Author: Rius Ottenheim, Nathaly
Title: Psychosocial and biological aspects of dispositional optimism at old age
Date: 2012-09-06

Chapter 5

Physical activity after myocardial infarction: is it related to mental health?

European Journal of Preventive Cardiology

Nathaly Rius-Ottenheim
Johanna M Geleijnse
Daan Kromhout
Roos C van der Mast
Frans G Zitman
Erik J Giltay

Abstract

Background Physical inactivity and poor mental well-being are associated with poorer prognoses in patients with cardiovascular disease. We aimed to analyze the cross-sectional and prospective associations between physical activity and mental well-being in patients with a history of myocardial infarction.
Design Longitudinal, observational study.
Methods 600 older subjects with a history of myocardial infarction (age range 60-80 years) who participated in the Alpha Omega Trial (AOT) were tested twice at baseline and at 40 months follow-up for physical activity (with the Physical Activity Scale for the Elderly [PASE]), depressive symptoms (with the Geriatric Depression Scale [GDS-15]), and dispositional optimism (with the Life Orientation Test [LOT-R]). Linear (multilevel) and logistic regression analyses were used to examine cross-sectional and longitudinal associations.
Results Physical activity was cross-sectionally associated with depressive symptoms (adjusted beta=–0.143; p= 0.001), but not with dispositional optimism (adjusted beta=0.074; p=0.07). We found a synchrony of change between physical activity and depressive symptoms (adjusted beta=–0.155; p<0.001), but not with dispositional optimism (adjusted beta=0.049; p=0.24). Baseline physical activity did not predict depressive symptoms at 40 months of follow-up.
Conclusions Concordant inverse associations were observed for (changes) in physical activity and depressive symptoms. Physical activity did not predict depressive symptoms or low optimism.

Introduction

Physical activity is thought to confer benefits on mental health in older adults (Camacho, Roberts, Lazarus, Kaplan, & Cohen, 1991; Lampinen, Heikkinen, Kauppinen, & Heikkinen, 2006; Strawbridge, Deleger, Roberts, & Kaplan, 2002). It has been shown that older adults who engage in regular physical activities are less likely to have depressive symptoms and are more optimistic than their less physically active peers (Camacho et al., 1991; Giltay, Geleijnse, Zitman, Buijsse, & Kromhout, 2007). Conversely, the combination of physical inactivity with depressive symptoms and low optimism increases the risk of cardiovascular morbidity and mortality in patients with a history of myocardial infarction (Lett et al., 2004; Frasure-Smith et al., 2009; Davidson, Mostofsky, & Whang, 2010; Giltay, Geleijnse, Zitman, Hoekstra, & Schouten, 2004; Netz, Wu, Becker, & Tenenbaum, 2005). Therefore, a better understanding of the relationship between physical activity and mental health is of particular importance in older patients with cardiovascular disease (Donker, 2000).

Several cross-sectional, population-based studies have shown an inverse association between physical activity and depressive symptoms (Conn, 2010; Camacho et al., 1991; Strohle, 2009; Teychenne, Ball, & Salmon, 2008; Sanchez-Villegas et al., 2008; Jonsdottir, Rodjer, Hadzibajramovic, Borjesson, & Ahlborg, 2010). However, the longitudinal relationship between physical activity and depressive symptoms has been less extensively investigated and the results have been inconsistent. While some previous prospective studies found evidence of a predictive effect of physical inactivity on depressive symptoms (Camacho et al., 1991; Farmer et al., 1988; Wise, Adams-Campbell, Palmer, & Rosenberg, 2006), others did not (Cooper-Patrick, Ford, Mead, Chang, & Klag, 1997; Kritz-Silverstein, Barrett-Connor, & Corbeau, 2001; Weyerer, 1992). These inconsistencies may be explained by other factors such as the presence of depressive symptoms at baseline being a stronger determinant for future depressive symptoms than physical inactivity (Lampinen et al., 2006). Only two studies have described an inverse longitudinal relationship between baseline physical activity and depressive symptoms among community-dwelling adults free of depressive symptoms at baseline (Camacho et al., 1991; Farmer et al., 1988). However, both studies measured physical activity with a single self-report global question, instead of a validated tool that incorporated a broad range of activities (Macera et al., 2001; Sternfeld, Cauley, Harlow, Liu, & e, 2000).

The association between physical activity and depressive symptoms has been less well investigated in patients with cardiovascular disease In a study among 189 patients with history of acute myocardial infarction (MI), coronary bypass surgery, or a percutaneous coronary intervention, an inverse association was found between participation in an exercise training and prevalence of depressive symptoms (i.e. reduction of 40% of depressive symptoms in the intervention group). Furthermore, both exercise and depressive symptoms were longitudinally associated with survival (Milani, Lavie, Mehra, & Ventura, 2011). Similarly, in a recent study among 5888 ambulatory patients with CHD (defined as angina, previous MI or coronary revascularization) an odds ratio of 3.4 was reported for the lowest physical activity group regarding their risk for depressive symptoms. Both studies found that physical inactivity and depressive symptoms were partly independent predictors of cardiovascular mortality (Win et al., 2011; Milani et al., 2011).

