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Published in:
Journal of Epidemiology and Community Health

DOI:
10.1136/jech.2009.103077

Full title:
Concurrent and prospective associations
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MeSH keywords: cohort studies, exercise, longitudinal studies; mental health, risk factors

TEXT WORD COUNT: 2948

ABSTRACT WORD COUNT: 250 words

REFERENCES: 50

FIGURES : 2

TABLES: 2

ABSTRACT

Background: Leisure-time physical activity (LTPA) shows promise for reducing the risk of poor mental health in later life, although gender- and age-specific research is required to clarify this association. This study examined the concurrent and prospective relationships between both LTPA and walking with mental health in older women.

Methods: Community-dwelling women aged 73–78 years completed mailed surveys in 1999, 2002, and 2005 for the Australian Longitudinal Study on Women's Health. Respondents reported their weekly minutes of walking, moderate LTPA, and vigorous LTPA. Mental health was defined as the number of depression and anxiety symptoms, as assessed with the Goldberg Anxiety and Depression Scale (GADS). Multivariable linear mixed models, adjusted for socio-demographic and health-related variables, were used to examine associations between 5 levels of LTPA (none, very low, low, intermediate, and high) and GADS scores. For women who reported walking as their only LTPA, associations between walking and GADS scores were also examined. Women who reported clinical levels of depression or anxiety in 1999 were excluded, resulting in data from 6,653 women being included in these analyses.

Results: Inverse dose-response associations were observed between both LTPA and walking with GADS scores in concurrent and prospective models ($p<0.001$). Even low levels of LTPA and walking were associated with lowered scores. The lowest scores were observed in women reporting high levels of LTPA or walking.

Conclusion: The results support an inverse dose-response association between both LTPA and walking with mental health, over 6 years in older women without clinical depression or anxiety.

Poor mental health interferes with well-being and daily functioning, and may go untreated in older people, resulting in reduced quality of life.[1] Depression in later life is a risk factor for social isolation and restricted activities,[2] impairments in mobility and functioning,[3] exacerbation of physical illnesses,[4] and increased health service use.[2] The proportion of people using anxiety medication is higher for those aged 65-74 years (20%) than for any other age group.[5]

Physical activity (PA) shows promise for the prevention and management of poor mental health in older adults. Cross-sectional studies suggest an inverse association between PA and depression.[6-10] Moreover, intervention trials indicate that PA can improve psychological well-being[11] and reduce symptoms of negative affect,[12] depression,[13] and anxiety.[14-16] However, while some prospective studies have indicated an association between PA and decreased risk of depression[10, 17-19] and increased psychological well-being,[20, 21] others have found no association for depression.[7, 8]

One important difference among studies is the consideration of factors which may confound the association between PA and mental health. Covariates identified in prospective studies of older adults have included indicators of (a) sociodemographics, such as social class,[19] income level,[17] financial strain,[10] and marital status;[10, 19, 20] (b) health, such as chronic illness;[10, 17, 21] (c) lifestyle, such as smoking status[8, 10] and body mass index;[8, 10, 20] (d) social connections, such as social support or relations;[8, 10] and (e) stress, such as the occurrence of major life events.[20] As past poor mental health is one of the strongest predictors of future poor mental health,[7, 21] this is another potential covariate, with one study excluding participants with clinical signs of poor mental health[8] and another stratifying by level of symptomatology.[18]

The association between PA and mental health may be moderated by age, gender, and the type of activity done. Findings from intervention studies with older adults suggested a gradual decrease in the favorable effect of PA on psychological well-being and depression with age.[11] The results of these studies also suggest no gender differences,[11, 22] although prospective studies of mixed-aged adults suggest that PA has differential protective effects on the mental health of men and women.[23-25] One retrospective study of older adults showed that light exercise (e.g., walking) was inversely associated with depression in women but not in men, and that strenuous exercise was inversely associated with depression in men, but not in women.[26] Another found that walking was more strongly associated with well-being in late mid-aged adults than in younger adults.[27]

