Brief Report

Correlates of objectively measured physical activity in cardiac patients

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Abstract: Cardiac patients would benefit from increasing their physical activity (PA) levels. Understanding of factors that influence cardiac patients' PA participation would benefit the development of effective interventions. Therefore, the purpose of this study was to determine correlates of objectively-measured PA in cardiac patients. Participants were 65 cardiac patients (74% male, 95% white), age 58.6±10.6 years. The amount of time spent in PA was measured by ActiGraph GT3X accelerometers for 7 days prior to joining cardiac rehabilitation programs (CRP). A total of 25 potential determinants of PA across multiple domains (demographic, clinical, psychosocial, and behavioral) were measured via self-reported questionnaire and clinical examinations. Backward elimination model selection procedures were performed to examine associations of potential determinants with total PA (min/day) and moderate-to-vigorous PA (MVPA) (min/day). Patients spent 153.8±62.8 and 8.4±8.1 min/day in total PA and MVPA, respectively. Across four domains, ten and five potential correlates were found to be significant in univariate analyses for MVPA and total PA, respectively. In the final model, functional capacity, PA readiness, and participation in regular exercise were positively associated with MVPA (R^2 =26.6%). Functional capacity and PA readiness were also positively associated with total PA (R^2 =15.9%). Future initiatives to increase PA levels in cardiac patients could be improved by considering patients' functional capacity, PA readiness, and exercise history in designing interventions.

Keywords: Cardiac rehabilitation; coronary heart disease (CHD); correlates; physical activity (PA)

Submitted Sep 10, 2014. Accepted for publication Oct 15, 2014.
doi: 10.3978/j.issn.2223-3652.2014.10.06
View this article at: http://dx.doi.org/10.3978/j.issn.2223-3652.2014.10.06

Introduction

Worldwide, coronary heart disease (CHD) is the leading cause of death, accounting for over 13% of all death in middle-to-high-income countries, and its prevalence continues to increase (1). There are currently over 26 million non-institutionalized cardiac patients in the U.S., and survival of those patients need to be improved via cost-effective interventions (2), such as cardiac rehabilitation programs (CRP). CRP centered on regular exercise programming has been shown to be effective in improving cardiovascular health in cardiac patients (3,4). However, despite the well-known benefits of regular physical activity (PA) on long-term health (5-7), many cardiac patients remain insufficiently active (8), particularly when they do not participate in CRP (9,10). Hence, it is important to understand factors related to being physically active in order to develop effective interventions to elicit regular PA.

Extensive research has revealed demographic, psychosocial, behavioral, and environmental factors were to be associated with participation in regular PA in healthy, non-diseased populations (11). However, few studies

have examined correlates of PA in cardiac patients, and fewer studies have used objective measures of PA (i.e., accelerometer) in cardiac patients. The purpose of this study was therefore to determine correlates of objectively-measured PA in cardiac patients.

Methods

Participants and settings

Sixty-five (74% male, 95% white, age 58.6±10.6 years) post phase II cardiac patients who were clinically stable and eligible, but not enrolled in maintenance CRP took part in this study. Written informed consent was completed by all patients, and this study was approved by the Institutional Review Boards at Ball State University and Indiana University Health-Ball Memorial Hospital. Patients with any conditions (e.g., heart failure, COPD, orthopedic limitation) that limit habitual PA were excluded from participation. Patient's participation in PA (min/day) was measured by ActiGraph GT3X accelerometers for 7 consecutive days in order to achieve sufficient reliability (12). The accelerometers were initialized to collect activity counts in 60-second intervals). The amount of time spent in total PA (light-to-vigorous PA) and moderate-to-vigorous PA (MVPA) was assessed using previously validated accelerometer cut points in adults (total PA ≥100, MVPA ≥1,952 counts/min (13,14). All potential correlates were measured via self-reported questionnaire or clinical examinations. Each participant completed a questionnaire on health-related psychosocial and behavioral factors, and underwent a thorough clinical examination that included anthropometry measurement, dual-energy X-ray absorptiometry (DXA) scan, functional capacity test (6-minute walk test), blood pressure measurement, and fasting blood chemistry analyses. A total of 25 potential correlates of PA were measured across four domains: (I) socio-demographic; (II) clinical; (III) psychosocial; and (IV) behavioral. The names and definitions of 25 potential correlates are presented in *Table 1*.

Statistical analyses

Pearson correlation coefficients between all potential correlates and PA were estimated, and then only correlates with P values of <15 were selected for the final model building process. Backward elimination model selection procedures were performed to examine associations of potential determinants with total PA and MVPA using SAS (Version 9.3, NC, USA). Statistical significance was set at α =05.

