Paper

Does the Usage of a Pedometer and a Diary Improve Physical Activity during the Snowy Season?

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This study was designed to investigate whether self-monitoring using a pedometer and a diary improves physical activity (PA) during the snowy season. This study examined 191 women aged 40-77 years, residing in a snowy area (Hokkaido, Japan). Each participant was asked to record their daily steps, as measured using a pedometer, in a diary for 10 months. Height, body weight, and PA were assessed using the short version of the International Physical Activity Questionnaire (IPAQ). Data were first collected in May 2008 (baseline), then October 2008 (2nd investigation), and in February 2009 (3rd investigation). Of the participants, 94 did all tests, 73 were the focus of the analyses, and 21 had no data or abnormal data. Participants were divided into two groups according to their records of daily step counts in the diaries during the snowy season between the second and third investigations. These groups were good record-keepers (GR *n*=29; they continued to record more than 3 days/week during the investigation period) and poor record-keepers (PR *n*=44; they did not continue to record to the end of the investigation period). Results from two-way repeated measures ANOVA (groups × investigation times) showed no significant interaction in body weight and physical activity parameters. These results suggest that self-monitoring of PA using a pedometer and a diary does not improve PA or reduce body weight during the snowy season. The reasons might be that participants in our study were healthy and active, and that we did not set a PA goal.

Key words : winter; snowy area; step counts; recording; middle-aged women

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1. Introduction

In Japan, the prevalence of obesity after middle-age decreases in men and increases in women (Ministry of Health, Labour and Welfare, Japan, 2009). Obesity, which is related to the decrease of physical activity (PA) (DiPietro, 1995), is known to increase the risk of cardiovascular disease (Lavie et al., 2009). Moreover, decreased PA might be a risk factor for cardiovascular disease such as myocardial infarction (Anand et al., 2008). The "Kenkou-nippon 21" recommendation for national health improvement in the 21st century for women is to walk 8300 steps per day (Ministry of Health, Labour and Welfare, Japan, 2000). However, the steps walked daily according to a final report were fewer for women than men (Ministry of Health, Labour and Welfare, Japan, 2011). These reports suggest the need to increase the level of PA, particularly in women.

Pedometers are easy to use, inexpensive, and less time-consuming than counseling based on conversation (Aittasalo et al., 2006). The use of such devices is well known to have a positive influence on PA (Bravata et al., 2007; Kang et al., 2009). Moreover, several studies have demonstrated the effectiveness of self-monitoring of PA maintenance or enhancement using a pedometer and step-recording diary (Aittasalo et al., 2006; Bravata et al., 2007; Clemes and Parker, 2009; Zoellner et al., 2009). Zoellner et al. (2009) attributed the effectiveness of pedometer and

diary use to increased motivation to maintain PA.

Although PA decreases in winter (Buchowski et al., 2009; Ma et al., 2006; Merchant et al., 2007; Plasqui & Westerterp, 2004; Shephard & Aoyagi, 2009; Togo et al., 2005; Tucker & Gilliland, 2007; Tudor-Locke et al., 2004; Yasunaga et al., 2008) no study has assessed differences of self-monitoring effects among seasons (Aittasalo et al., 2006; Bravata et al., 2007; Clemes and Parker, 2009; Zoellner et al., 2009). In snowy areas, icy roads make walking more difficult and might engender a loss of motivation to go outside (i.e. inactivity). Consequently, the possibility exists that environmental factors (low temperature, snowfall, etc.) reduce PA self-monitoring effectiveness. No study has examined the effect of PA self-monitoring on PA in snowy areas.

This study was undertaken to ascertain whether usage of a pedometer and a step-recording diary improves the PA of women living in snowy areas during the snowy season.

2. Methods

2.1. Environmental conditions in Ebetsu city in Hokkaido during winter

This investigation was conducted in Ebetsu city in Hokkaido (latitude 45º north and longitude 141º east). The average temperature in winter (December 2008–March 2009) was below 0 degrees. The total amount of snowfall was greater than 4 m (Table 1). Consequently, during the snowy season, snow and ice cover the ground.

2.2. Subjects

We specifically examined women who can walk without a stick or a wheelchair because disabilities of the legs influence PA. In all, 191 women aged 40–77 years participated in this study. They were members of the sports club affiliated with the Northern Region Lifelong Sports Research Center (SPOR), Hokusho University, and participated in several fitness classes, learning subjects such as yoga, aerobic dancing, and water exercises. The purposes, possible risks, issues related to safety, management of personal data, and merits of this study were explained. Informed consent was obtained from each participant. This study was approved by the ethical committee of the Northern Region Lifelong Sports Research Center at Hokusho University.