Few prospective studies have explored the dose-response relationship between PA and poor mental health, and none has focused on older adults.[28] A review of PA and depression in younger and mid-aged adults identified five dose-response studies, with reduced risk of depression from PA ranging from 1-7 hours/week; 20 minutes to 1 hour/week; and 20-30 minutes, 2-3 times/week.[29] Our previous research indicated that the equivalent of >150 minutes/week of moderate-intensity PA was associated with a decreased risk of poor mental health in sedentary mid-aged women.[30]

In summary, PA may be an important strategy for reducing the risk of poor mental health in later life, although more gender- and age-specific research is necessary to clarify this association, and to quantify the dose of PA required. As older women are more likely than older men to report symptoms of poor mental health and to use medication for poor mental health,[5] we focused on older women. The aim of this study was to explore concurrent and prospective

dose-response associations between PA and symptoms of depression and anxiety in a non-clinical, community-based sample of women aged 73 years or older.

METHODS

The Australian Longitudinal Study on Women's Health

The Australian Longitudinal Study on Women's Health (ALSWH) is a prospective study of factors affecting the health and well-being of Australian women aged 18-23 years (young), 45-50 years (mid-age), and 70-75 years (older) in 1996. Samples were randomly drawn from the national health insurance database, which includes all Australian citizens and permanent residents.[31] Women from rural and remote areas were intentionally over-sampled. Mailed surveys were first administered in 1996 and have subsequently been administered on a rolling basis every 3 years. The study was approved by the University of Newcastle Ethics Committee. Written informed consent was received from all respondents. Study details can be found at the ALSWH website.[32]

Study sample

These analyses included data collected from the older cohort in 1999, 2002 and 2005, time points for which the same LTPA measure was used. In 1996, 12,432 older women agreed to participate in the study. They were representative of women aged 70-75 years in Australia except for over-representation of women who were married or had a tertiary education.[31] Sixteen percent were lost to follow-up between 1996 and 1999, the latter being the baseline year for these analyses. The main reasons for attrition were withdrawal (29%), death (26%), non-return (24%) and inability to be re-contacted (15%).[33] Of 10,030 women who completed the 1999 survey, 8370 (83.4%) were eligible for this study as they did not have a clinical level of depression or anxiety

symptoms, defined as reporting no treatment for or diagnosis of depression or anxiety, no use of medications for depression or anxiety, and no anxiety/panic attacks.

Measurements

Depression and Anxiety

Scores on the Goldberg Anxiety and Depression Scale (GADS)[34] were used to measure symptoms of depression and anxiety. With recent research supporting the use of one composite depression and anxiety score in older adults,[35] responses were summed across all items to create a score ranging from 0–18 with a high score indicating more symptoms. Among older women who completed the 2002 ALSWH survey, scores demonstrated high sensitivity and specificity in relation to other measures of depression and anxiety symptoms, including the SF-36 mental health score, doctor-diagnosed depression and anxiety, and medication for depression and anxiety.[36] Depression and anxiety dimensions were highly correlated (r=0.65), which replicated findings from previous studies with community-dwelling adults[37] and older adults,[38] and a one overall scale (i.e., one factor) was found to be optimal.[36] Internal consistency was high (Cronbach's alpha=0.84).[36]

Leisure-Time Physical Activity and Walking

Items from the Active Australia survey[39-41] were used to measure LTPA, including walking. Minutes spent during the last week (in ≥10-minute sessions) walking briskly ("for recreation or exercise or to get from place to place"), in moderate-intensity LTPA ("like golf, social tennis, moderate exercise classes, recreational swimming, line dancing"), and in vigorous-intensity LTPA ("that makes you breathe harder or puff and pant, like aerobics, competitive sport, vigorous cycling, running, swimming") were reported. As described elsewhere,[42] a summary score took into account the differences in energy expenditure of the three LTPA types and the

large skewness of the data. The score was computed by multiplying the minutes in each type of LTPA by an assigned metabolic equivalent value (MET): (walking=3.0 METs; moderate-intensity LTPA=4.0 METs; vigorous-intensity LTPA=7.5 METs). LTPA was then categorized based on total MET.minutes/week: none (<40); very low (40-<180); low (180-<300); intermediate (300-<600); and high (≥600). The lower cut-off for the high category is equivalent to 150 minutes per week of moderate-intensity PA (i.e., 150 minutes x 4 METS = 600 MET.minutes), consistent with Australian and U.S. PA guidelines.[43, 44] A separate MET.minutes/week of walking variable was computed as minutes spent walking multiplied by 3.0 (METs) and categorized the same way.

