancing bouts of activity were performed in periods of approximately 1 minute duration, which may be due to unavoidable environmental interruptions. These bouts of activity are much shorter than those advocated in the ACSM guidelines, raising questions regarding how actual behaviour, based on objective monitoring, can be reconciled with guidelines based on self-reported PA.

Keywords: (4-6)

physical activity; objective monitoring; activity monitor; health promotion; public health; walking

Introduction

There is compelling evidence that maintaining a physically active lifestyle has important health benefits and reduces the risk of all-cause mortality and chronic diseases (Pate et al. 1995; Schnohr et al. 2003). Accordingly, promoting and prescribing health enhancing physical activity (PA) has become a public health priority.

In structured exercise, the relationship between dose and health response is well documented and prescription is standardised in terms of volume, frequency, type, duration and intensity (Kesaniemi et al. 2001). However, the optimum combination of these parameters in free-living PA is still a matter of debate (Blair et al. 2004), and a number of different PA guidelines and health messages have evolved over recent years (Haskell et al. 2007; Hatano et al. 1993; Pate et al. 1995). These guidelines have generally been developed from epidemiologic studies which were based on self reported PA weighted against health risk factors.

Three of the major PA guidelines reflect different ways in which PA can be described. The popular health message of "10,000 steps a day" (10KSTEP; Hatano et al. 1993), recommends taking 10,000 steps each day, and is purely a measure of the volume of PA. Recognising the important role that the intensity of PA plays in enhancing health, the Centres for Disease Control and Prevention and the American College of Sports Medicine (ACSM) published guidelines in 1995 (30MIN_MA) recommending an accumulation of 30 minutes of moderate intensity physical activity on most days of the week (Pate et al. 1995), a measure of both the intensity and the volume of PA. It was a requirement of the 30MIN_MA guidelines that moderate intensity activity be accrued in bouts of at least 8 to 10 minutes duration, however these guidelines have often been simplified to omit the restrictions on the duration of an individual bout. Consequently, revised guidelines were issued in 2007 by the American Collage of Sports Medicine and the American Heart Association (ACSM), clarifying that the 30 minutes of moderate activity on at least five days of the week, be accrued in bouts of at least 10 minutes duration (Haskell et al. 2007). The revised recommendation was based on studies reporting that the benefits of three bouts of 10 minutes of walking during a day are similar to those of a

single bout of 30 minutes (Jakicic et al. 1999; Moreau et al. 2001; Murphy et al. 2002), and includes a measure of the duration of PA, as well as intensity and volume.

Assessing PA using self-reported methods has many caveats (Ainsworth and Levy 2004), and in recent years the development of activity monitoring tools has made it possible to obtain objective PA data (Ward et al. 2005). These new objective methods have emerged as viable alternatives to self-report, allowing PA to be monitored with far greater accuracy. The purpose of this study was to describe adherence to two different interpretations of PA guidelines and one popular health message in a healthy working population using an objective measurement tool.

Methods

Participants

Participants for the study were postal workers, recruited from offices in Glasgow, UK. Postal workers within Glasgow were informed of the study via work e-mail, and participants volunteered to take part in the study. Postal workers were selected because there were clear distinctions in required activity levels at work between occupational categories. In this study, participants were either delivery postal workers who walked their delivery route (active workers; Dictionary of Occupational Titles (DOT); National academy of sciences, committee on occupational classification and analysis 2003; code 230.367-010, physical level "medium") or office based postal workers (sedentary workers; DOT codes 243.137-010 or 209.687-026, physical level "light"). These categories were used to allow a comparison between individuals with typically active and sedentary employment types.

Participants were non-smokers aged between 20 and 60 years, had been working for at least three months prior to the study, and were not on any medication for chronic heart disease, diabetes, hypertension or hypercholesterolemia. Written informed consent was obtained from all participants. The study was approved by the School of Health and Social Care, Glasgow Caledonian University ethics committee, and was performed in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki.