2.3. Procedure

The investigations were longitudinal: the first (baseline), second, and third were conducted respectively in May and October 2008, and in February of the following year. At the start of the baseline investigation, each participant received a pedometer (Omron HJ-005; Omron Healthcare Inc., Japan) and a step-recording diary. The diary had a calendar format, enabling each participant to record step counts every day. In this study, participants were not forced to wear a pedometer, set a goal, record step counts, increase PA, or keep records because it was important to observe the effects of self-monitoring on PA. In all, 191, 125 and 94 participants joined in the baseline, second, and third investigations, respectively. Their daily recorded steps during the intervention period were checked at the

Table 1. Month-averaged data for selected meteorological variables at Ebetsu city, Hokkaido

	2008									2009		
	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar
Mean ambient temperature (℃)	6.9	10.7	15.5	19.5	19.6	17.1	11.0	2.4	-1.2	-4.3	-4.3	-0.3
Maximum ambient temperature (℃)	13.3	16.2	21.1	23.9	24.4	23.1	16.4	7.3	2.3	-0.3	-0.7	3.7
Minimum ambient temperature (℃)	0.8	5.8	11.2	16.5	15.8	10.9	5.4	-2.5	-5.5	-9.7	-9.9	-5.0
Precipitation (mm)	7.0	63.0	41.0	85.5	90.5	38.0	83.5	54.5	80.0	51.0	57.5	41.0
Snow accumulation (cm)	-	-	-	-	-	-	-	23	130	156	134	48
Mean wind speed (m/s)	4.2	5.0	3.7	4.4	3.6	3.1	3.2	3.2	3.7	3.0	3.5	4.0
Duration of bright sunshine (h)	190.4	179.0	185.3	124.3	180.5	198.7	147.0	114.5	64.3	81.3	92.8	141.3

Note . Snowfall during April--October was not measured. The data above were quoted from Ebetsu city web site (http://www.city.ebetsu.hokkaido.jp) and Japan Meteorological Agency web site (http://www.data.jma.go.jp).

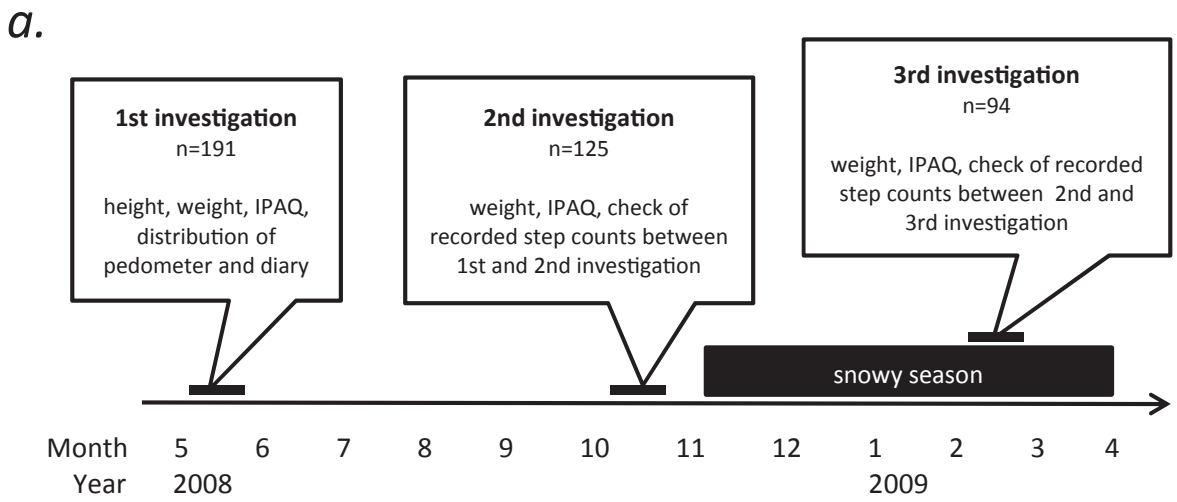

Fig 1. Procedures of investigation (a) and subject selection (b); IPAQ, International physicalactivity questionnaire.

times of the second and third investigations (Fig. 1a).

At that time, participants were not given feedback data or advised to increase PA. They were divided into two groups according to their records of daily step counts in the diaries between the second to the third investigations.