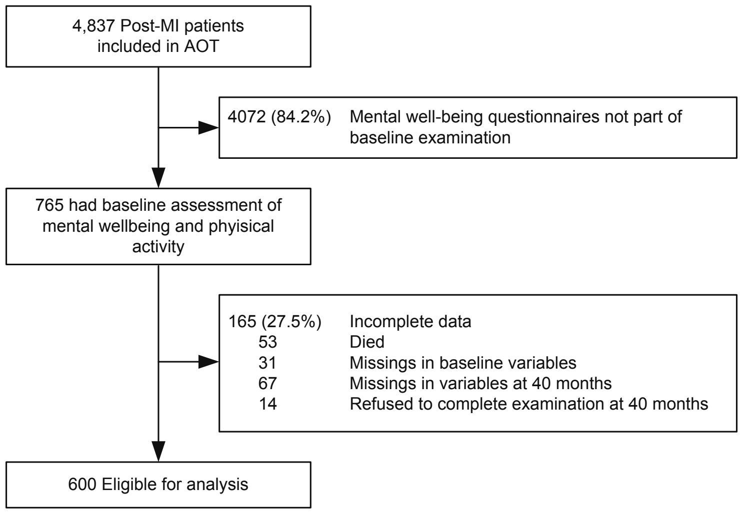
Physical activity has not only been related to the state-like depressive symptoms, but also to positive psychological traits (Gauvin & Spence, 1996; Reed & Ones, 2006; Scully, Kremer, Meade, Graham, & Dudgeon, 1998; Baruth et al., 2011; Stubbe, de Moor, Boomsma, & de Geus, 2007). Dispositional optimism refers to one's generalized positive expectations towards the future (Carver, Scheier, & Segerstrom, 2010; Scheier, Carver, & Bridges, 1994a). People with high dispositional optimism tend to expect good things rather than bad things to happen in their future. On the contrary, people with depressive symptoms incline to anticipate negative outcomes of life challenges and have the perception that these situations are unchangeable and uncontrollable. These perceptions of lack of control on a stressor are linked to learned helplessness (Maier & Seligman, 1976). The differences in the way that we see our future are thought to greatly influence our behavior and our health. Dispositional optimism may protect against the development of depressive symptoms (Giltay, Zitman, & Kromhout, 2006). Furthermore, dispositional optimism reduces cardiovascular risk in community dwelling elderly subjects (Giltay, Kamphuis, Kalmijn, Zitman, & Kromhout, 2006; Giltay et al., 2004). It has been hypothesized that dispositional optimism reduces cardiovascular risk by influencing lifestyle, including physical activity (Kavussanu & McAuley, 1995; Giltay et al., 2007).In a study among 773 community-dwelling older men, higher optimism was strongly associated with higher levels of physical activity (Giltay et al., 2007). The longitudinal relationship between physical activity and optimism remains largely unexplored. Nevertheless, an observational study with a follow-up of only one week found a positive association between physical activity and positive affect(Mata et al., 2011), an affective state that is related to optimism in the same way depression is related to neuroticism.

In the present study, data from the Alpha Omega Trial (AOT) (Kromhout, Giltay, & Geleijnse, 2010) were used to examine, both cross-sectionally and longitudinally, the potential associations of physical activity with depressive symptoms and dispositional optimism. We aimed to assess (a) whether physical activity was associated with depressive symptoms and dispositional optimism; (b) whether or not changes in physical activity were associated with changes in depressive symptoms and dispositional optimism (i.e. synchrony of change); and (c) to investigate the prospective association of baseline low physical activity with depressive symptoms and low optimism over time.

Methods

Study sample

Participants were recruited as part of the Alpha Omega Trial, a randomized, double-blind controlled trial that investigated the effects of n-3 fatty acids on relapse of cardiovascular disease in a sample of elderly subjects with a history of myocardial infarction. Post-MI patients were recruited by cardiologists from 32 hospitals between 2002 and 2006, and the date of final follow-up was December 23rd, 2009. Subjects were considered eligible for the trial if they were aged between 60 to 80 years, if they had a verified diagnosed myocardial infarction up to 10 years before randomization, were not cognitively impaired (i.e. MMSE score ≥22points), and were willing to provide written informed consent (Geleijnse et al., 2010; Kromhout et al., 2010). These selection criteria resulted in a sample of 4837 eligible subjects who were subsequently randomized into the following four groups of n-3 fatty acids: a combination of eicosapentanoic acid (EPA) and docosahexaenoic acid (DHA); alpha-linolenic acid (ALA); a combination of EPA, DHA, and ALA; or placebo. Of the 4837 participants included in the initial sample, 765 participants completed baseline questionnaires on physical activity, depressive symptoms, and dispositional optimism. During follow-up, 53 participants died, 14 participants refused further participation in the study, and 31 participants had missing values on the covariates included in the present analysis. This resulted in a sample of 667 participants at the end of the follow-up. Of the 667 remaining participants, 67 had missing values on the covariates at the end of the follow-up. Thus, the final sample used for the present analysis comprised 600 participants (Figure 1). The trial was conducted in compliance with the Declaration of Helsinki and approved by the Medical Ethics Committee of South-West Holland and by the ethics committees of all participating hospitals. Written informed consent was obtained from all participants.