Potential Confounding Variables

Potential confounders found to be associated with depression or anxiety in the literature included: area of residence (urban, large town, small town/rural area; derived from postal codes); highest educational level attained; ability to manage on one's income (a proxy for income status; categorized as "difficult/impossible" or "not difficult/impossible"); number of stressful life events in the past 12 months (e.g., death of spouse or partner, moving house, natural disaster), number of chronic conditions (from a list of health conditions, including diabetes, cancer, and heart disease) that women reported they had been told they had by a doctor in the previous 3 years[45]; and smoking status. The social environment was assessed as marital status and social support networks, which was measured with a modified version of the Social Networks subscale of the Duke Social Support Index.[46] Body mass index (BMI) was calculated as kg/m^2 based on reported height without shoes and weight without clothes or shoes, and categorized using the World Health Organization classification system.[47]

Statistical analyses

STATA 10.0 (StataCorp, College Station, TX, 2007) was used to compute linear mixed models (the XTMIXED function), which allows for the inclusion of all available data. Individuals served as random effects. Year of assessment served as a covariate to account for changes in the outcome as the women aged. Values from preceding and subsequent surveys were used to impute missing data for predictor variables measured at multiple time points. The HOT DECK function, in which all other variables in the dataset are used to impute a value, was used to impute predictor variables measured only once. Women with missing outcome data or with predictor variable data that could not be imputed were excluded. All predictor variables were entered as categorical variables except social network, which was entered as a continuous variable. Both simple models (adjusted for area of residence, education and marital status) and mulitivariable models (adjusted for all potential confounders) were computed to examination associations between the LTPA and walking variables and GADS scores.

To examine the cross-sectional (concurrent) relationships between LTPA and GADS scores, LTPA and potential confounders measured in 2002 and 2005 served as fixed effects in models without a time lag, with GADS scores in 2002 and 2005 serving as the outcome variable. To examine the association between past LTPA and GADS scores, LTPA and potential confounders measured in 1999 and 2002 served as fixed effects in prospective models with time-lag, with GADS scores in 2002 and 2005 serving as the outcome variable. Among women who reported no moderate or vigorous LTPA in 1999 or in 2002 (i.e., reported walking as their only LTPA), the same modeling was used, except walking replaced LTPA as the predictor variable of interest. For all models, least-square means and 95% confidence intervals for GADS scores were estimated, and a test for linear trend was computed by computing the same models as described, for a second time, but treating the LTPA variable in each model as a continuous variable.

RESULTS

Of the 8370 women who were eligible for this study, 1465 women (17.5%) were excluded because they had missing outcome data in 2002 or 2005. An additional 252 were excluded because they had missing data that could not be imputed for a confounding variable or for LTPA in 1999 or 2002, leaving data from 6653 women (79.5% of those eligible) available for analyses.

Characteristics of the women whose data were included in the analyses and those whose data were excluded are presented in Table 1. Compared with women whose data were included, those whose data were excluded were more likely to have a low level of education ($p<0.001$), live in a large town ($p<0.001$), be widowed ($p<0.001$), be experiencing more stressful life events ($p<0.001$), report at least three chronic conditions ($p=0.001$), be a current smoker ($p<0.001$), be classified as underweight ($p<0.001$), and be participating in no LTPA ($p<0.001$).

Table 1 Comparison of women whose data were included in the analysis sample to those whose data were not, using data collected in 1999

	Included (N=6653)		**Excluded (N=1717)**		**p-value**
Variables	**n**	**%***	**n**	**%***	
Education					<0.001
No high school	1,927	(29.0)	659	(38.4)	
Some high school	2,668	(40.1)	664	(38.7)	
Completed high school	926	(13.9)	196	(11.4)	
Trade certificate/university degree	1,132	(17.0)	198	(11.5)	
Area of residence					0.001
Urban	2,768	(41.6)	679	(39.6)	
Large town	813	(12.2)	267	(15.6)	

