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FACTORS ASSOCIATED WITH OBJECTIVELY MEASURED EXERCISE PARTICIPATION AFTER HOSPITALIZATION FOR ACUTE CORONARY SYNDROME

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Abstract

BACKGROUND: Guidelines recommend exercise for secondary prevention of acute coronary syndrome (ACS), however adherence to guidelines is low. A paucity of data examining factors associated with objectively-measured exercise post-discharge in ACS survivors exists. The purpose of this study was to identify factors associated with exercise during the 5 weeks after ACS discharge.

METHODS: A sample of 151 ACS patients treated at a university hospital were enrolled into an observational cohort study and wore an accelerometer for 35 days post-discharge. Days on which participants accumulated ≥30 mins of moderate-to-vigorous physical activity in bouts ≥10 mins were considered exercise days. Participants were categorized as non-exercisers (0 exercise days) or exercisers (≥1 exercise day). A multi-variable logistic regression model was used to examine the association between exercise and socio-demographics, depression, SF-12 physical and mental health scores, disease severity, length of hospitalization, and percutaneous coronary intervention.

RESULTS: 39.7% of participants were non-exercisers. Factors associated with non-exercise were age (OR: 1.11; 95% CI: 1.06–1.17, p<.001), female sex (OR: 2.76; 95% CI: 1.10–6.95, p=.031), and lower SF-12 physical health score (OR: 0.94; 95% CI: 0.90–0.98, p=.005).

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Declaration of conflicting interests

The authors report no relationships that could be construed as a conflict of interest.

All authors take responsibility for all aspects of the reliability and freedom from bias of the data presented and their discussed interpretation.

CONCLUSION: In ACS patients in whom exercise participation was objectively measured for 5 weeks post-discharge, demographic and poor physical health factors were associated with non-exercise. These findings identify populations (e.g. older adults, women) at especially high risk for being physically inactive in whom more intense intervention may be warranted.

Keywords

Acute Coronary Syndrome; accelerometry; physical activity; exercise; demographic factors

INTRODUCTION

Acute coronary syndrome (ACS), which includes the diagnoses of unstable angina and acute myocardial infarction (MI), is a major public health burden (1). Over 1.1 million people are hospitalized annually for ACS in the United States alone. Individuals who experience an ACS event face substantial long-term morbidity/mortality risk (2). Within 1-year, 1 out of 5 patients will die, and a similar proportion are re-hospitalized for a recurrent cardiac event (3). As a result, there is a need to identify preventive strategies aimed at modifiable risk factors that reduce the risk of subsequent cardiac events and mortality in this patient population.

A substantial body of evidence has shown that aerobic exercise is associated with both primary and secondary prevention of ACS (4). Accordingly, secondary prevention guidelines from the American Heart Association (AHA) and American College of Cardiology (ACC) recommend that post-ACS patients (after one week post-discharge) participate in ≥30 minutes of moderate-to-vigorous physical activity (MVPA) on at least five days/week (5). Recently, we reported that a strikingly low proportion (~16%) of ACS patients met these guidelines in the first 5 weeks post-discharge (6). To date, however, there is a lack of data examining factors associated with exercise participation in this population during the post-discharge period, a critical window for forming and re-forming healthy habits. Identifying potential correlates of exercise participation, therefore, may aid in the development of future interventions to improve MVPA levels in this patient population.

Previous studies examining physical activity in ACS patients have predominantly evaluated MVPA through questionnaires and self-report diaries; methodologies known to overestimate physical activity and be prone to inherent biases (2, 6–8). Accelerometers, which are portable, unobtrusive devices that measure bodily changes in velocity, are now widely recognized as a valid and reliable tool for objectively assessing physical activity under free-living conditions that can overcome limitations of self-report. As such, they may yield more accurate information concerning the determinants of exercise and may be helpful in understanding long-term exercise patterns and identifying those who may benefit from more intensive intervention (6). Using accelerometers to collect continuous physical activity data over an extended period, the purpose of this study was to examine potential socio-demographic, psychosocial, and health related factors associated with objectively-measured engagement in physical exercise during the 5 weeks post-discharge following an ACS event.