Protocol

Demographic information was recorded for each participant: age; gender; weight; body mass index (BMI); and occupation category. Participants were provided with an objective activity monitor and asked to wear the monitor continuously (including overnight but excluding showering) for seven days. After collection, data were downloaded onto a PC.

Instrument

The activPAL™ activity monitor was used to measure free-living PA. The monitor records time spent sitting or lying, standing and walking on a second-by-second basis. For each period of stepping, it calculates, from measurements based on strides, the number of steps and the average cadence of that bout. Monitor reliability and accuracy have been validated for postural classification, and for the calculation of step count and cadence in a general population (Godfrey et al. 2007; Grant et al. 2006; Ryan et al. 2006).

Data Analysis

The activPAL™ monitor identifies periods of stepping (walking and running). Other modes of exercise may not be recognised by the monitor, although activities which include running or walking within them (e.g. sports activities such as football or badminton) would be categorised as a stepping activity. This is in line with other assessments of compliance with PA guidelines in regarding walking is the most common form of exercise (Morris and Hardman 1997; Rafferty et al 2003). The activPAL™ activity monitor assesses postural information, and differentiates between periods of walking and standing. A single continuous period of walking is here considered as a single bout of walking. Periods of walking are interspersed by periods of standing. There is no information regarding minimum duration of standing that constitutes a reasonable break in activity, therefore for the purposes of this analysis, the standard monitor setting of 10s was used.

The activity data were analysed using the two interpretations of PA guidelines and one popular health message which reflect different prescription parameters. These were:

- 1) 10KSTEP: A popular health message which advises individuals to take 10,000 steps a day, and is a measure of volume of PA (Hatano et al. 1993). For comparison with the other guidelines this was operationalised to 10,000 steps per day on at least 5 days of the week;
- 2) 30MIN_MA: Thirty minutes of moderate activity on at least 5 days of the week. This is based on the ACSM recommendations (Pate et al. 1995), and was operationalised for the purposes of this analysis, according to the misinterpretation that there are no restrictions on the duration of individual bouts of moderate intensity activity. In this form it is a measure of the volume and intensity of PA;
- 3) ACSM: The American College of Sports Medicine's recommendation advocating 30 minutes of moderate activity on at least 5 days of the week, accumulated in bouts of at least 10 minutes (Haskell et al. 2007). It is based on a measure of volume, intensity and duration of PA.

The 30MIN_MA and ACSM guidelines recommend undertaking PA at a moderate activity level, and this was associated with a metabolic cost of between 3 and 6 MET (Haskell et al. 2007). There are recognised problems with estimating energy expenditure from accelerometer based activity monitors (Ward et al. 2005). In this study, therefore, the cadence of the stepping periods was deemed a more prudent and direct way to infer intensity, than estimated energy expenditure. A small study of treadmill based walking found that 25 men, walking at a mean metabolic rate of 5METs (i.e. moderate intensity activity), had a walking cadence of 123.6 ± 4.9 steps/minutes (medium speed, 6.4 kmh^{-1} ; Tudor-Locke et al. 2005). In order to include anyone walking within this moderate intensity range, a threshold value was used that was three standard deviations below the mean value (which would include 99% of the population, assuming a normal distribution). The threshold for a walking pace of moderate intensity was therefore defined as 109 steps/minute.

The daily total step count was compiled for each participant, a participant was considered to be compliant with the 10KSTEP guideline on a day, if they had taken at least 10,000 steps on that day. Walking bouts where the cadence was above 109 steps/minute were identified, and were summed to provide the daily time spent walking at a moderate intensity. Participants were deemed compliant with the

30MIN_MA guidelines on a day, if the total time spent walking at a moderate intensity was at least 30 minutes for that day. For the ACSM guidelines, those bouts of walking at a moderate intensity of at least 10 minutes duration were summed to provide a daily total, and participants were deemed compliant on a day, if they reached at least 30 minutes on that day. For each participant, the number of days for which each guideline was met was calculated. Participants were considered compliant with a guideline if they met the daily requirements for that guideline on at least 5 days of the week.