Physical activity

Physical activity was assessed using the Physical Activity Scale for the Elderly (PASE), a validated brief self-report questionnaire designed to measure the level of self-reported physical activity in individuals aged 65 years or older (Schuit, Schouten, Westerterp, & Saris, 1997; Washburn, McAuley, Katula, Mihalko, & Boileau, 1999). This scale comprises 12 items regarding occupational, household, and leisure activities during the previous week to the assessment. The total PASE score is calculated by multiplying duration of activity (hours per week) or participation in an activity (yes/no) by empirically derived weight, daily energy expenditures (metabolic equivalents of task [MET]) and self-reported physical activity, and then summing the product for all 12 items. In our analyses, we also used the continuous measure of physical activity MET hours per week. One MET is the equivalent to the rate of energy consumption of a person at rest (e.g. sitting quietly for 1 hour).

Psychometric assessment

Depressive symptoms at baseline and during follow-up were assessed with the 15-item version of the Geriatric Depression Scale (GDS-15). The GDS-15 is a validated self-report instrument designed to assess depressive symptoms in older people (de Craen, Heeren, & Gussekloo, 2003). This instrument is especially useful to measure depressive symptoms in older patients with cardiovascular disease, as it excludes somatic symptoms that might also be related to physical illnesses rather than to depressive symptoms (Yesavage et al., 1982). The total score ranges from 0 to 15 points, with higher scores indicating more depressive symptoms. For the computation of the GDS-15 score, two missing items were allowed, being subsequently imputed with the mean of the remaining items. The Cronbach's alpha was 0.77.

Dispositional optimism was assessed using the Life Orientation Test Revised (LOT–R). The LOT–R is a 10-item self-report questionnaire with six items that yield an optimism score and four filler items (Scheier, Carver, & Bridges, 1994b). The scale included three negatively stated items which required reversed coding before total score computation. Subjects were asked to express the extent of their agreement with each of the items, coding their responses on a 5-point Likert type scale. The LOT-R score ranges from 0-24, with higher scores being indicative for higher optimism levels. For the computation of the optimism scores, one missing item per subject was allowed, being subsequently imputed with the mean of the remaining items. The Cronbach's alpha was 0.57.

Covariates

At baseline, data were collected on demographic factors, lifestyle, medical history, current health status, and medication use. Information about the highest attained level of education was used as an indicator of socioeconomic status, with more than 11 years of education as the upper category. Marital status was dichotomized into the categories being married (or cohabiting) or not (i.e. unmarried, divorced, widow). Smoking habits were categorized into never smoked, smoked in the past, and current smoking. Alcohol use was categorized into no alcohol use, use of 1 to 13 alcohol units per week, and use of more than 14 alcohol units per week. Body mass index (BMI) was calculated from the measured weight and height. Reported self-rated health was dichotomized into excellent to good self-rated health and moderate to poor self-rated health. Treatment group represents the randomized groups that received one of the following interventions: administration of a combination of the n-3 fatty acids EPA and DHA; administration of ALA; administration of a combination of ALA, EPA and DHA; or administration of placebo (Kromhout et al., 2010). Cognitive function was measured with the Mini Mental State Examination (MMSE) and was included in the multivariable analyses as a continuous variable.

Statistical analyses

Sociodemographic and baseline characteristics were summarized using descriptive statistics. Categorical variables were presented as proportions. Continuous data were presented as mean (standard deviation) or as median (interquartile ranges), when appropriate. If the criteria of normality were not met (i.e. depressive symptoms and physical activity), log-transformed values were used to improve their distributions.

Because the two observations (i.e. baseline and at 40 months) were not independent, multilevel regression analyses (i.e. linear mixed models) with an unstructured covariance matrix were used to investigate the cross-sectional associations of physical activity with depressive symptoms and dispositional optimism. Associations were first assessed in a crude model. Subsequently, we repeated the linear regression analyses adjusting first for age and gender (Model 1) and then additionally adjusting for education, marital status, smoking habits, alcohol use, body mass index, MMSE score, treatment group, diabetes mellitus, stroke at baseline, and time since last MI (Model 2). Data are presented as standardized beta coefficients.

Linear regression analyses were used to analyze the temporal associations of absolute changes (i.e. delta) in physical activity with absolute changes in depressive symptoms and dispositional optimism scores in univariate and multivariable models, as described in the previous paragraph. Data are presented as standardized beta coefficients.

Logistic regression analyses were conducted to examine the predictive effect of physical activity and depressive symptoms in both in univariate and multivariable models. To this purpose, we dichotomized the variables "physical activity", "depressive symptoms", and "low optimism". Moderate and/or vigorous physical activity was defined as "physical activity lasting more than 30 minutes, during at least 5 days per week, with energy expenditure higher than 3 METs" (Pate et al., 1995). Presence of depressive symptoms was defined as a score higher or equal to 4 points on the GDS-15 . This cut-off has shown to have a specificity of 76% in a previous study with older persons (de Craen et al., 2003). Low optimism was defined as a score lower than 12 points on the LOT-R. This cut-off has been less well investigated, but earlier studies of our group using the same sample showed that this cut-off represented 20% of the subjects with the lowest scores (van de Rest et al., 2010). Furthermore, we excluded from the analyses the subjects with depressive symptoms at baseline, as defined by a GDS score ≥4 points, (n=155, 25.8%) and low optimism at baseline, as defined by a LOT-R score < 12 points, (n=107, 17.8%).

All tests were two-tailed with $p<0.05$ denoting statistically significance. The software used was SPSS version 17.0 (SPSS Inc., Chicago, Ill).