METHODS

Study Population:

ACS patients from a university hospital in Upper Manhattan were enrolled into the Prescription Use, Lifestyle, and Stress Evaluation (PULSE) study, an observational cohort study conducted from February 2009-September 2012 (N=1087) (9), designed to examine behavioral and biological pathways that confer increased risk for recurrent cardiac events. A diagnosis of and hospitalization for ACS was the inclusion criteria where ACS events were defined according to AHA/ACC criteria as either acute MI, with or without ST-elevation, or unstable angina. All patients had symptoms consistent with acute MI and at least one of the following: ischemic electrocardiographic changes, angiogram indicative of coronary artery disease on admission, and/or documented history of coronary artery disease according to a stress test during the index admission or previous coronary angiogram. Patients presenting with serum troponin I levels >0.4 ng/ml were categorized as MI. Exclusion criteria included patients <18 years old, those without English or Spanish proficiency, those who lacked the ability to comply with the study protocol, and those who lacked medical stability. All participants gave written informed consent, and the study protocol conforms to the ethical guidelines of the 1975 Declaration of Helsinki as reflected in a priori approval by the institution's human research committee, Columbia University Medical Center Institutional Review Board.

An ancillary study to objectively measure physical activity for 5 weeks post-discharge via accelerometry was conducted among the PULSE cohort (10), which is the focus of this paper. A sample of 620 patients agreed to participate in the physical activity study. Of these, 431 returned the accelerometer with useable data (~71%). After restricting the sample to those with sufficient wear time (≥ 10 hours on ≥ 3 days in each week), and excluding patients who underwent coronary artery bypass grafting or were re-hospitalized before day 35 post-discharge, 151 patients comprised the sample for the current analysis (Supplemental Figure 1). Characteristics of participants included/excluded from the current analyses are shown in Supplemental Table 1.

Accelerometer Protocol:

Participants wore an Actical accelerometer (Philips Respironics, Bend, OR) on their non-dominant wrist for 35 days post-discharge. The Actical is an omni-directional accelerometer that records activity counts in one-minute epochs to quantify physical activity. The Actical has been validated for wrist wear (11, 12). Participants were fitted at or soon after discharge and asked to wear the accelerometer continuously and return the device via mail at the end of the monitoring period. Non-wear time was defined as ≥90 consecutive minutes of zero counts, with allowance of 1–2 minutes of nonzero counts if no counts were detected in the 30-minute windows at the start or end of the 90-minute (or longer) period (13). An adherent day was defined as ≥10 hours of wear time, and ≥3 adherent days in each week (weeks 2–5) were required for inclusion in this analysis (14).

Exercise Participation Status:

Activity counts ≥1065 for each one-minute epoch were categorized as MVPA (11). An exercise day was defined as ≥30 minutes/day of MVPA bout minutes where ≥8 out of 10 consecutive minutes qualified as an MVPA bout (15). The 30-minute MVPA threshold was selected in accordance with AHA/ACC physical activity recommendations for ACS patients (16). Ten minute MVPA bouts were quantified (and considered akin to exercise) in accordance with federal physical activity guidelines which recommend MVPA in episodes ≥10 minutes (17). Participants were categorized as non-exercisers if they had 0 exercise days over weeks 2–5 and as exercisers if they had ≥1 exercise days over weeks 2–5. Week 1 post-discharge was excluded from classification of exerciser/non-exerciser because AHA/ACC guidelines do not endorse MVPA during this time period (16). The threshold to define exercisers/non-exercisers was selected based on our previous report that few ACS patients engage in any exercise, and considering that patients whom chose not to exercise at all represent a patient population for which targeted interventions may be most warranted (6). We also tested higher thresholds to define exercisers/non-exercisers. As described below, similar results were observed and did not yield any additional useful information.