2.4. Measurements

Height was measured using a height stadiometer (Stadiometer; Yagami Inc., Japan) to the nearest 0.1 cm. The body weight was measured using a weight scale (Body fat analyzer; Tanita Corp., Japan) to the nearest 0.1 kg. During the measurements, participants wore T-shirts and long pants for all investigations.

PA was assessed using the International Physical Activity Questionnaire (IPAQ) short version (Craig et al., 2003; Murase et al., 2002). This questionnaire can assess vigorous, moderate and walking activity in terms of intensity (vigorous vs. moderate vs. slow), duration (min/day), and frequency (times/week). Metabolic equivalents (METs) at each activity level were 8 (vigorous activity), 4 (moderate activity), 5 (vigorous walking), 3.3 (moderate walking; breathing somewhat harder because of the speed), and 2.5 (slow walking; slow speed). Total activity was calculated by summing vigorous, moderate, and walking (moderate and slow) activity. PA was assessed as MET-minutes per week (Craig et al., 2003). We asked participants to answer the question about their PA during the prior 4 weeks. Additionally, the activities of fitness class in the SPOR were included in IPAQ.

2.5. Statistics

Data were presented as mean ± SD. Outlier analysis (Mahalanobis distance) was applied to IPAQ data to exclude abnormal data. After modifying the data, two-way repeated measures ANOVA (groups × investigation times) was used. If interaction was found, then a post hoc test (Tukey–Kramer HSD test) was applied to all combinations (2 groups × 3 investigation times; 6 pairs). If there were main effects, then one-way repeated measures ANOVA and a post hoc test were applied to each factor. Statistical significance was inferred for results of 5%. Statistical software was used (JMP 8.0; SAS Institute Inc., Cary, NC).

3. Results

Because 5 of 94 participants who had partly finished three investigations had no data in IPAQ, they were excluded. Results from the Mahalanobis distance among vigorous, moderate, walking, and total activity were assessed using IPAQ, 16 of 89 participants were selected as having abnormal data. They had more than 5000METs-min per week of vigorous activity. Finally, data of 73 participants were examined in analyses. Then participants were divided into two groups. The good record-keepers continued to record more than 3 days/week during the investigation period (GR). Poor record-keepers did not continue to record to the end of the investigation period (PR). No participant continued to record data for fewer than an average of 3 days / week during the investigation

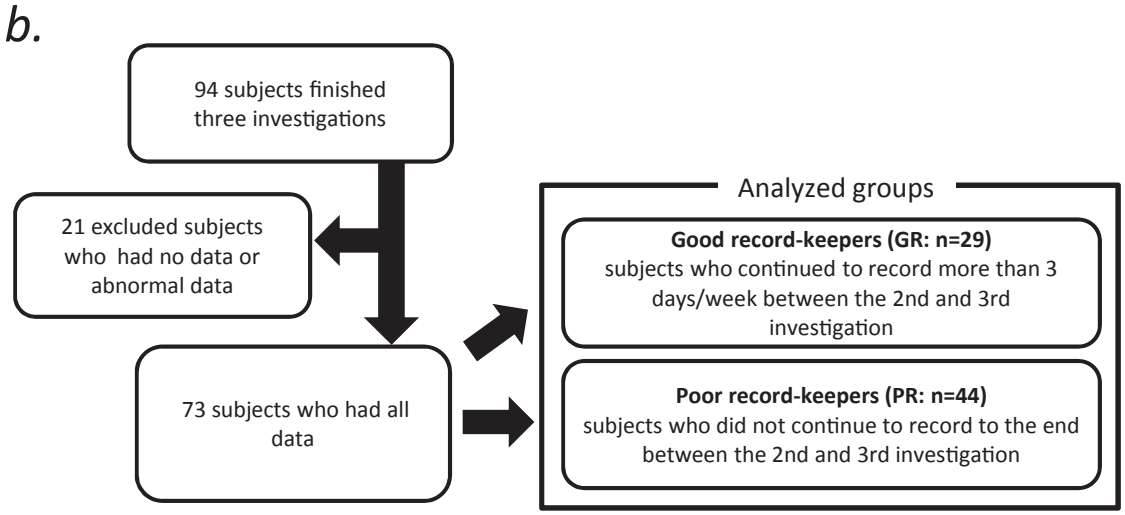

Fig 1. Procedures of investigation (a) and subject selection (b); IPAQ, International physicalactivity questionnaire.