Small town/remote area	3,072	(46.2)	771	(44.9)	
Income management:					0.70
Not impossible or difficult	5,160	(77.6)	1,329	(77.4)	
Impossible or difficult	1,493	(22.4)	375	(21.8)	
Missing	*0*	*(0.00)*	*13*	(0.8)	
Marital status					0.001
Married/de facto	3,518	(52.9)	818	(47.6)	
Separated/divorced/never married	504	(7.6)	138	(8.0)	
Widowed	2,631	(39.6)	760	(44.3)	
Missing	*0*	*(0.00)*	*1*	(0.1)	
Number of stressful life events					<0.001
0	2,244	(33.7)	833	(48.5)	
1	1,954	(29.4)	445	(25.9)	
2	1,374	(20.7)	240	(14.0)	
3	1,081	(16.3)	199	(11.6)	
Number of chronic conditions					<0.001
0	1,794	(27.0)	491	(28.6)	
1	2,249	(33.8)	514	(29.9)	
2	1,507	(22.7)	369	(21.5)	
3 or more	1,103	(16.6)	343	(20.0)	
Smoking status					<0.001
Never	4,301	(64.7)	1,077	(62.7)	
Former	2,027	(30.5)	500	(29.1)	
Current	325	(4.9)	140	(8.2)	
Body mass index (kg/m^2)					<0.001
Healthy weight (18.5-<25)	3,254	(49.0)	628	(36.6)	
Underweight (<18.5)	187	(2.8)	66	(3.8)	
Overweight (25-<30)	2,317	(34.9)	375	(21.8)	
Obese (≥30)	881	(13.3)	164	(9.6)	

Missing	*0*	*(0.0)*	*484*	*(28.2)*	
Leisure-time physical activity (MET.min/wk†)					<0.001
None (0-<40)	1,725	(25.9)	532	(31.0)	
Very low (40-<180)	422	(6.3)	78	(4.5)	
Low (180-<300)	533	(8.0)	101	(5.9)	
Intermediate (300-<600)	1,211	(18.2)	329	(19.2)	
High (≥600)	2762	(41.5)	653	(38.0)	
Missing	*0*	*(0.0)*	*24*	*(1.4)*	

Respondents were excluded if they had missing data for the outcome variable or for a predictor variable that could not be imputed.

*****Percentage may not add up to 100% due to rounding errors.

†MET.minutes were computed as the sum of total leisure-time physical activity (LTPA) minutes after weighting time in each activity by its assigned metabolic equivalent value (walking: 3.0; moderate LTPA: 4.0; vigorous LTPA: 7.5).[42]

In 1999, 26% of the women in the included sample reported no LTPA. Another 12% reported moderate- or vigorous-intensity LTPA but not walking, and 39% reported walking as their only LTPA. The remaining 23% reported walking, as well as moderate- and/or vigorous-intensity LTPA.

The results of modeling the associations between concurrent and past activity (i.e., LTPA and walking) with GADS scores are shown in Table 2. Inverse dose-response associations were observed between both LTPA and walking with GADS scores in concurrent and prospective models ($p<0.001$). For both LTPA and walking, decreases in mean GADS scores, adjusted for the covariates in the respective models, were more pronounced for concurrent activity than for past activity. As shown by examining the confidence intervals in Figure 1, in fully-adjusted

models of concurrent activity, mean GADS scores were significantly lower for each activity category above the none category than for the none category, and means of each activity category were similar for LTPA and walking. As shown in Figure 2, in fully-adjusted models of past activity, GADS scores were significantly lower for all LTPA and walking categories above the very low category, compared with the none category, and again means of each activity category were for similar LTPA and walking.