Potential Factors Associated with Exercise Status:

The potential factors examined in the present study were selected *a priori* based on previous literature that has linked these factors as correlates of exercise/non-exercise in cardiac or other populations (18–21). Socio-demographic factors (age, sex, race, ethnicity, social support, education), psychological symptoms (depression), measures of health-related factors (body mass index [BMI], sleep quality, Global Registry of Acute Coronary Events (GRACE) mortality risk score, Charlson comorbidity index [CCI], SF-12 physical and mental health scores, left ventricular ejection fraction [LVEF], history of congestive heart failure [CHF]), and hospitalization characteristics (length of hospitalization, percutaneous coronary intervention [PCI], ACS type) were all examined as potential correlates of objectively-measured exercise.

Socio-demographic factors, depression, and physical and mental health scores were obtained in-hospital at baseline and were determined by patient interview using standard questionnaires; sleep quality was assessed at a one-month follow up; GRACE risk score, CCI, LVEF, CHF, length of hospital stay, PCI, and ACS type were ascertained by medical record chart review. Social support was measured by the ENRICHD Social Support Inventory (ESSI) (22, 23), depression by the Beck Depression Inventory (BDI) (24), sleep quality by the Pittsburgh Sleep Quality Index (PSQI) (25), and physical and mental health-related quality of life by the 12-item Short Form Health Survey (SF-12) (26). All measures are detailed further in the online supplement.

Statistical Analyses:

The number of exercise days over weeks 2–5 post-discharge is reported as the percentage of valid wear days over this time that met MVPA criteria. Multi-variable logistic regression models were used to examine the factors associated with non-exercise. All variables that could be were expressed continuously (age, education, depression, PSQI, SF-12, GRACE risk and CCI scores, LVEF, length of hospital stay) and remaining variables were expressed

categorically (sex, race, ethnicity, social support, CHF, PCI, ACS type [see supplement for details]). Crude (unadjusted) odds ratios (OR) were initially calculated for each individual factor. Models were then adjusted for age, sex, race, ethnicity, BMI, and number of valid wear days (Model 1) and further adjusted for those factors with a p≤0.10 in model 1 (Model 2).

Two sensitivity analyses were conducted. First, all analyses were repeated defining non-exercisers as having exercise days on ≤10% of valid wear days over weeks 2–5. Second, analyses were repeated restricting the study sample to those with ≥4 valid wear days/week for weeks 2–5. Data analyses were conducted using SPSS version 22 (SPSS Inc, Chicago, IL).

RESULTS

Participant Characteristics:

Table 1 presents participant characteristics overall and by exercise participation status. Among the 151 participants, the mean (±SD) of age and BMI were 63.5±11.4 years and 28.9±5.5 kg/m^2, respectively. Participants were predominantly male (69.5%), of mixed ethnicity (18.1 % black; 35.1% Hispanic), and the majority presented with unstable angina (58.3%). The mean length of hospital stay was 3.6±3.0 days, 84.1% of participants had PCI, and 16.1% had reduced LVEF defined as less than 40% (mean ± SD 49.4 ± 12.5). The median percent exercise days was 5.88% over a median of 26.0 and a range of 15.0–28.0 valid wear days, respectively. Among the 151 participants, 39.7% were classified as non-exercisers.

Factors Associated with Exercise Status:

In unadjusted and partially adjusted models (Model 1), female sex (95% CI: 1.30–7.71, p=0.011), older age (95% CI: 1.06–1.16, p<.001), GRACE risk score (95% CI: 1.02–1.04, p<0.001), and CCI (95% CI: 1.05–1.58, p=0.014) were significantly associated with greater odds of being a non-exerciser, while a better SF-12 physical health score was significantly associated with lower odds of being a non-exerciser (95% CI: 0.90–0.98, p=.005). In a model that adjusted for all covariates in model 1 and correlates with a p≤0.10 in model 1, female sex (95% CI: 1.10–6.95, p=0.031) and older age (95% CI: 1.06–1.17, p<.001) remained significantly associated with greater odds of being a non-exerciser and higher SF-12 physical health score remained significantly associated with lower odds of being a non-exerciser (95% CI: 0.90–0.98, p=.005). In sensitivity analyses, the pattern of results was similar when non-exerciser status was defined as exercise on ≤10% of valid wear days, and when restricted to participants with ≥4 valid wear days/week (data not shown).

