

# A pedometer-based physical activity intervention for patients entering a maintenance cardiac rehabilitation program: a pilot study

Leonard A. Kaminsky<sup>1</sup>, Jason Jones<sup>1</sup>, Katrina Riggan<sup>2</sup>, Scott J. Strath<sup>3</sup>

<sup>1</sup>Human Performance Laboratory, Ball State University, Muncie, IN, USA; <sup>2</sup>Cardiopulmonary Rehabilitation Program, IU Health Ball Memorial Hospital, Muncie, IN, USA; <sup>3</sup>Physical Activity and Health Research Lab, University of Wisconsin-Milwaukee, Milwaukee, WI, USA

*Corresponding to:* Leonard A. Kaminsky, PhD. Clinical Exercise Physiology Program, Human Performance Laboratory, Muncie, IN 47306, USA. Email: kaminskyla@bsu.edu.

**Purpose:** To compare the effects of an individualized pedometer-driven physical activity (PA) intervention with the usual time-based PA recommendations given to patients entering a maintenance cardiac rehabilitation (CR) program.

**Methods:** A total of 18 subjects entering a maintenance CR program were recruited and completed the study. Subjects were randomized into pedometer feedback [PF: n=10 (2 women), 53.3±8.1 yrs] and usual care [UC: n=8 (2 women), 59.4±9.9 yrs] groups. New Lifestyles NL-1000 pedometers were used to monitor ambulatory PA. Subjects in both groups participated in the same maintenance CR program for a total of 8 weeks and all were encouraged to obtain a minimum of 30-40 min/d of moderate-vigorous-intensity physical activity (MVPA), on days they did not attend CR. Subjects in the PF group were given individualized daily stepcount goals (increase 10% of baseline steps/d each week) for weeks 2-8. Ambulatory PA was measured with pedometers, recording both total number of steps/d and min/d of MVPA. Measures were obtained during the first week of the maintenance CR program and during the 8th week. Data were also compared between days subjects attended and on days they did not attend.

**Results:** By the 8th week of CR, PF subjects increased daily stepcounts by 42% (2,297±1,606 steps/d, P=0.001), with a 36% increase on CR days (2,654±2,089 steps/d, P=0.003) and a 45% increase on days they did not attend CR (1,872±2,026 steps/d, P=0.017). There were no changes observed in the UC group.

**Conclusions:** Providing pedometers with individualized stepcount goals to patients entering a CR program was superior to the usual time-based PA recommendations for increasing PA.

**Key Words:** Cardiac rehabilitation; pedometer; physical activity



Submitted Feb 22, 2013. Accepted for publication Mar 19, 2013.

doi: 10.3978/j.issn.2223-3652.2013.03.03

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## Introduction

The health benefits of regular moderate-vigorous-intensity physical activity (MVPA) are substantial and well accepted as a means to prevent chronic disease development (1,2). It is also well known that exercise-based cardiac rehabilitation (CR) programs play an important role in secondary prevention (3,4). Consensus statements recommend 30-60 min/d of moderate-intensity physical activity (PA)

on 7 days/week (minimum or 5 days/week) for secondary prevention in patients with established coronary disease (5). Despite the many benefits of increased daily PA for cardiac patients, it has been reported that only 40% of patients attending maintenance CR obtain recommended levels of PA (6). Recent studies of patients attending CR programs showed that although patients achieve recommended amounts of PA on days attending CR, they do not reach

recommended PA levels on days they do not participate in CR programs (7-9).