Table 2 Least square means and 95% confidence intervals for GADS scores, for women in each concurrent and past physical activity category: results from linear mix-models analyses

	Simple models*			**Fully-adjusted models***		
Variables	**adjusted mean**	**95% CI**	**trend p-value**	**adjusted mean**	**95% CI**	**trend p-value**
Concurrent LTPA† (MET.mins/wk‡)			<0.001			<0.001
None (0-<40)	6.05	5.93 to 6.17		5.99	5.88 to 6.11	
Very low (40-<180)	5.41	5.18 to 5.63		5.27	5.05 to 5.49	
Low (180-<300)	5.26	5.05 to 5.48		5.05	4.84 to 5.26	
Intermediate (300-<600)	5.15	4.99 to 5.31		4.81	4.65 to 4.96	
High (≥600)	4.55	4.42 to 4.68		4.25	4.13 to 4.37	
Past LTPA§ (MET.mins/wk‡)			<0.001			<0.001
None (0-<40)	5.47	5.32 to 5.59		5.69	5.56 to 5.82	
Very low (40-<180)	5.24	5.01 to 5.47		5.35	5.12 to 5.57	

Low (180-<300)	5.10	4.89 to 5.30		5.14	4.94 to 5.35	
Intermediate (300-<600)	5.11	4.96 to 5.26		5.18	5.03 to 5.33	
High (≥600)	4.92	4.81 to 5.04		4.95	4.83 to 5.06	
Concurrent walking[†] (MET.mins/wk[††])			<0.001			<0.001
None (0-<40)	6.10	5.98 to 6.23		6.01	5.90 to 6.13	
Very low (40-<180)	5.48	5.24 to 5.72		5.32	5.09 to 5.55	
Low (180-<300)	5.32	5.08 to 5.56		5.08	4.84 to 5.31	
Intermediate (300-<600)	5.26	5.07 to 5.45		4.96	4.77 to 5.14	
High (≥600)	4.78	4.58 to 4.98		4.55	4.36 to 4.74	
Past walking[§] (MET.mins/wk[††])			<0.001			<0.001
None (0-<40)	5.60	5.46 to 5.73		5.80	5.66 to 5.93	
Very low (40-<180)	5.36	5.12 to 5.59		5.45	5.21 to 5.68	
Low (180-<300)	5.14	4.92 to 5.37		5.17	4.94 to 5.40	
Intermediate (300-<600)	4.97	4.79 to 5.15		5.02	4.84 to 5.21	
High (≥600)	4.97	4.79 to 5.15		4.97	4.80 to 5.15	

*****Simple models: means adjusted for education, area of residence, and marital status; full models: further adjustments for income management, social networks, number of stressful life events, number of chronic conditions, smoking status, and body mass index.

[†]Concurrent LTPA and walking were assessed at the same time as depression and anxiety (GADS scores).

[‡]MET.minutes were computed as the sum of total leisure-time physical activity (LTPA) minutes after weighting time in each activity by its assigned metabolic equivalent value (walking: 3.0; moderate LTPA: 4.0; vigorous LTPA: 7.5).[42]

[§]Past LTPA and walking were assessed 3 years earlier than depression and anxiety (GADS scores) were assessed.

[††]MET.minutes were computed as total walking minutes weighted by the metabolic equivalent value assigned to walking (3.0)

DISCUSSION

To the best of our knowledge, this study is the first to show both concurrent and prospective inverse dose-response relationships between LTPA level and symptoms of poor mental health in older adults. The findings indicate that among women aged 73-83 years without clinical depression or anxiety, higher levels of LTPA were associated with fewer depression and anxiety symptoms. The dose-response relationship between activity and mental health was remarkably similar for women who reported walking as their only form of physical activity. For both LTPA and walking, differences in mental health between the lowest and highest activity levels were small, equating to 1.5-1.7 symptoms in concurrent models but less than one symptom (0.74-.83) in prospective models. However, these findings are comparable with those found by others who examined PA and depressed mood in older adults,[8] and such differences could have large impacts at the population-level.[48]

Our findings support previous cross-sectional research with older adults that indicate an inverse association between PA and poor mental health,[6-9] and a positive association between walking and well-being.[27] The findings also support prospective studies that demonstrate that

PA is protective against poor mental health in later life.[10, 17, 19] Other prospective studies, however, have found no such association,[7, 8] but these studies used comparatively simple measures of PA, whereas the measure of PA in the present study provided an indication of energy expenditure based on duration and intensity of LTPA.