DISCUSSION

Among a cohort of ACS patients, our study utilized objectively-measured physical activity collected continuously over a 35-day period post-discharge to examine factors associated with non-participation in exercise. In this sample, strikingly, ~40% of participants did not engage in a single day of health-enhancing physical activity akin to exercise (e.g. ≥30 MVPA bout min) during weeks 2–5 following hospitalization for a cardiac event. We found

that socio-demographic factors (older age, female sex), and health status (lower physical health score) were associated with a lack of participation in exercise during the month following hospitalization. These findings highlight that physical inactivity is highly prevalent among ACS patients. Further, they identify populations (e.g. older adults, women) at especially high risk for being physically inactive in whom more intense intervention may be warranted.

To improve functional capacity and quality of life, enhance vocational status, stabilize modifiable cardiovascular risk factors, and decrease risk for subsequent cardiac events (5, 16), guidelines recommend ACS patients accumulate ≥30 minutes of MVPA on most days of the week. Our previous findings showed that a small proportion of ACS patients (~16%), however, met physical activity guidelines post-discharge (6). In the present study, we extend our previous findings by showing that nearly half of post-ACS patients did not exercise at all during weeks 2–5 post-discharge; a striking finding given that such patients would seemingly have reason to be highly motivated to adopt healthy lifestyle habits during this timeframe. These low exercise rates are mirrored by the well-documented low cardiac rehabilitation (CR) referral, participation, and completion rates in this population (27). Thus, there is a clear and pressing need for secondary prevention efforts to increase MVPA in this patient population.

In the present study, we identified key socio-demographic factors correlated with nonparticipation in exercise among ACS patients, including older age and female sex. These findings are consistent with findings from the general population where exercise participation has been demonstrated to decrease with age and be higher among males (28, 29). Our findings are also consistent with a cohort study of 782 cardiac patients which observed lower physical activity levels (assessed by 7-day physical activity recall) among women and older aged patients 2–12 months post-hospitalization (20), with the present study extending the current evidence base by confirming previously observed associations with objective measures of MVPA and showing that age and sex differences exist as early as the first month post-hospitalization. While we have identified correlates of non-exercise, future research should seek to identify the mechanisms contributing to these observed age and sex differences. Decreased functional capacity and social support, and increased co-morbid conditions have been proposed as partial explanations of the age-related differences in MVPA post-ACS (30). With respect to gender differences, compared to men, women report greater psychological distress, lower social support, more family/social commitments that are perceived as barriers to exercise, and cope differently in response to a cardiac event, with evidence suggesting that women tend to minimize the impact of their health situation and avoid burdening their social contacts (30). Future research elucidating the efficacy of tailored-exercise and CR-based programs for these patient populations may be warranted.

In addition to socio-demographic factors, a lower SF-12 physical health score was associated with non-exercise participation in the present study. While clinical measures of physical health (e.g. comorbidities, GRACE risk score, LVEF) were not significant factors associated with being a non-exerciser, the SF-12 health survey evaluates health features (including social, emotional and physical components, pain, and vitality) that are not entirely assessed with conventional clinical measures (26). In this context, our results indicate that a patient's

own assessment of their physical health may be predictive of participation in exercise, regardless of health status indicated by clinical measures. Previous studies have reported that self-reported health-related quality of life is associated with health behaviors in a manner that is distinct and separate from the relationship between actual health status and behaviors (31, 32). Irrespective of the contributing factors, in accordance with social cognitive theory it has been argued that changing beliefs (such as perception of one's health) may be an effective way of modifying exercise uptake. Future research is needed to examine the impact of increasing self-perceptions of health on exercise participation in cardiac populations. It should, however, be acknowledged that physical activity has been demonstrated to be a powerful tool for improving perceived/measured physical function and reducing adiposity. Thus, the observed associations may be bi-directional and underscore the importance of physical activity in mitigating a potentially vicious cycle (e.g. inactivity leading to decreased physical function, leading to more inactivity).