A meta-analysis examining pedometer interventions provides clear evidence that pedometer-driven PA interventions effectively increase daily PA in previously sedentary or irregularly active populations (10). Pedometer-driven PA interventions have been shown to be superior to time-based PA recommendations in improving PA levels in previously inactive women (11). However, time-based recommendations (i.e. 30-60 min/d MVPA) are commonly provided to patients that participate in CR programs to encourage activity on days they do not attend CR. Recently, evidence has shown the potential for utilizing pedometers to help cardiac patients increase their daily PA levels. Ayabe *et al.* (12) found patients who had attended a maintenance CR program for >6 months could increase PA through the use of self monitoring with a pedometer over a 3-week time period. Similarly, Butler *et al.* (13) found cardiac patients obtained greater increases in PA after completion of a CR program through the use of pedometer feedback over a 6-week time period in conjunction with goal-setting and telephone follow-up. Presently, it is not known if using pedometers would increase PA levels of patients when first joining a CR program and if a pedometer approach would be superior to the typical time-based recommendations. Thus, the purpose of this pilot study was to determine if daily PA levels of patients during the first 8-weeks of a maintenance CR program would differ between those receiving individualized pedometer-feedback (PF) *vs.* a usual care (UC) approach of obtaining time-based PA recommendations, particularly on days they do not participate in CR. It was hypothesized that PF would result in greater amounts of daily PA (steps/day and MVPA minutes/day) on both days they participated and did not participate in CR, than the UC approach.

## Methods

### Subjects

Subjects were recruited upon referral to the maintenance CR program. Eligibility and study inclusion criteria were inactive men and women joining the maintenance CR program with a primary diagnosis of either myocardial infarction, coronary artery bypass graft surgery, percutaneous coronary intervention, heart valve repair/replacement, stable angina, or heart transplant. Inactivity status was determined at the baseline assessment and defined as  $\leq 7,500$  steps/d, based on previous findings showing those classified as sedentary

Variable	PF (n=10)	UC (n=8)
MI	4	2
CABG	2	2
PCI	3	1
Transplant	--	1
AVR	1	--
MVR	--	1
Stable Angina	--	1

PF, pedometer feedback; UC, usual care; AVR, aortic valve replacement; CABG, coronary artery bypass graft; MI, myocardial infarction; MVR, mitral valve replacement PCI, percutaneous coronary intervention

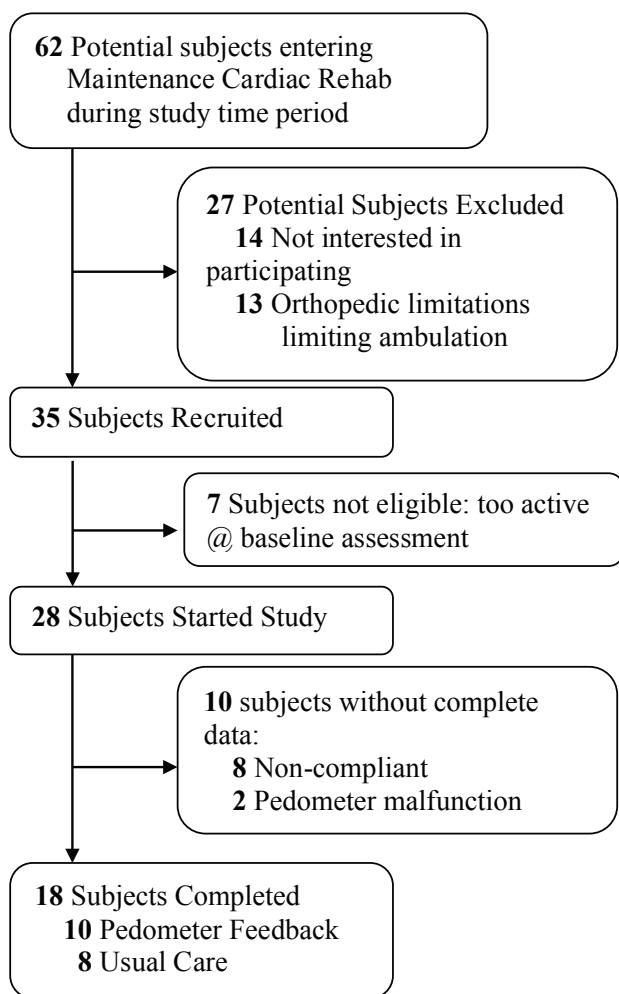
or low active were more responsive to increasing their PA compared to regularly active subjects (14). Exclusion criteria included a diagnosis of heart failure or other comorbidity with physician order to limit activity to below moderate-intensity, or inability to self-ambulate without assistive devices. All subjects signed an informed consent document previously approved by the Institutional Review Boards from Ball State University and Ball Memorial Hospital prior to participation. *Figure 1* illustrates study recruitment and completion. A total of 18 subjects [PF n=10 (2 women), 53.3±8.1 yrs, 31.5±6.9 kg/m<sup>2</sup>; UC n=8 (2 women), 59.4±9.9 yrs, 32.4±6.2 kg/m<sup>2</sup>], participated in the study. Cardiac diagnoses for the subjects are provided in *Table 1*. There were no significant differences between groups at baseline for age (P=0.241) or body mass index (P=0.987).