Data are primarily presented as the number of days for which each participant was compliant with the guidelines, and the number of participants who were compliant with the guidelines. Additionally, data are presented as metrics associated with the guidelines (number of steps; time spent walking; time spent walking at moderate intensity; the number and duration of walking bouts at a moderate intensity). Each of the metrics associated with the guidelines was normally distributed (as tested by the kolgorov-smirnov test), and comparisons between participants grouped by occupation category were performed using an independent t-test. A p-value < 0.05 was considered to be significant. All data analysis was performed using SPSS (version 15).

Results

Participants

One hundred and fourteen postal workers were recruited to the study. Incomplete data sets, with less than seven complete consecutive days of data, were excluded from the analysis (n=36). Analysis was, therefore, conducted on data from the 78 participants for whom there was a complete data set of seven consecutive days.

The 78 participants included 11 female postal workers. There were 39 active workers (5 female), and 39 sedentary workers (6 female). The mean age of participants was 40 (\pm 8) years, range between 22 and 60 years; the mean weight of participants was 80 kg (\pm 13); and the mean BMI of participants was 26.8 (\pm 3.4) kg.m⁻². The gender distribution was similar, and there were no significant group differences in age, weight or BMI between active and sedentary workers (table 1).

Number of Steps

The mean daily step count for the whole population was 14,036. The mean daily step count of active workers (17,065 ± 4,000) was significantly greater ($p < 0.001$) than those taken by sedentary workers (11,007 ± 4,000; figure 1a).

10KSTEP guidelines

The 10KSTEP guidelines were met on at least 5 days of the week by 41 participants (53%; table 2). More active workers met the 10KSTEP guidelines (77% , $n=30$; figure 1b), than sedentary workers (28%, $n=11$).

Time Spent Walking

All of the participants walked, at any intensity, for at least 30 minutes per day, with active workers spending significantly more time walking each day than sedentary workers (210 ± 48 min/day compared with 147 ± 43; $p < 0.001$).

Time Spent Walking at a Moderate Intensity

On average, participants spent 22 min/day walking at a moderate intensity (walking at cadence > 109 step/min). Active workers spent significantly longer per day walking at a moderate intensity (28 min/day) than sedentary workers (16 min/day; $p < 0.01$; figure 1c).

30MIN_MA guidelines

The 30MIN_MA guidelines were met by 8 participants (10%; table 2) on five or more days of the week. More active workers were compliant with the guidelines (15%; $n=6$) than sedentary workers (5%; $n=2$; figure 1d).

Bouts of Walking at a Moderate Intensity

Participants accumulated on average 21.7 bouts of walking at a moderate intensity per day. Active (22.4 bouts/day) and sedentary (20.9 bouts/day) workers performed a similar number of moderate intensity walking bouts, and no significant difference was found. However, a significant difference was found for the length of walking bouts of moderate intensity ($p < 0.01$) between active (mean 1.44 minutes per bout)

and sedentary (mean 0.92 minutes per bout) workers. The average length of moderate intensity walking bouts was 1.18 minutes.

ACSM guidelines

When considering bouts of walking at a moderate intensity which are a duration of at least ten minutes, the time spent walking at a moderate intensity was significantly reduced. Only one participant (an active worker) was compliant with the ACSM guidelines (table 2). Most participants (60%; n=47) did not comply with the ACSM daily recommended allowance on any day of the week (figure 1e).

Discussion

These results demonstrate that compliance with PA guidelines in a healthy working population, when assessed using an objective monitor, is generally low. In a group of 185 Australian adults, working in an office, 30% walked with a daily mean of at least 10,000 steps per day, measured using a pedometer (Miller and Brown 2004). This was a lower adherence than that of all participants to the 10KSTEP guidelines in the current study (53%), but was in line with the adherence of the sedentary, office based, workers (28%). The low compliance in the current study with the ACSM guidelines (1%), broadly agrees with the adherence of 1828 American adults to these guidelines (3.5%), monitored using an accelerometer (Troiano et al. 2005). Compliance varied considerably depending on the guideline used, and this large variation in adherence to PA guidelines supports similar findings in children (Pate et al. 2002).