We also examined modifiable risk factors (social support, depression, sleep quality) which could be potential targets for intervention to increase MVPA in ACS patients. Persistent depression and low social support have previously been reported to be associated with lower physical activity in ACS patients; while poor sleep quality has been linked to lower physical activity in the general population (10, 33). No such associations were observed in the present study. Possible reasons for these discrepancies may, in part, be attributed to the use of an objective measure of physical activity, the time period of assessment (e.g. immediately vs. several months post-hospitalization), differences in study measures used to assess risk factors (e.g. BDI for depression), and analytic differences in covariates and operationalization of physical activity. Future research may need to consider examining other modifiable factors that can be targeted for intervention to increase MVPA in ACS patients.

Our findings should be viewed in the context of several limitations. First, patients were enrolled from a single site in an urban area, which may limit study generalizability. Second, compliance to the accelerometer protocol was relatively low (~53%). Finally, the majority of our sample presented with unstable angina (~58%), which may limit applicability of the results for patients with MI.

Notwithstanding these limitations, the strengths of our study include the use of objective measures of physical activity over an extended period (5 weeks), and the examination of physical activity levels during a critical period after discharge when patients are forming, or re-forming, health habits. Conventional accelerometer protocols often entail 7-day monitoring periods; thus, the present study represents one of the longest accelerometer protocols conducted in ACS patients, and permitted the categorization of exerciser/non-exerciser status using approximately 1 month of objective data.

In conclusion, in this sample of ACS patients, a striking proportion (~40%) were categorized as non-exercisers over the first month following hospitalization. We identified key socio-demographic and health-related factors associated with non-exercise, which is particularly important in the context of recent findings that a very low proportion of post-ACS patients meet physical activity guidelines. Collectively these results provide valuable context for

understanding exercise participation in the current ACS population, and highlight the need to increase efforts to promote physical activity for secondary prevention.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Highlights:

- A striking 40% of patients did not exercise a single day over 5 weeks post-ACS.
- Older age, female sex, and poor physical health were associated with non-exercise.
- Older adults and women may need robust intervention to promote exercise post-ACS.

Table 1

Participant characteristics overall and by exercise participation status

Variable	Overall Sample Population n=151	Exercisers n=91	Non-Exercisers[a] n=60
Socio-demographic			
Age (years)	63.5 ± 11.4 years	59.5 ± 10.4	69.6 ± 10.2
Female (%)	30.5%	20.9%	45.0%
Black Race (%)	18.1%	22.5%	11.7%
Hispanic Ethnicity	35.1%	41.8%	25.0%
Low Social Support[b]	24.7%	24.4%	25.0%
Education (years)	13.5 ± 4.2 years	13.2 ± 4.3	13.8 ± 4.1
Psychological			
Depressive Symptoms[c]	8.8 ± 7.2	8.2 ± 7	9.7 ± 7.4
Health Status/Disease Severity			
Body Mass Index (kg/m^2)	28.9 ± 5.5	28.4 ± 5.3	29.7 ± 5.8
Sleep Quality[d]	5.3 ± 4.1	5.4 ± 4.2	5.2 ± 4
SF-12 Mental Health Score[e]	52.6 ± 10.9	52.5 ± 11.2	52.8 ± 10.6
SF-12 Physical Health Score[e]	39.7 ± 10.7	42.0 ± 10.5	36.0 ± 9.9
GRACE Risk Score[f]	91.0 ± 30.4	82.0 ± 26	104.6 ± 31.7
Charlson Comorbidity Index	1.6 ± 1.7	1.3 ± 1.5	2.0 ± 1.8
Left Ventricular Ejection Fraction (%)	49.4 ± 12.5	49.7 ± 11.5	49 ± 14
Prior Congestive Heart Failure	13.9%	9.9%	20.0%
Hospitalization Characteristics			
Length of Hospital Stay (days)	3.6 ± 3.0	3.4 ± 2.3	3.8 ± 3.8
Percutaneous Coronary Intervention	84.1%	84.6%	83.3%
ACS Type			
Unstable Angina	58.3%	57.1%	60.0%
NSTEMI	29.1%	28.6%	30.0%
STEMI	12.6%	14.3%	10.0%

Data presented as mean ± SD or percent.