### Study design

Subjects meeting inclusion criteria were alternately, in order of enrollment, assigned to either PF or UC. Subjects were stratified by gender by placing every other male and female in the PF group in an attempt to maintain equal gender distribution in both groups. The duration of the study was 8 weeks with the first week used to establish the baseline PA, and the following 7 weeks as the intervention period.

### Physical activity assessment

PA was assessed with NL-1000 pedometers (New-Lifestyles, Inc. Lee's Summit, MO) which utilize a piezoelectric accelerometer strain gauge to measure stepcounts and compute MVPA time. The standard NL-1000 intensity



**Figure 1** Subject recruitment and completion. Too Active >7,500/day at baseline. Non-compliant – attended CR <2 days/week

threshold of  $\geq 4$  for MVPA was utilized. Validity of stepcounts obtained by NL-series pedometers has been demonstrated with middle aged and older populations (15,16). To establish baseline PA levels, all subjects were instructed to wear a pedometer at the waist on either a belt or elastic band for 7-consecutive days, during all waking hours. Prior to pedometer use, all subjects completed a 20-step test to confirm pedometer placement at the waist location provided accuracy within  $\pm 2$  of actual steps. Subjects in the PF group wore the pedometer daily for the entire study period, whereas the UC group only wore the pedometer during initial assessment week and during week 8. With each week of pedometer use, subjects completed a PA log form to report pedometer wear-time on a given day.

All subjects were encouraged to use ambulatory activities

as the primary mode of PA during CR, however 7 subjects (PF, 4; UC, 3) used a recumbent stepper as a complementary mode. The steps accumulated on the stepper were added to the daily pedometer stepcount totals.

### *Physical activity intervention*

All subjects, regardless of group, were given the same recommendation to obtain a minimum of 30-40 min/d MVPA, on days they did not attend CR. The CR program uses 30-40 minutes for all patients when first starting the program. Following baseline assessment, PF subjects received individualized daily stepcount goals to increase by 10% of baseline steps/d for weeks 2-8. For example, a PF subject with 4,000 steps/d at baseline had a weekly increment of 400 steps/d (e.g., weekly stepcount goals of 4,400, 4,800, 5,200, 5,600, 6,000, 6,400, and 6,800 steps/d for weeks 2-8). Daily stepcount goals ranged from 4,227-7,302 steps/d at week 2 to 6,533-11,286 steps/d at week 8, which reflects that on average subjects obtained their step goal on 5 of 7 weeks. To encourage compliance with the daily stepcount goals, PF subjects were instructed to obtain pedometer feedback by recording stepcounts at lunch, dinner, and bedtime. If stepcount goals were not achieved by dinnertime, subjects were encouraged to walk to achieve daily goals.

### *Statistical analysis*

Quality control criteria for pedometer data to be included for analysis were: worn  $\geq 4$  d/week (including 1 weekend day),  $\geq 8$  hrs/d,  $\geq 1,500$  steps/d, and attended CR  $\geq 2$  d/week. Data analyses were performed using SPSS 19.0 for Windows (SPSS Inc., Chicago, IL). A 3-way analysis of variance (ANOVA) was performed with one between factor (group: PF *vs.* UC) and two within factors (time: baseline *vs.* 8 weeks and CR attendance: CR *vs.* NCR), along with a Shapiro-Wilk test of normality. Tests for normality were met for all distributions with the exception of MVPA for the UC group, which showed positive skew. Thus the 25<sup>th</sup>, 50<sup>th</sup>, and 75<sup>th</sup> percentile data were also reported. Significance was set at  $P < 0.05$  for all analyses.