Table 2. Physical characteristics of GR and PR at the first investigation

	N	Age (years)	Height (cm)	Body weight (kg)	BMI
GR	29	57.7±10.3	156.8±5.0	53.4±7.3	21.7±2.5
PR	44	56.9±9.2	155.3±4.9	53.8±6.3	22.3±2.5

Data are shown as mean±SD.

GR, good record-keeper; PR, poor record-keeper

period (Fig. 1b).

Average recording rates and daily step counts for GR were 90.3 ± 16.3% and 9858 ± 3643/day, respectively, from the baseline to the second investigation. They were 82.5 ± 21.6% and 8758 ± 4653/day from the second to third investigation. Table 2 shows the physical characteristics of GR and PR at the baseline. No significant differences were found in age, height, body weight and BMI between the GR and PR.

Results of the two-way repeated measures ANOVA for body weight and four physical activity parameters are presented in Figure 2. No significant interaction was found among any parameters. However, significant main effects were found for vigorous, moderate and total activity. Results from the post hoc test for three physical activity parameters reveal that the second investigation showed significantly higher value than the baseline or the third investigation.

4. Discussion

This study was conducted to investigate whether the PA of women residing in a snowy area was improved by pedometer and diary usage. Results from this longitudinal investigation over a period of 10 months showed that these tools did not improve PA in either the snowy or non-snowy season.

Previous studies (Aittasalo et al., 2006; Bravata et al., 2007; Clemes and Parker, 2009; Zoellner et al., 2009) revealed that pedometer and diary usage increased PA. However, our study showed no positive effect. We can give two reasons for this result. The first is that participants in our study were active and healthy. In a review that summarized the effect on PA of pedometer usage (Bravata et al., 2007), most participants were overweight or inactive or controlled serum lipid levels. Their average step counts were 7473 steps/day. Our study used IPAQ instead of a pedometer at the baseline. The PA, which was assessed by IPAQ at the baseline was close to the PA of the third investigation, the average step counts of GR at the third investigation were 8758 steps/day. Consequently, a pedometer and diary might not produce positive effects because our participants were more active than those in the earlier study (Bravata et al., 2007). In addition, 89% of our participants' BMI were of the normal range (18.50–24.99, WHO), 84% were normal