Results

Cross-sectional results

Table 1 shows the sociodemographic and health characteristics of the 600 participants of the Alpha Omega Trial with complete data for the main outcome variables. The included subjects had a mean age of 68.5 years and were predominantly male (81%). Most participants were married and had a low educational level. The median baseline MMSE score was 27 points. The mean BMI was 27 kg/m2 and more than one fifth of the participants fulfilled the criterion of obesity (i.e. BMI ≥30 kg/m2). The mean time elapsed since the last MI was 3.9 years. After 40 months of follow-up, there was a decrease in the number of married participants and a decrease in the number of subjects who reported drinking more than 14 alcohol units per week. There were 10 participants who initiated antidepressants during follow-up, whereas 6 participants stopped using antidepressants. No further changes were observed in sociodemographic or health characteristics after 40 months of follow-up.

Table 1. Characteristics of 600 patients with a history of MI.

Variables	Baseline n=600	After 40 months of follow-up n=600
Age, mean (SD), years	68.5 (5.5)	71.8 (5.5)
Male, n (%)	488 (81.3%)	488 (81.3%)
Married, n (%)	512 (85.3%)	490 (81.8%)
High education[a], n (%)	95 (15.8%)	95 (15.8%)
Current smoking, n (%)	84 (14.0%)	84 (14.0%)
Alcohol use, n (%)	136 (22.7%)	108 (18.0%)
• No alcohol use	127 (21.4%)	145 (24.7%)
• 1-13 units of alcohol/week	311 (52.4%)	321 (54.6%)
• ≥14 units of alcohol/week	156 (26.3%)	122 (20.7%)
Moderate to poor self-rated health, n (%)	127 (21.2%)	130(21.6%)
Time since last MI, mean (SD), years	3.9 (2.9)	7.3 (2.9)

Participants were included according to completeness of data for all variables.

High education is defined as having more than 11 years of education or having at least completed secondary education.

Table 2. Physical activity and mental well-being variables of 600 patients with a history of MI.

Variables		Baseline	After 40 months
Moderate leisure activities, minutes per day – no. (%)			
•	0 min/day	240 (40.0%)	237 (39.5%)
•	1-29 min/day	147 (24.5%)	139 (23.2%)
•	>30 min/day	213 (35.5%)	224 (37.3%)
Moderate and/or vigorous leisure activities, minutes per day – no. (%)			
•	0 min/day	213 (35.5%)	212 (35.3%)
•	1-29 min/day	146 (24.3%)	136 (22.7%)
•	>30 min/day	241 (40.2%)	252 (42.0%)
Recommendation for healthy physical activity (n, %)*		241 (40.2%)	252 (42.0%)
MET-minutes per day (median, IQR)**		227 (90-424)	343 (90-476)
Antidepressant use (n, %)		22 (3.7%)	26 (4.3%)
Depressive symptoms (n, %) †		92 (15.3%)	114 (19.0%)
Low optimism (n, %) ‡		93 (15.5%)	79 (13.2%)

Participants were included according to completeness of data for all variables.

* Norm for healthy physical activity is defined as a physical activity lasting more than 30 minutes, during at least 5 days per week, with energy expenditure higher than 3 METs.

**MET: Metabolic Equivalent of Task; GDS-15: 15-item Geriatric Depression Scale; LOT-R: Life Orientation Test Revised.

† Depressive symptoms were defined as having a GDS score≥ 4 points.

‡ Low optimism was defined as having a LOT-R score< 12 points.

Table 2 presents the characteristics at baseline and at 40 months for the main variables physical activity, depressive symptoms, and dispositional optimism. The results show an increase in the percentage of participants reporting moderate and/or vigorous physical activity that fulfilled the recommendation of healthy physical activity, as well as a higher median of MET-minutes per day after 40 months of follow-up. At the same time, there was a slight increase in depressive symptoms and antidepressant use over time. Finally, the percentage of participants that scored low on the optimism scale decreased over time.

Table 3 and Figure 2 present the results of the cross-sectional univariate analyses on the association of physical activity with depressive symptoms and dispositional optimism. There results show a negative cross-sectional association between physical activity and depressive symptoms, both at baseline and after 40 months. Physical activity was cross-sectionally associated with dispositional optimism in the univariate analyses, but this association disappeared after adjustment for covariates (Table 3).

Longitudinal results

Results from the analyses of the associations between absolute changes in physical activity, on the one hand, with absolute changes in depressive symptoms and changes in optimism scores, on the other hand, showed that physical activity changed in synchrony with depressive symptoms (adjusted beta= -0.155; p<0.001) (Table 3). Thus, increases in physical activity were strongly associated with decreases in depressive symptoms over time, and vice versa. By contrast, no reciprocal relationship was found with dispositional optimism, particularly not after adjustment for relevant confounders in Model 2. These results are graphically presented in Figure 2C.

Results from the logistic regression analyses for both depressive symptoms and disposi-

Table 3. Multi-level and longitudinal associations between physical activity, depressive symptoms and dispositional optimism in 600 patients with a history of MI.