Results

Descriptive statistics of potential correlates and participants' clinical characteristics including PA levels are presented in *Table 1*. On average, cardiac patients spent 8.4±8.1 and 153.8±62.8 min/day in MVPA and total PA, respectively. The univariate analyses showed that ten and five factors across four domains were significantly correlated with MVPA and total PA, respectively (*Table 2*). In the final model (*Table 3*), functional capacity, PA readiness, and exercise history were directly associated with MVPA (adjusted R^2 =27%). Functional capacity and PA readiness were also directly associated with total PA in the final model (adjusted R^2 =16%).

Discussion

To the best of our knowledge, this was the first study including objective measures of PA and factors across multiple domains to determine correlates of PA in cardiac patients. A key finding of this study was that three factors across clinical (functional capacity), psychosocial (PA readiness), and behavioral domains (exercise history for MVPA only) were identified as positive correlates of cardiac patients' participation in PA. We also found that most (98%) of cardiac patients in this study were insufficiently active (MVPA <150 min/week). As the cardiac rehabilitation is a multicomponent intervention, these findings are particularly important to clinicians and researchers because they suggest that PA inventions for cardiac patients or CRP should be developed with consideration of factors across multiple.

In a recent review, past participation in exercise was one of the most consistent correlates of PA in cardiac patients (15). In the current study we observed a direct association between exercise history and patients' current levels of MVPA. Although past behavior is not modifiable, this finding provides an important consideration for future interventions, that previously inactive cardiac patients are in a great need of PA interventions. In addition, we found that functional capacity was a consistent positive correlate for both MVPA and total PA. Recent studies also showed that functional capacity was directly associated with PA in cardiac patients (15,16), implying that interventions to promote PA should include components specifically aiming to increase functional capacity in this patient population.

Table 1 Potential correlates, physical activity levels, and clinical characteristics of cardiac patients

Variable names	Definition	Range or categories	Mean (SD) or %
Physical activity			
MVPA	Moderate-to-vigorous PA	0-35 min/day	8.4 (8.1)
Total PA	Light-to-vigorous PA	55-341 min/day	153.8 (62.8)
Wear time	Accelerometer wear time	10.9-17.4 h/day	14.1 (1.5)
Demographic			
Age	Current age (years)	33.0-82.0 years	58.6 (10.6)
Sex	Gender	Male, female	74% (male)
Race	Race/ethnicity	African American, white, other	95% (white)
Living situation	Living alone or with others	Alone, with family or others	83% (with family)
Family income	Annual family income	[1-5]: [1:≤$20,000, 5:≥$80,000]	75% (≥$40,000)
Occupation	Employment status	Yes, No	46% (yes)
Clinical			
BMI	Body Mass Index	21.4-45.5 kg/m^2	32.5 (10.2)
Fat mass	Total body fat mass (DXA)	15.8-65.3 kg	35.1 (11.8)
WC	Waist circumference	72-136 cm	105.2 (13.9)
HTN	High blood pressure (systolic or diastolic)	Yes, no	66% (yes)
Dyslipidemia	High blood cholesterol (total or LDL)	Yes, no	49% (yes)
Diabetes	High blood glucose (≥126 mg/dL)	Yes, no	25% (yes)
Lung disease	Lung of respiratory disease	Yes, no	11% (yes)
Arthritis	Rheumatism or arthritis	Yes, no	58% (yes)
BMD	Bone mineral density (DXA)	0.98-1.56 g/m^2	1.26 (0.13)
Functional capacity	6-minute walking test (distance walked)	972-2,106 feet	1,651.8 (231.5)
Menopause	Years for menopause (female only)	9-55 years	14.8 (13.7)
Age hospitalized	Age when hospitalized for most recent coronary event	33-80 years	57.2 (10.9)
Psychosocial			
PA readiness	PA stage of change	[1-5]: [1:precontemplation, 5:maintenance]	3.2 (1.1)
Self-efficacy	Self-efficacy in regular PA	0-25 patients	15.5 (4.0)
Social support (family)	Social support for PA by family	0-65 patients	35.3 (11.8)
Social support (friends)	Social support for PA by friends	0-65 patients	26.9 (8.1)
Behavioral			
Smoking history	Current smoker	Yes, no	18% (yes)
Exercise history	Participation in regular exercise program	Yes, no	51% (yes)
Pet ownership	Current pet ownership	Yes, no	71% (yes)

MVPA, moderate-to-vigorous PA; PA, physical activity; DXA, dual-energy X-ray absorptiometry; WC, waist circumference; HTN, hypertension; BMD, bone mineral density.