[a]Non-exercise was defined as participants who did not accrue any exercise days; defined as at least 30 minutes per day of MVPA bout minutes in bouts of at least 8 out of 10 consecutive minutes of MVPA.

[b]ENRICHD social support index (ESSI)

[c]Beck Depression Inventory (BDI)

[d]Pittsburgh Sleep Quality Index (PSQI)

[e]Short-form 12 Health Survey (SF-12)

[f]Global Registry of Acute Coronary Events

Table 2

Factors associated with non-exercise

	Unadjusted Model[a]		Model 1[b]		Model 2[cb]	
Variable	**OR (95% CI)**	**p value**	**OR (95% CI)**	**p value**	**OR (95% CI)**	**p value**
Socio-demographic						
Age (years)	1.11 (1.06–1.15)	<0.001	1.11 (1.06–1.16)	<0.001	1.11 (1.06–1.17)	<0.001***
Female	3.10 (1.51–6.35)	0.002	3.16 (1.30–7.71)	0.011	2.76 (1.10–6.95)	0.031*
Black Race	0.46 (0.18–1.16)	0.098	0.55 (0.17–1.77)	0.320	0.49 (0.15–1.61)	0.238
Hispanic Ethnicity	0.47 (0.23–0.95)	0.036	0.42 (0.17–1.04)	0.062	0.42 (0.16–1.09)	0.075
Low Social Support	1.03 (0.48–2.2)	0.938	0.90 (0.36–2.25)	0.827	-	-
Education (years)	1.04 (0.96–1.12)	0.363	1.09 (0.96–1.23)	0.172	-	-
Psychological						
Depressive Symptoms	1.03 (0.98–1.08)	0.226	1.02 (0.96–1.08)	0.547	-	-
Health Status/Disease Severity						
Body Mass Index (kg/m^2)	1.05 (0.99–1.11)	0.141	1.06 (0.99–1.14)	0.121	1.05 (0.97–1.13)	0.232
Sleep Quality	0.99 (0.91–1.07)	0.752	0.97 (0.87–1.07)	0.541	-	-
Perceived Mental Health	1.00 (0.97–1.03)	0.847	1.03 (0.99–1.07)	0.182	-	-
Perceived Physical Health	0.95 (0.91–0.98)	0.001	0.94 (0.90–0.98)	0.005	0.94 (0.90–0.98)	0.005**
GRACE risk score	1.03 (1.02–1.04)	<0.001	1.01 (0.99–1.03)	0.548	-	-
Charlson Comorbidity Index	1.29 (1.05–1.58)	0.014	1.10 (0.88–1.38)	0.419	-	-
Left Ventricular Ejection Fraction (%)	1.00 (0.97–1.02)	0.763	1.01 (0.97–1.04)	0.741	-	-
Prior Congestive Heart Failure	2.28 (0.89–5.80)	0.084	1.41 (0.45–4.44)	0.553	-	-
Hospitalization Characteristics						
Length of Hospital Stay (days)	1.05 (0.94–1.17)	0.369	1.08 (0.93–1.25)	0.315	-	-
Percutaneous Coronary Intervention	0.91 (0.38–2.21)	0.833	0.87 (0.30–2.53)	0.799	-	-
ACS Type						
Unstable Angina	1.00 (ref)	-	1.00 (ref)	-	-	-
NSTEMI	1.00 (0.48–2.09)	1.000	1.45 (0.58–3.64)	0.427	-	-
STEMI	0.67 (0.23–1.92)	0.452	0.72 (0.20–2.63)	0.622	-	-

ACS, acute coronary syndrome, NSIEMI, non-ST segment elevation myocardial infarction, STEMI, ST segment elevation myocardial infarction.

[a] all correlates examined separately.

[b] adjustment for age, sex, race, ethnicity, BMI, and number of valid wear days.

[c] adjustment for covariates in model 1 plus all variables with p<0.10 in Model 1.

[d] Non-exercise was defined as participants who did not accrue any exercise days; defined as at least 30 minutes per day of moderate-to-vigorous physical activity (MVPA) bout minutes in bouts of at least 8 out of 10 consecutive minutes of MVPA.

* P<0.05

** P<0.01

*** P<0.001