Variables	Physical activity			
	Cross-sectional multi-level association		Longitudinal delta association	
	Beta	P-value	Beta	P-value
Depressive symptoms				
• Crude association	–0.225	< 0.001	–0.156	< 0.001
• Model 1	–0.209	< 0.001	–0.154	< 0.001
• Model 2	–0.104	0.02	–0.155	< 0.001
Dispositional optimism				
• Crude association	0.101	0.001	0.042	0.30
• Model 1	0.092	0.002	0.044	0.29
• Model 2	0.052	0.21	0.049	0.24

P-values for linear trend, obtained with linear regression analyses.
Cross-sectional multi-level associations are represented by the beta-coefficients for the cross-sectional association between depressive symptoms and physical activity at baseline and 40 months (taking into account within-subject effects); longitudinal delta associations are represented by the beta-coefficients for the association between the absolute changes (i.e. delta's) over 40 months of depressive symptoms and physical activity.

Model 1: adjusted for age and gender.

Model 2: adjusted for age, sex, education, marital status, smoking habits, alcohol use, treatment group, diabetes mellitus, stroke, time since myocardial infarction, BMI, and MMSE score.

Table 4. Prediction models for baseline physical activity predicting depressive symptoms and dispositional optimism after 40 months of follow-up in patients with a history of MI.

	Baseline moderate and/or vigorous leisure physical activity				
	No activity (ref)	1-29 min/day	p-value	≥ 30 min/day	p-value
Depressive symptoms at 40 months					
• No. of subjects	141	113	–	191	–
• Cases with depressive symptoms at 40 months, n (%)	16 (11.3%)	13 (11.5%)	–	16 (8.4%)	–
• Crude	1.0	1.02 (0.47-2.21)	0.97	0.71 (0.34-1.48)	0.37
• Model 1	1.0	1.01 (0.46-2.20)	0.98	0.76 (0.36-1.58)	0.46
• Model 2	1.0	1.30 (0.53-3.15)	0.57	0.85 (0.38-0.90)	0.58
Low dispositional optimism at 40 months:					
• No. of subjects	166	119	–	208	–
• Cases with low optimism at 40 months, n (%)	18 (10.8%)	10 (8.4%)	–	14 (6.7%)	–
• Crude	1.0	0.75 (0.34–1.70)	0.50	0.59 (0.29–1.23)	0.16
• Model 1	1.0	0.76 (0.34–1.72)	0.51	0.57 (0.27–1.18)	0.13
• Model 2	1.0	0.89 (0.37-2.15)	0.80	0.67 (0.30-1.48)	0.32

Data are presented as OR (95%CI).

* Analyses were done in 445 subjects free of depressive symptoms and antidepressant treatment at baseline. The absence of depressive symptoms was defined as having a GDS-15 score ≤4 points.

** Analyses were done in 493 subjects free of low dispositional optimism scores and antidepressant treatment at baseline. Low dispositional optimism was defined as having a LOT-R score <12 points.

P-values obtained using logistic regression.

Model 1: adjusted for age and gender.

Model 2: adjusted for age, sex, education, marital status, smoking habits, alcohol use, treatment group, diabetes mellitus, stroke, time since myocardial infarction, BMI, and MMSE score.

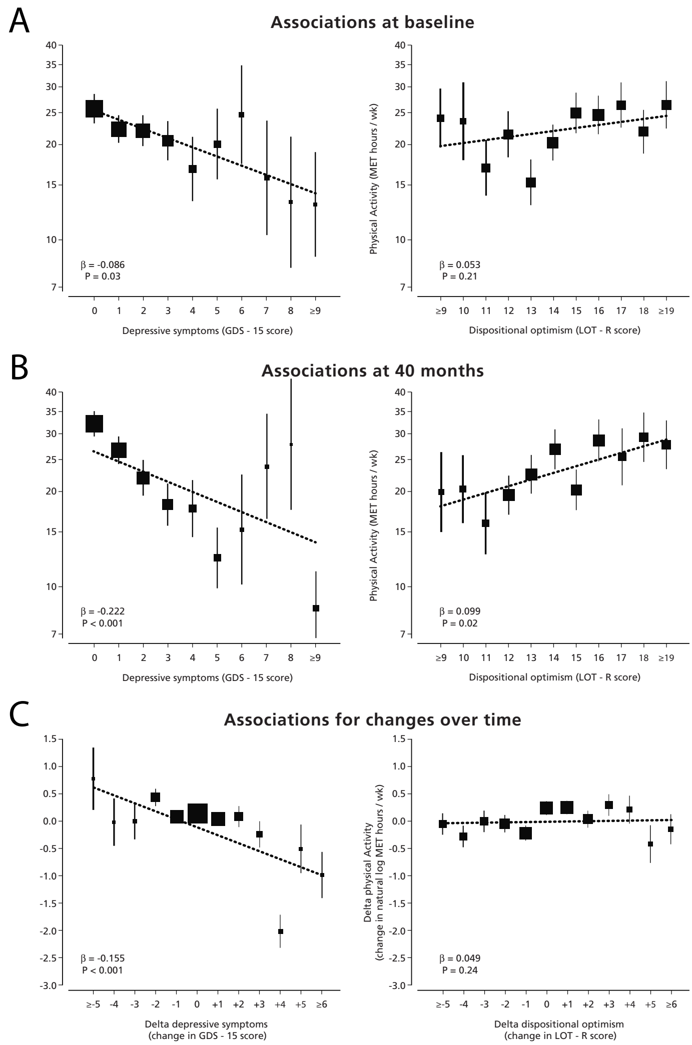


Figure 1. Associations between physical activity on the one hand and depressive symptoms and dispositional optimism scores on the other hand in 600 patients with a history of MI Figure 1A corresponds to the associations at baseline, Figure 1B depicts the association after 10 month of follow-up; Figure 1C shows synchrony of change during follow-up. Mean standard scores (with error bars representing standard errors) are presented. The box size is proportional to the number of patients P-values were obtained with one-way ANOVA analyses for linear trend.

tional optimism are presented in Table 4. Among the participants without depressive symptoms at baseline, participants who reported moderate and/or vigorous activity were not at a statistically significant lower risk of having depressive symptoms after 40 months of follow-up compared to participants who reported no baseline physical activity. Similarly, in those participants without low optimism at baseline, no protective effect of baseline physical activity against low dispositional optimism at 40 months was found.