### **Results**

During the 8-week study period, subjects attended CR  $\approx 3.3$  d/week (PF,  $3.0 \pm 0.7$  sessions/week ; UC,  $2.7 \pm 0.8$  sessions/week,  $P = 0.514$ ). The 3-way interaction between

**Table 2** Difference in physical activity measures at baseline and following 8 weeks of CR in both the PF and UC groups. (mean  $\pm$  SD and 25<sup>th</sup>, 50<sup>th</sup>, 75<sup>th</sup> percentile)

	PF		UC	
	Baseline	Week 8	Baseline	Week 8
All days (steps/d)	5,742 $\pm$ 959	8,005 $\pm$ 1,874*	5,446 $\pm$ 959	5,906 $\pm$ 1,877
CR-day (steps/d) <sup>‡</sup>	7,355 $\pm$ 1495	10,009 $\pm$ 2,147	6,748 $\pm$ 1,399	6,969 $\pm$ 1,849
25/50/75% ile	5,879/7,650/8,526	8,198/9,627/12,261	5,534/6,536/8,075	5,858/7,341/8,458
NCR-day (steps/d)	4,129 $\pm$ 1,278	6,001 $\pm$ 2,152	4,143 $\pm$ 1,354	4,844 $\pm$ 2,075
25/50/75% ile	3,331/3,967/4,806	4,375/6,004/8,428	2,932/3,993/5,152	3,198/4,679/5,710
All days (MVPA min/d)	10.2 $\pm$ 8.0	17.7 $\pm$ 10.5*	8.5 $\pm$ 8.0	7.7 $\pm$ 10.5
CR-Day (MVPA min/d) <sup>‡</sup>	15.3 $\pm$ 14.1	25.1 $\pm$ 20.5	10.4 $\pm$ 11.5	11.4 $\pm$ 11.1
25/50/75% ile	2.6/12.0/27.9	7.5/19.8/46.3	4.0/5.1/20.9	2.7/6.6/21.9
NCR-day (MVPA min/d)	5.2 $\pm$ 5.2	10.4 $\pm$ 9.4	6.7 $\pm$ 7.1	4.0 $\pm$ 3.4
25/50/75% ile	1.0/4.6/6.7	2.6/8.8/17.7	2.8/3.6/10.0	2.3/2.8/4.2

PF, pedometer feedback; UC, usual care; PA, physical activity; CR, cardiac rehab; MVPA, moderate-vigorous intensity physical activity; NCR, non-cardiac rehab. \*Significantly different from baseline ( $P < 0.05$ ). <sup>‡</sup>Significant main effect difference between CR and NCR days ( $P < 0.001$ )

group-time-CR attendance for steps/day approached significance,  $P = 0.060$ , however was not significant for MVPA min/d (Table 2). There was a significant interaction between group and time for both steps/d and MVPA min/d,  $P < 0.04$  and  $P < 0.01$ . PF subjects significantly increased from baseline to 8-weeks by 2,263 steps/d (39%) and 7.5 MVPA min/d (73%). There was no difference from baseline to 8-weeks for the UC group. There was a significant main effect for CR attendance in steps/d (CR: 7,770 $\pm$ 1,432 vs. NCR: 4,779 $\pm$ 1,371 steps/d,  $P < 0.001$ ).