Compliance decreased rapidly as the guidelines became more prescriptive. The highest compliance was with the 10KSTEP guidelines, which only prescribed the volume of the PA required. In addition, all participants walked for at least 30 minutes each day of data collection (a volume metric in line with the 30MIN_MA and ACSM guidelines). Most of the participants, however, did not walk with a sufficiently high cadence to be judged as walking at a moderate intensity, as required for the 30MIN_MA and ACSM guidelines. The daily average time spent walking at a moderate intensity in this population was 22 min/day, and only 10% of participants met the 30MIN_MA guidelines. Finally, the introduction of a minimum duration of 10 minutes for bouts of walking at a moderate intensity, in the ACSM guidelines, further

reduced the compliance of this population to a single participant. As a group, those participants in an active occupation were more active than those participants in a sedentary occupation. However, having an active occupation did not necessarily translate into meeting the more rigorous PA guidelines.

The implication from these results, is that the majority of participants generally do not walk at a moderate intensity in a continuous manner. Indeed, the mean length of a walking bout at a moderate intensity was of the order of only one minute. Short gaps between walking bouts are a natural consequence of the interruptions in everyday life. For example, a postal worker delivering mail while walking along a street, might pause on several occasions to put mail through the door or to cross the street. It appears, therefore, that achieving continuous bouts of moderate activity of the duration of at least 10 minutes during everyday life is difficult, even for individuals whose occupation ostensibly involves walking for long periods, such as the delivery postman taking part in this study. This study indicates that when measured objectively, and without additional processing to reassemble walking bouts split by short breaks, the ACSM recommendations to accumulate moderate activity in continuous bouts of 10 minutes are quite different from the actual pattern of moderate activity in free living conditions.

The ACSM guidelines, are based on epidemiologic data which was gathered using self-report measures (Troiano et al. 2008). Self-reported PA will often take into account the perceived total duration of PA, but may not take into account the actual fragmentation of moderate activity episodes (Pate et al. 1995). So, the postal worker delivering the mail when walking along a street, might report a morning delivering mail as a single episode of walking at a moderate intensity lasting more than 30 minutes, but this would be measured objectively as few, if any, bouts above ten minutes of walking at moderate intensity. Self-reported PA and objectively monitored PA may, therefore, measure two separate constructs, with self-report methods assessing perceived PA, and objective methods assessing actual PA.

The consequence of this difference in construct, for assessment of compliance to the ACSM guidelines using objective measurement techniques, is that the breaks between bouts must be considered, and dealt with as post-processing of the

objective data. One solution is the stitching together of several short bouts of walking with an acceptably short break between them. In this study gaps between walking bouts of 10s were considered to break a walking bout, whereas Troiano et al. (2008) only considered gaps longer than 2 minutes. The choice of allowable gap length in both studies was constrained by the instrument used to collect the data, the activPAL has a minimum standing or sedentary bout length of 10s, whereas the Actigraph used by Troiano et al. (2008) collected data using a one minute epoch length. The populations within these studies were different, and the difference in gap length was not the only methodological difference between studies, but the compliance to the ACSM guidelines of both studies were at similar, extremely low, levels (1% and 3.5% respectively), and it is possible that a difference of almost 2 minutes in the potential size of a gap between PA bouts, did not make an appreciable difference to compliance with the ACSM guidelines. Had a longer duration of gap been used in this analysis, it is possible that compliance to the ACSM guidelines would have been higher, however it should be noted that the largest potential value of compliance was 10% (the compliance level with the 30MIN_MA guidelines).

A number of currently unanswered questions are raised regarding the reconciliation and interpretation of objectively measured PA with PA guidelines. How short can continuous bouts of PA be and still be health enhancing? How long can any gaps between bouts of PA be to still be considered the same set of PA? What is the range and variation of the gaps in PA which occur when moving in a modern, urban environment? Further research is required to resolve these issues. Physiological and larger epidemiological studies, using objective measures of PA, are required to ascertain the relationship between the pattern of moderate intensity activity and health.