Discussion

Our study among older subjects with a history of MI showed that physical inactivity was cross-sectionally associated with depressive symptoms, but not with dispositional optimism. We found a reciprocal relationship of physical activity with depressive symptoms, but not with dispositional optimism. Low physical activity at baseline did, however, not predict future depressive symptoms or low dispositional optimism.

A major strength of this study was its prospective longitudinal design and the use of a validated physical activity questionnaire (i.e. PASE) that allowed retrieving detailed information on common leisure or household activities, which are very relevant in older subjects. Nevertheless, some limitations should be considered. Because physical activity was assessed using a self-report questionnaire, it is possible that the provided information resulted in an overestimation and measurement error of actual physical activities (Conway, Seale, Jacobs, Irwin, & Ainsworth, 2002). Another limitation of our study is that depressive symptoms were assessed using the GDS-15 instead of a structured interview. The GDS-15 is, however, a reliable instrument which specifically assesses depressive symptoms in older subjects with limited items considering somatic symptoms (de Craen et al., 2003), which is particularly relevant in patients with somatic conditions as the symptoms could derive from their somatic condition rather than from depressive symptoms.

Our finding of synchrony of change between physical activity and depressive symptoms is in line with the results of a recent study among older European community-dwelling subjects which found a reciprocal relationship between physical activity and depression (Lindwall, Larsman, & Hagger, 2011). Both studies suggest a dynamic interplay between physical activity and depressive symptoms across time. In our study, however, less physical activity at baseline was not predictive of depressive symptoms at 40 months. The lack of a predictive effect of physical activity on depressive symptoms is in line with several population-based studies among older subjects, which found a cross-sectional, but no longitudinal association between physical activity and depressive symptoms (Weyerer, 1992; Kritz-Silverstein et al., 2001; Cooper-Patrick et al., 1997; Perrino, Mason, Brown, & Szapocznik, 2010). However, our findings are discrepant with some other prospective studies that did find physical activity to predict depressive symptoms in subjects free of depressive symptoms at baseline (Camacho et al., 1991; Farmer et al., 1988; Wise et al., 2006). These inconsistencies could be due to the different questionnaires used to assess physical activity, differences in age, differences in prevalence rates of depressive symptoms, or the inclusion of patients with a history of MI in our study while previous prospective studies were done in the general population.

Our finding of an inverse association between physical activity and depressive symptoms coincides with the results of other cross-sectional studies among patients with cardiovascular disease (Win et al., 2011; Milani et al., 2011). A variety of biological and psychological mechanisms may explain the strong association between these phenomena. Physical activity may positively affect mood by increasing brain levels of monoamines and endorphins (Dishman, 1997; Chaouloff, 1997), or increasing cerebral blood flow (Rogers, Meyer, & Mortel, 1990). Physical activity may also influence depressive symptoms by improving self-esteem and providing a greater sense of self-mastery and autonomy (McAuley et al., 2007; Aamot et al., 2010) . Furthermore, the social interaction that derives from physical activity through sport participation and joining sports clubs may provide social support (Trost, Owen, Bauman, Sallis, & Brown, 2002). Although we cannot exclude the possibility that there is a direct causal relationship between physical activity and depressive symptoms, a likely explanation is that physical activity and depressive symptoms affect each other on the short-term time frame only.

References

Aamot, I., Moholdt, T., Amundsen, B., Solberg, H., Morkved, S., & Stoylen, A. (2010). Onset of exercise training 14 days after uncomplicated myocardial infarction: a randomized controlled trial. *Eur J Cardiovasc Prev Rehabil, 17, 387-392.*

Baruth, M., Lee, D., Sui, X., Church, T., Marcus, B., Wilcox, S. et al. (2011). Emotional Outlook on Life Predicts Increases in Physical Activity Among Initially Inactive Men. *Health Educ Behav.*

Camacho, T., Roberts, R., Lazarus, N., Kaplan, G., & Cohen, R. (1991). Physical activity and depression: evidence from the Alameda County Study. *Am J Epidemiol, 134, 220-231.*

Carver, C., Scheier, M., & Segerstrom, S. (2010). Optimism. *Clin Psychol Rev.*

Chaouloff, F. (1997). Effects of acute physical exercise on central serotonergic systems. *Med Sci Sports Exerc, 29, 58-62.*

Conn, V. (2010). Depressive symptom outcomes of physical activity interventions: meta-analysis findings. *Ann Behav Med, 39, 128-138.*

Conway, J., Seale, J., Jacobs, D. J., Irwin, M., & Ainsworth, B. (2002). Comparison of energy expenditure estimates from doubly labeled water, a physical activity questionnaire, and physical activity records. *Am J Clin Nutr, 75, 519-525.*