## Discussion

This is the first study to employ an individualized pedometer-driven PA intervention with patients beginning a maintenance CR program. The main study findings reveal that subjects in the PF group increased daily stepcounts by 42% (2,297 $\pm$ 1,606 steps/d,  $P = 0.001$ ) from the first to the 8<sup>th</sup> week of CR, while no significant changes were found for UC subjects during the intervention period. Our results are similar to those from Hultquist *et al.* (11) who studied the efficacy of a 10,000 steps/d recommendation compared to 30 min/d MVPA in sedentary middle-aged women. At the end of the 4-week intervention, subjects in their pedometer group were accumulating significantly greater stepcounts than the time-based group (10,159 $\pm$ 292 vs. 8,270 $\pm$ 354 steps/d,  $P < 0.005$ ). Thus, providing PA monitors with individualized

stepcount goals to cardiac patients entering a CR program or other inactive populations results in greater increases in daily PA levels compared to only providing individuals a time-based PA recommendation.

All patients starting maintenance CR are prescribed 30-50 min/d of exercise during CR sessions, which can be observed by the ~3,000 steps/d difference between CR and NCR days at baseline in both groups. In addition to increases in overall daily stepcounts, the PF group in the present study significantly increased daily stepcounts during CR days over the course of the intervention by 36% (2,654 $\pm$ 2,089 steps/d,  $P = 0.003$ ) and NCR days by 45% (1,872 $\pm$ 2,026 steps/d,  $P = 0.017$ ). There were no significant changes in stepcounts for the UC group on CR days. This suggests the progressively increasing stepcount goal (adding 10% of baseline each week) encouraged the PF group to increase their PA more even more than they achieved during CR on days they attended CR.

Previous reports have showed that patients participating in a CR program accumulate significantly greater stepcounts on days patients attend CR compared to NCR days (7-9). Consistent with these reports, subjects in the present study were observed to have accumulated greater stepcounts on CR compared to NCR days. The 3-way interaction between group-time-CR attendance for steps/day was not significant,  $P = 0.060$  which suggests no advantage for the PF group on NCR days. However, it is worth noting that

the PF group had a 45% increase in steps/d on NCR days by week 8 compared to an increase of only 17% in steps/d for the UC group. It is noteworthy to recognize that the PF subjects averaged only  $10.4 \pm 9.4$  min of MVPA by week 8 on NCR days, which is far short of the minimal goal of 30 min/d of MVPA. Thus, while using pedometers with goals appear efficacious in increasing both steps/d and time spent in MVPA, it is clear that greater efforts are necessary to further increase PA levels of cardiac patients, especially on days they do not attend CR programs. Although the subjects in the PF group increased the time spent in MVPA, the  $17.7 \pm 10.5$  min/d at 8 weeks was still far short of the 30 min/d goal. Future efforts should explore if self-monitoring with pedometers for longer than 8 weeks would be successful in patients reaching  $\geq 30$  min/d of MVPA. It would also be of interest to explore if providing additional feedback, as shown to be effective as part of a telephone counseling session (17), would improve success in reach daily PA goals. One approach worth investigating would be for CR staff to take on an enhanced role by with recording pedometer data and providing feedback, similar to what they do for assessments such as resting blood pressure.

Ayabe *et al.* (12) conducted the only other known pedometer intervention study in a maintenance CR program, by examining the effects using goals of either  $\geq 10,000$  steps/d or  $\geq 30$  min/d of MVPA. Both groups used pedometers to provide feedback and were instructed to accumulate either the targeted amount of steps or time of MVPA, and to monitor and record either the stepcounts or time. Both groups had significant increases in daily stepcounts throughout the 3-week intervention period, (step goal:  $11,517 \pm 3,383$  to  $12,809 \pm 2,479$ ,  $P=0.04$ ; time goal:  $10,810 \pm 3,211$  to  $13,355 \pm 3,498$ ,  $P=0.004$ ), however only the group monitoring the time spent in MVPA increased daily time spent in MVPA ( $36 \pm 11$  to  $52 \pm 15$  min/d,  $P=0.008$ ). Thus, it appears that using low-cost PA monitors, with capabilities to provide feedback to individuals, can be important tools to help cardiac patients increase their PA levels. Whereas, the Ayabe *et al.* (12) study cohort showed this in CR patients who already had an established maintenance CR program (attended maintenance CR  $\geq 6$  months and were obtaining  $\geq 10,000$  steps/d), the present study demonstrated the usefulness of PA monitoring feedback for helping patients beginning a maintenance CR program to increase their PA levels.