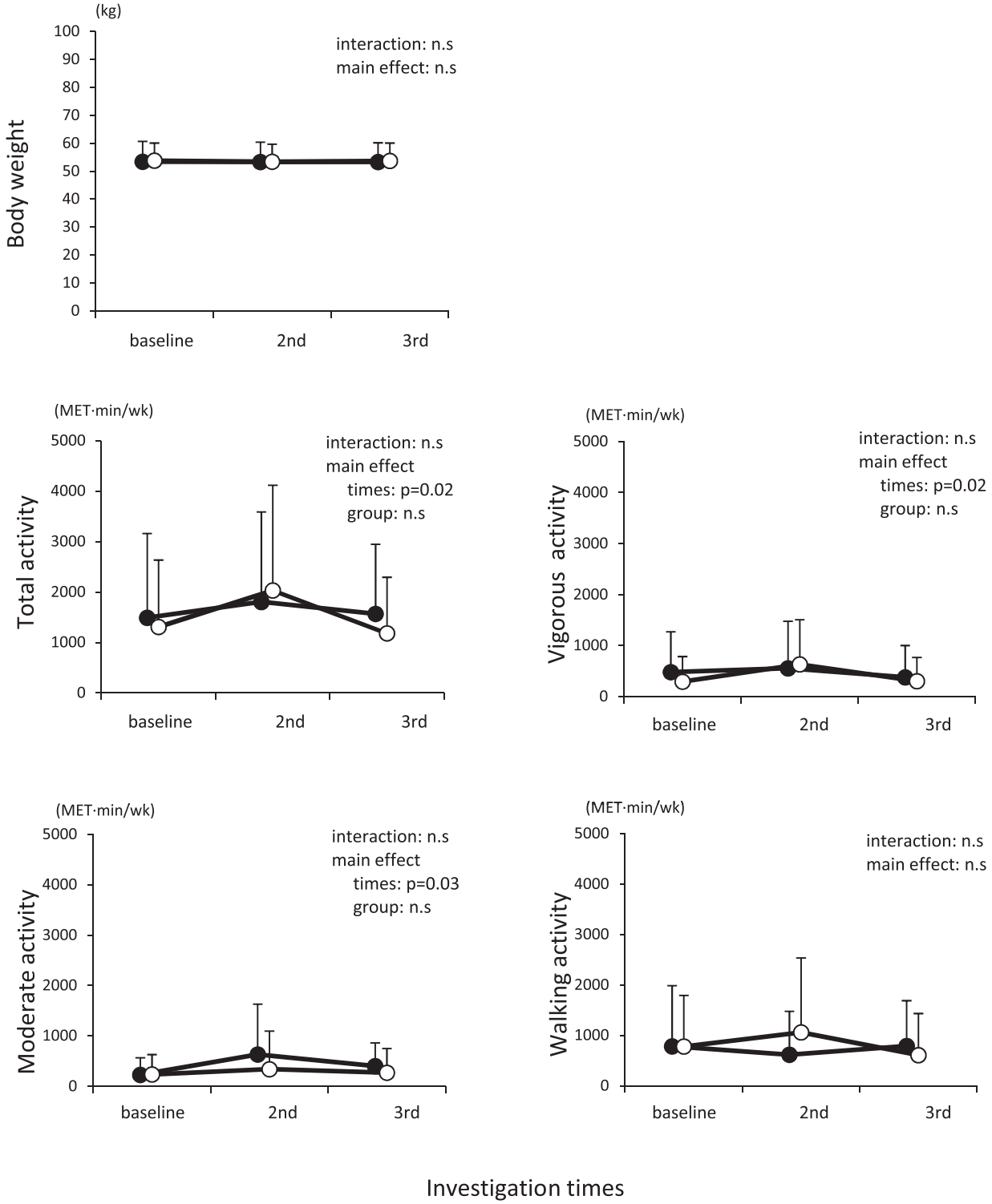

Figure 2. Change of body weight and physical activity. Black and white circles respectively show GR and PR. Values are mean and standard deviation. n.s: no significant

or prehypertension systolic blood pressure (<140 mmHg, Chobanian et al., 2003). They did not have vascular disease or type 2 diabetes. Because most participants were in a healthy condition, perhaps they felt no pressing need to increase their PA. A second reason is that we did not set a PA goal. Although the earlier study (Bravata et al., 2007) revealed a positive effect of setting a PA goal, we expected that participants would be able to maintain their PA to check their past step counts on the diary at least, especially in the snowy season. However, no significant difference was found between GR and PR: PA decreased significantly more in the snowy season compared to the

non-snowy season. Setting a goal is a motivational factor of PA (Bravata et al., 2007). The results of our study might underscore the importance of setting a PA goal.

Body weight remained almost unchanged, decreasing 0.3 kg on average in the GR and 0.3 kg in the PR from the baseline to the second investigation and increasing on average 0.2 kg in the GR and 0.4 kg in the PR from the second to third investigation. Lower temperatures and bad weather such as snow fall and cold winds in winter reportedly engender inactivity (Buchowski et al., 2009; Ma et al., 2006; Merchant et al., 2006; Plasqui & Westerterp, 2004; Shephard & Aoyagi, 2009; Togo et al., 2005; Tucker & Gilliland, 2007; Tudor-Locked et al., 2004; Yasunaga et al., 2008). Moreover, daily caloric intake was reported as higher during autumn–winter than during winter–summer. However, the annual body weight change was small (about 0.5 kg) (Ma et al., 2006). In the present study, although PA was higher in the GR than the PR in the snowy season, a significant between-group difference in energy expenditure does not necessarily engender a significant between-group difference in body weight loss. That point was also demonstrated in a previous study (Ma et al., 2006).

This study has several limitations. First, PA was assessed using IPAQ rather than commercially available pedometers. However, the main purpose of the present study was to investigate the effects of self-monitoring on PA. Because less than two months of data were available for the PR, it was impossible to evaluate the PA of the PR using pedometer data. Second, we did not set a control group. Therefore, this method might be unable to clarify the effectiveness of using a pedometer and diary. Third, the drop-out rate was 51% over the 10-month period of this study. Although the reason remains unclear, a possible explanation is that we did not force the participants to join actively in the three investigations. These investigations were conducted before or after each fitness class. Consequently, participants had to visit the research center earlier or stay later for measurements. This inconvenience might engender reduced motivation and a high drop-out rate. Nevertheless, previous interventional studies (Fitzsimons et al., 2012; Sugiura et al., 2002) also reported high drop-out rates (39–42%) as found in results of our study. It is likely that the high drop-out rate of our study is not unusual.

5. Conclusions

We investigated whether the use of a pedometer and step-recording diary improves the PA of women living in snowy areas during the snowy season. However, results showed no effectiveness of these tools. The reasons might be that participants in our study were healthy and active, and that we did not set a PA goal.

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