PA readiness, also known as Stages of Change, was positively associated with both MVPA and total PA. In the context of PA, Stages of Change postulates that individuals progress through different stages of readiness as they change levels of PA (17). Evidence showed that PA readiness was positively associated with PA participation in cardiac patients (18,19). Consequently, these findings suggest that assessing and incorporating PA readiness is beneficial to

Table 2 Univariate analysis between potential correlates and physical activity in cardiac patients

Determinants	Physical activity (min/day)	
	MVPA	Total PA
Demographic		
Age	–0.13	–0.09
Sex	–0.19*	–0.06
Race	–0.01	0.07
Living situation	0.20*	0.17
Family income	0.12	–0.18
Occupation	0.28**	0.23**
Clinical		
BMI	–0.23**	–0.18
Fat mass	–0.14	–0.14
WC	–0.19	–0.13
HTN	–0.08	–0.12
Dyslipidemia	–0.09	–0.08
Diabetes	–0.15	–0.02
Lung disease	–0.10	–0.04
Arthritis	–0.15	0.12
BMD	–0.19	0.02
Functional capacity	0.40**	0.29**
Age hospitalized	–0.22*	–0.22*
Psychosocial		
PA readiness (stage of change)	0.33**	0.36**
Self-efficacy	0.30**	0.16
Social support (family)	0.25**	0.27**
Social support (friends)	–0.03	0.10
Behavioral		
Smoking	0.06	–0.05
Exercise history	0.19*	0.07
Pet ownership	–0.03	0.12

*, P<0.15; **, P<0.05; MVPA, moderate-to-vigorous PA; PA, physical activity; WC, waist circumference; HTN, hypertension; BMD, bone mineral density.

Table 3 Multiple regression analysis for associations between determinants and physical activity in cardiac patients†

Determinants	Physical activity (min/day)	
	MVPA β (SE)	Total PA β (SE)
Functional capacity (10 feet)	0.13 (0.01)*	0.61 (0.30)*
PA readiness (stage of change)	2.08 (0.78)*	17.8 (6.41)*
Exercise history	0.17 (0.07)*	–
Adjusted R^2	26.6%	15.9%

†, final model (N=65), linear regression model after manual backward elimination process; β, beta coefficient; *, P<0.05; MVPA, moderate-to-vigorous PA; PA, physical activity.

maximize the effectiveness of PA interventions or CRP.

Social support by family and friends has been found as a consistent psychosocial correlate in healthy populations (11); however, it was not a significant correlate in this study. Although previous studies have reported significant associations between social supports and PA in cardiac patients (20), null associations were not uncommon (16), thus the influence of social support on cardiac patient's PA remain inconclusive (15).

All three of the correlates of PA, exercise history, functional capacity, and PA readiness, found in the current study are consistent with previous observations in the literature (15,16,18,19). Thus, consideration of these factors is important for CR Program Directors and clinicians when working with cardiac patients in a PA intervention. Cardiac patients without a history of exercise, and/or those with a lower functional capacity, and/or those in the pre-contemplation or contemplation stages of change may have a more difficult time achieving success in the PA intervention program. These patients will likely need more attention and assistance in the form of education and counseling to change their PA behavior. Additionally, interventions that provide a more individualized approach to increasing PA (e.g., increasing daily steps by 10% of their current level each week) may be more appropriate for patients with these characteristics. Patients who do comply with the PA intervention should obtain functional capacity improvements, which then could lead to longer-term compliance.

Strengths of this study include comprehensive measures of potential correlates and objectively-measured PA. Cross-sectional design and lack of information on environmental factors represent limitations of the current study, therefore prospective studies including larger samples and more potential correlates are warranted to better understand determinants of PA in cardiac patients.

In summary, functional capacity, PA readiness, and exercise history were shown to be important factors influencing cardiac patients' PA. Considering the low levels of PA in cardiac patients, interventions or CRP should

include correlates identified in this study as their key components to promote PA in cardiac patients.

Acknowledgements

We thank the cardiopulmonary rehabilitation team at IU Health - Ball Memorial Hospital and research staff at Ball State University's Human Performance Laboratory for their assistance for this study. We also thank American Heart Association for the grant support (AHA Midwest Affiliate Grant-in-Aid) for this study.

Authors' contributions: WB has contributed to the design, data analysis, and manuscript preparation. CO, KR, SS, and LK contributed to the initiation the study and the acquisition of the data, interpretation of the data, and assistance with the manuscript preparation.

Disclosure: The authors declare no conflict of interest.

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Cite this article as: Byun W, Ozemek C, Riggin K, Strath S, Kaminsky L. Correlates of objectively measured physical activity in cardiac patients. Cardiovascular Diagnosis and Therapy 2014;4(5):406-410. doi: 10.3978/j.issn.2223-3652.2014.10.06