Cooper-Patrick, L., Ford, D., Mead, L., Chang, P., & Klag, M. (1997). Exercise and depression in midlife: a prospective study. *Am J Public Health, 87, 670-673.*

Davidson, K., Mostofsky, E., & Whang, W. (2010). Don't worry, be happy: positive affect and reduced 10-year incident coronary heart disease: the Canadian Nova Scotia Health Survey. *Eur Heart J, 31, 1065-1070.*

de Craen, A., Heeren, T., & Gussekloo, J. (2003). Accuracy of the 15-item geriatric depression scale (GDS-15) in a community sample of the oldest old. *Int J Geriatr Psychiatry, 18, 63-66.*

Dishman, R. (1997). Brain monoamines, exercise, and behavioral stress: animal models. *Med Sci Sports Exerc, 29, 63-74.*

Donker, F. (2000). Cardiac rehabilitation: a review of current developments. *Clin Psychol Rev, 20, 923-943.*

Farmer, M., Locke, B. Z., Moscicki, E., Dannenberg, A., Larson, D., & Radloff, L. (1988). Physical activity and depressive symptoms: the NHANES I Epidemiologic Follow-up Study. *Am J Epidemiol, 128, 1340-1351.*

Frasure-Smith, N., Lesperance, F., Habra, M., Talajic, M., Khairy, P., Dorian, P. et al. (2009). Elevated depression symptoms predict long-term cardiovascular mortality in patients with atrial fibrillation and heart failure. *Circulation, 120, 134-40, 3p.*

Gauvin, L. & Spence, J. (1996). Physical activity and psychological well-being: knowledge base, current issues, and caveats. *Nutr Rev, 54, S53-S65.*

Geleijnse, J., Giltay, E., Schouten, E., de, G. J., Griep, L., Teitsma-Jansen, A. et al. (2010). Effect of low doses of n-3 fatty acids on cardiovascular diseases in 4,837 post-myocardial infarction patients: design and baseline characteristics of the Alpha Omega Trial. *Am Heart J, 159, 539-546.*

Giltay, E., Geleijnse, J., Zitman, F., Buijsse, B., & Kromhout, D. (2007). Lifestyle and dietary correlates of dispositional optimism in men: The Zutphen Elderly Study. *J Psychosom Res, 63, 483-490.*

Giltay, E., Geleijnse, J., Zitman, F., Hoekstra, T., & Schouten, E. (2004). Dispositional optimism and all-cause and cardiovascular mortality in a prospective cohort of elderly dutch men and women. *Arch Gen Psychiatry, 61, 1126-1135.*

Giltay, E., Kamphuis, M., Kalmijn, S., Zitman, F., & Kromhout, D. (2006). Dispositional optimism and the risk of cardiovascular death: the Zutphen Elderly Study. *Arch Intern Med, 166, 431-436.*

Giltay, E., Zitman, F., & Kromhout, D. (2006). Dispositional optimism and the risk of depressive symptoms during 15 years of follow-up: the Zutphen Elderly Study. *J Affect Disord, 91, 45-52.*

Jonsdottir, I., Rodjer, L., Hadzibajramovic, E., Borjesson, M., & Ahlborg, G. Jr. (2010). A prospective study of leisure-time physical activity and mental health in Swedish health care workers and social insurance officers. *Prev Med, 51, 373-377.*

Kavussanu, M. & McAuley, E. (1995). Exercise and optimism: are highly active individuals more optimistic? *Journal of Sport and Exercise Psychology, 17, 246-258.*

Kritz-Silverstein, D., Barrett-Connor, E., & Corbeau, C. (2001). Cross-sectional and prospective study of exercise and depressed mood in the elderly : the Rancho Bernardo study. *Am J Epidemiol, 153, 596-603.*

Kromhout, D., Giltay, E., & Geleijnse, J. (2010). n-3 fatty acids and cardiovascular events after myocardial infarction. *N Engl J Med, 363, 2015-2026.*

Lampinen, P., Heikkinen, R., Kauppinen, M., & Heikkinen, E. (2006). Activity as a predictor of mental well-being among older adults. *Aging Ment Health, 10, 454-466.*

Lett, H., Blumenthal, J., Babyak, M., Sherwood, A., Strauman, T., Robins, C. et al. (2004). Depression as a risk factor for coronary artery disease: evidence, mechanisms, and treatment. *Psychosom Med, 66, 305-315.*

Lindwall, M., Larsman, P., & Hagger, M. (2011). The reciprocal relationship between physical activity and depression in older european adults: A prospective cross-lagged panel design using share data. *Health Psychol.*

Macera, C., Ham, S., Jones, D., Kimsey, C., Ainsworth, B., & Neff, L. (2001). Limitations on the use of a single screening question to measure sedentary behavior. *Am J Public Health, 91, 2010-2012.*

Maier, S. & Seligman, M. (1976). Learned helplessness: Theory and evidence. *Journal of Experimental Psychology, 105, 3-46.*

Mata, J., Thompson, R., Jaeggi, S., Buschkuehl, M., Jonides, J., & Gotlib, I. (2011). Walk on the bright side: Physical activity and affect in major depressive disorder. *J Abnorm Psychol.*