The strengths of this study lie in the use of a valid objective monitor which is capable of assessing both the step count and the time spent in moderate intensity, thus allowing a direct comparison of the guidelines using data from a single monitor. Pre-defined groups were used to differentiate between active and sedentary employment types. In addition, data was only analysed from participants when there were seven continuous days of data available for analysis. While fewer days

may characterise habitual PA for an individual (Matthews et al. 2002), when describing the adherence to PA guidelines that operate in terms of PA per week, analysis of data from seven consecutive days is stronger than using inferred weekly PA from a shorter measurement period.

Limitations of this study include a modest sample size, which may make it difficult to generalise the results to a wider population. Participants volunteered to take part in the study, which may have led to a selection bias within the participants, and the results of this study should be applied to the whole population of postal workers only with caution. There may have been a tendency for more active postal workers to have volunteered, which could mean that the percentages of compliance with the physical activity guidelines are too optimistic for the population as a whole. Leading a physically active lifestyle, in line with the ACSM guidelines, whilst providing health benefits, may not lead to weight loss (Haskell et al. 2007), and the moderate difference in compliance between the two working groups in this study would not expect to also be reflected in a difference in BMI. Only periods of stepping were assessed in the analysis, which may have led to some participants not meeting the guidelines due to other forms of exercise not involving stepping in which they participated (e.g. swimming, rowing, weight lifting, cycling) not being included in the analysis. The effect of this will be limited, as many sports incorporate walking or running which would be assessed, and is unlikely to have had a significant effect on the low numbers of participants meeting the ACSM guidelines. In addition, as the 10KSTEP guideline only assesses periods of stepping, it would not be affected. We used an objective activity monitor to infer the intensity of PA, and there are a number of limitations with this; the monitor cannot take account of upper limb activity, changes in intensity due to walking on different inclines, or changes in intensity of PA manifested by a change in stride length rather than a change in cadence. Finally, our method of inferring moderate intensity activity using a cadence threshold, was based on data published using only a small number of participants (Tudor-Locke et al. 2005). Although individual variation has been accounted for by taking a cadence threshold at the lower end of a normal distribution curve, this may not be an appropriate threshold for all individuals. Additionally, this conservative approach towards the definition of the cadence

threshold, may have led to walking bouts which were lower than a moderate intensity being included in the analysis as moderate intensity walking bouts.

Conclusion

This study found that the adherence to PA guidelines in a healthy working population was low. Compliance varied with the PA guideline recommendations, and decreased as recommendations specified additional criteria to be met (volume, intensity, duration). In particular, the requirement to accumulate moderate intensity activity in bouts longer than ten minutes, as specified by the ACSM guidelines, was only achieved by a single participant.

The apparently low level of compliance with the guidelines might be a measurement artefact due to the difference in construct between the guidelines (based on self reported data) and monitoring based on an objective measure. Indeed, objective monitoring reveals that PA levels that are deemed health enhancing (i.e. moderate intensity activity, brisk walking) tend to be accumulated in short bursts (of the order of 1 minute duration) in free living conditions. There is a need for additional research to reconcile compliance with guidelines based on self-reported PA and the objective measurement of PA.

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Conflict of Interest

Professor Malcolm Granat is a named co-inventor of the activity monitor and has a directorship of the company PAL Technologies Ltd., Glasgow, UK. Professor Granat had no involvement in either data collection, or in the statistical analysis of the results. There was no financial contribution to this work from PAL Technologies Ltd..

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Table 1: Characteristics of the participants.

Characteristic	Group	
	Active workers (n=39)	Sedentary Workers (n=39)
gender (#female)	5 (13%)	6 (15%)
age (years)	40 (\pm 9)	40 (\pm 7)
weight (kg)	79 (\pm 13)	82 (\pm 12)
BMI ($\text{kg}\cdot\text{m}^{-2}$)	27 (\pm 4)	27 (\pm 3)

BMI: body mass index.