Results from the present study provide further support that short-term pedometer interventions can increase daily PA among overweight and older adults (15,18,19)

and in those with clinical diagnoses (coronary artery disease, osteoarthritis, diabetes, and etc.) (16,20-22). The research design employed in the current study is similar to that of Croteau *et al.* (23), who provided subjects with individualized stepcount goals ranging from 5-10% above baseline values during an 8-week study. Subjects in that study averaging  $\leq 8,000$  steps/d at baseline were instructed to increase stepcounts each week by 10%, those averaging 8,000-10,000 steps/d were instructed to increase stepcounts each week by 5%, and those subjects averaging  $\geq 10,000$  steps/d were instructed to maintain current PA habits (19). Croteau *et al.* (23) reported that subjects instructed to increase daily stepcounts each week by 10% demonstrated the greatest increase in daily stepcounts 39.9% ( $2,272 \pm 1,473$  steps/d) while subjects in the group instructed to increase daily stepcounts each week by 5% increased daily stepcounts by 24.9% ( $2,532 \pm 1,780$  steps/d). Croteau *et al.*'s findings, combined with the present study's results, suggest that increasing daily stepcount goals by 10%/week is an effective approach for increasing PA levels with individuals who are insufficiently active. Further research is warranted to assess if gender, clinical diagnoses (i.e. myocardial infarction, transplant, heart failure, and etc.) or other characteristics may influence this response. Although PA levels of subjects in the present study were increased more in the group using pedometers for feedback, it is important to recognize these patients were still not accumulating PA amounts suggested in national recommendations. Thus, for secondary prevention of coronary disease, it is important for healthcare professionals to recommend cardiac patients accumulate 30-60 minutes of MVPA daily and they should encourage patients to use pedometers.

### Study limitations

While the present study provides evidence that a short-term pedometer-intervention may increase daily PA, the following limitations are noted. The PA intervention used in this study was relatively short (8 weeks). Although significant increases in PA levels were observed in the PF group, these patients were still not reaching PA goals on NCR days. The usefulness of pedometers can also be questioned since 27 of the patients eligible for the study either couldn't use (orthopedic issues limiting ambulation) or were not interested in participation. The lack of interest could have been due, in part, to the daily requirement to wear a pedometer on their waistband. Additionally, of the 28 subjects eligible for study inclusion, 8 were not compliant

with the protocol. Other known limitations associated with pedometers are that they do not measure non-ambulatory forms of PA and only models with an accelerometer mechanism can access time spent in MVPA. Finally, this pilot study had a relatively small sample suggesting the interpretation of the results warrant appropriate caution. Future studies with larger sample sizes, in multiple CR programs, and for longer time periods are needed.

## Conclusions

Data from the present study provides further support of the benefits of pedometer use as a tool to help people increase their PA levels, including patients beginning a maintenance CR program. Pedometer-interventions can generally be administered with limited staff involvement and at little cost. CR programs should consider providing pedometers, with individualized stepcount goals, to patients entering a CR program to help them increase PA and ultimately meet recommendations for secondary prevention.

## Acknowledgements

Thank you to the cardiopulmonary rehabilitation team at IU Health - Ball Memorial Hospital and research staff at Ball State University's Human Performance Laboratory for their assistance in subject recruitment and data collection.

*Disclosure:* The authors declare no conflict of interest.

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**Cite this article as:** Kaminsky LA, Jones J, Riggin K, Strath SJ. A pedometer-based physical activity intervention for patients entering a maintenance cardiac rehabilitation program: a pilot study. *Cardiovasc Diagn Ther* 2013;3(2):73-79. doi: 10.3978/j.issn.2223-3652.2013.03.03