McAuley, E., Morris, K., Motl, R., Hu, L., Konopack, J., & Elavsky, S. (2007). Long-term follow-up of physical activity behavior in older adults. *Health Psychol, 26, 375-380.*

Milani, R., Lavie, C., Mehra, M., & Ventura, H. (2011). Impact of exercise training and depression on survival in heart failure due to coronary heart disease. *Am J Cardiol, 107, 64-68.*

Netz, Y., Wu, M., Becker, B., & Tenenbaum, G. (2005). Physical activity and psychological well-being in advanced age: a meta-analysis of intervention studies. *Psychol Aging, 20, 272-284.*

Pate, R., Pratt, M., Blair, S., Haskell, W., Macera, C., Bouchard, C. et al. (1995). Physical activity and public health. A recommendation from the Centers for Disease Control and Prevention and the American College of Sports Medicine. *JAMA, 273, 402-407.*

Perrino, T., Mason, C., Brown, S., & Szapocznik, J. (2010). The relationship between depressive symptoms and walking among Hispanic older adults: a longitudinal, cross-lagged panel analysis. *Aging Ment Health, 14, 211-219.*

Reed, J. & Ones, D. (2006). The effect of acute aerobic exercise on positive activated affect: A meta-analysis. *Psychology of Sport and Exercise, 7, 477-514*.

Rogers, R., Meyer, J., & Mortel, K. (1990). After reaching retirement age physical activity sustains cerebral perfusion and cognition. *J Am Geriatr Soc, 38, 123-128.*

Sanchez-Villegas, A., Ara, I., Guillen-Grima, F., Bes-Rastrollo, M., Varo-Cenarruzabeitia, J., & Martinez-Gonzalez, M. (2008). Physical activity, sedentary index, and mental disorders in the SUN cohort study. *Med Sci Sports Exerc, 40, 827-834.*

Scheier, M., Carver, C., & Bridges, M. (1994a). Distinguishing optimism from neuroticism (and trait anxiety, self-mastery, and self-esteem): a reevaluation of the Life Orientation Test. *Journal of Personality and Social Psychology, 67, 1063-1078.*

Scheier, M., Carver, C., & Bridges, M. (1994b). Distinguishing optimism from neuroticism (and trait anxiety, self-mastery, and self-esteem): a reevaluation of the Life Orientation Test. *J Pers Soc Psychol, 67, 1063-1078.*

Schuit, A., Schouten, E., Westerterp, K., & Saris, W. (1997). Validity of the Physical Activity Scale for the Elderly (PASE): according to energy expenditure assessed by the doubly labeled water method. *J Clin Epidemiol, 50, 541-546.*

Scully, D., Kremer, J., Meade, M., Graham, R., & Dudgeon, K. (1998). Physical exercise and psychological well being: a critical review. *Br J Sports Med, 32, 111-120.*

Sternfeld, B., Cauley, J., Harlow, S., Liu, G., & e, M. (2000). Assessment of physical activity with a single global question in a large, multiethnic sample of midlife women. *Am J Epidemiol, 152, 678-687.*

Strawbridge, W., Deleger, S., Roberts, R., & Kaplan, G. (2002). Physical activity reduces the risk of subsequent depression for older adults. *Am J Epidemiol, 156, 328-334.*

Strohle, A. (2009). Physical activity, exercise, depression and anxiety disorders. *J Neural Transm, 116, 777-784.*

Stubbe, J., de Moor, M., Boomsma, D., & de Geus, E. (2007). The association between exercise participation and well-being: a co-twin study. *Prev Med, 44, 148-152.*

Teychenne, M., Ball, K., & Salmon, J. (2008). Physical activity and likelihood of depression in adults: a review. *Prev Med, 46, 397-411.*

Trost, S., Owen, N., Bauman, A., Sallis, J., & Brown, W. (2002). Correlates of adults' participation in physical activity: review and update. *Med Sci Sports Exerc, 34, 1996-2001.*

van de Rest, O., de, G. J., Sytsma, F., Oude Griep, L., Geleijnse, J., Kromhout, D. et al. (2010). Association of n-3 long-chain PUFA and fish intake with depressive symptoms and low dispositional optimism in older subjects with a history of myocardial infarction. *Br J Nutr, 103, 1381-1387.*

Washburn, R., McAuley, E., Katula, J., Mihalko, S., & Boileau, R. (1999). The physical activity scale for the elderly (PASE): evidence for validity. *J Clin Epidemiol, 52, 643-651.*

Weyerer, S. (1992). Physical inactivity and depression in the community. Evidence from the Upper Bavarian Field Study. *Int J Sports Med, 13, 492-496.*

Win, S., Parakh, K., Eze-Nliam, C., Gottdiener, J., Kop, W., & Ziegelstein, R. (2011). Depressive symptoms, physical inactivity and risk of cardiovascular mortality in older adults: the Cardiovascular Health Study. *Heart, 97, 500-505.*

Wise, L., Adams-Campbell, L., Palmer, J., & Rosenberg, L. (2006). Leisure time physical activity in relation to depressive symptoms in the Black Women's Health Study. *Ann Behav Med, 32, 68-76.*

Yesavage, J. A., Brink, T. L., Rose, T. L., Lum, O., Huang, V., Adey, M. et al. (1982). Development and validation of a geriatric depression screening scale: a preliminary report. *J.Psychiatr.Res., 17, 37-49.*