Data are presented as number (and percentage) female for gender, and mean (\pm standard deviation) for age, weight and BMI.

Table 2: Compliance of the population with three physical activity guidelines.

Guideline	Group		
	All (n=78)	Active workers (n=39)	Sedentary Workers (n=39)
10KSTEP	41 (53%)	30 (77%)	11 (28%)
30MIN_MA	8 (10%)	6 (15%)	2 (5%)
ACSM07	1 (1%)	1 (3%)	0 (0%)

Data are presented as number (and percentage) compliant with the guideline

10KSTEP: "10,000 steps a day" guideline (Hatano et al. 1993);

30MIN_MA: Based on the 1995 guidelines from the American College of Sports Medicine, 30 minutes of moderate activity on at least 5 days of the week (Pate et al. 1995), and assuming no minimum bout length;

ACSM: 2007 guidelines from the American College of Sports Medicine, 30 minutes of moderate activity on at least 5 days of the week, accumulated in bouts of at least 10 minutes (Haskell et al. 2007);

Legend

Figure 1: Data from sedentary workers appear in white and data for active workers appear in black. (a) mean daily step count; (b) number of days on which the 10KSTEP recommendation is met; (c) average daily time spent walking at a moderate intensity; (d) number of days on which the 30MIN_MA guideline is met; (e) number of days on which the ACSM guideline is met.

□ Sedentary ■ Active

Figure 1(a) - 10K Steps Compliance

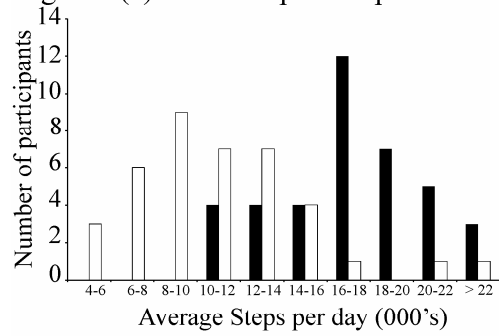


Figure 1(b) - 10K Steps Compliance

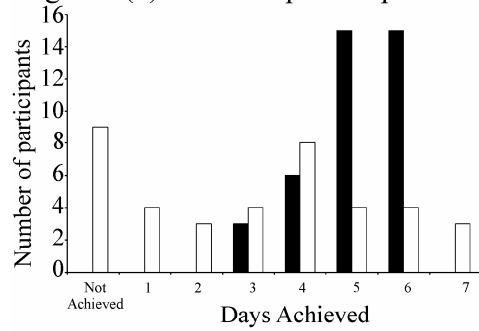


Figure 1(c) - ACSM 95 Compliance

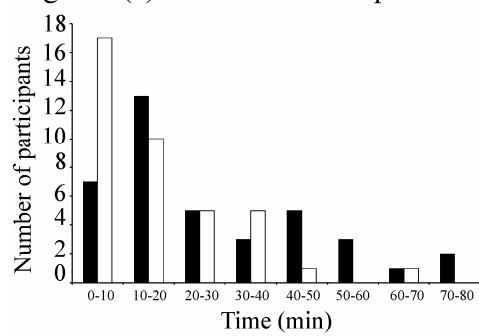


Figure 1(d) - ACSM 95 Compliance

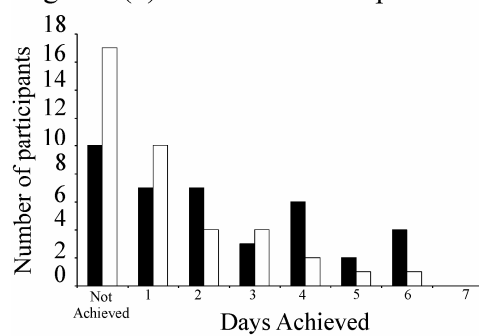


Figure 1(e) - ACSM 2007 Compliance