The current findings provide the first indication of the LTPA dose required to significantly reduce the future risk of poor mental health in older women without clinical depression or anxiety. The dose-response relationships between both concurrent and past LTPA with mental health over 6 years were very similar for women whose only physical activity was walking and those who reported walking as well as other LTPA. In all analyses, symptoms of depression and anxiety were lowest in the women reporting the highest levels of activity. However, even low levels of past activity (180 to <300 MET.mins/wk, or about 40-75 min of moderate-intensity LTPA), were associated with fewer symptoms. In contrast, most previous studies of dose indicate that ≥150 minutes/wk of moderate-intensity PA (equivalent to ≥600 MET.mins/wk) is required to decrease risk of depression,[29] although some intervention trials have demonstrated that lower PA levels can be beneficial for reducing depression and anxiety symptoms.[28]

The major strength of this study was the use of a large community-based sample of older women, a population not well-represented in previous studies examining the association between PA and poor mental health. The large sample size facilitated the inclusion of large numbers of study variables, and analyses were adjusted for potential confounders of the association between PA and mental health.[8, 10, 17, 19-21] The large sample size also allowed for PA variables to be categorized into five levels, for a more sensitive examination of dose-response relationships than used previously.

The primary limitation is the reliance on self-report data, which are vulnerable to bias and measurement error. Self-report PA data are, however, pragmatic for large population-based studies and are reliably associated with health-related outcomes.[49] The LTPA and outcome measures are widely used and have acceptable reliability and validity.[36-38, 40, 41] As the association between PA and mental health may be moderated by age[9, 11, 27] and gender,[23-26, 50] caution should be taken in generalizing these findings, from women aged 73-84 years, to other age groups or to older men. Study attrition could also have affected the results. The ALSWH included a fairly representative national sample of older women for the first survey in 1996,[31] but as with all prospective studies, women have withdrawn between survey administrations, with more healthy women remaining in the cohort.[33] The results of this "healthy" participation bias may be that the women retained in the study were more healthy than those lost to follow-up.

Conclusion

Poor mental health in later life has significant negative implications for psychological, social, and physical health, as well as for medication and health service utilization. The results of this study indicate that for older women in their 70s-80s, there are clear concurrent and prospective dose-response relationships between any type of LTPA and mental health, as well as between walking and mental health for those older women whose only LTPA is walking. Engaging in even low levels of LTPA or walking was associated with decreased depression and anxiety symptoms over 6 years. In conjunction with the consistently recognized physical benefits of PA, this study provides strong evidence that more attention should be given to promoting and supporting PA participation, in particular walking, in later life for women's mental health.

What is already known

Poor mental health in later life has significant negative implications for psychological, social, and physical health, as well as for medication and health service utilization. Cross-sectional and intervention studies of older adults indicate that physical activity may be inversely associated with poor mental health.

What this paper adds

For women in their 70s and 80s who do not have clinical signs of depression or anxiety, being physically active is associated with both current and future mental health. Engaging weekly in even low levels of leisure-time physical activity or of just walking may significantly reduce depression or anxiety symptoms over 6 years in older women. Older women should be encouraged to engage in walking, or other moderate-intensity physical activities, to reduce risk of poor mental health.

Acknowledgements: The research on which this paper is based was conducted as part of the Australian Longitudinal Study on Women's Health. It was conceived and developed by groups of inter-disciplinary researchers at the University of Newcastle and University of Queensland. We are grateful to the women who provided the survey data.

Funding: We are grateful to the Australian Government Department of Health and Ageing for funding of the ALSWH. Dr. Heesch was supported by a NHMRC program grant (Owen, Bauman and Brown; #301200) in Physical Activity and Health at The University of Queensland, School of Human Movement Studies. Dr. Burton was supported by a Heart Foundation Research Fellowship (PH08B3905) and an NHMRC Capacity Building Grant (252977) and Program Grant (301200) at The University of Queensland, School of Human Movement Studies. Funding sources had no role in this study.

Competing interests: None.

Figure 1. Least square means and 95% confidence intervals for GADS scores by concurrent LTPA and walking category, adjusted for education, area of residence, marital status, income management, social networks, number of stressful life events, number of chronic conditions, smoking status, and body mass index.

Figure 2. Least square means and 95% confidence intervals for GADS scores by past LTPA and walking category, adjusted for education, area of residence, marital status, income management, social networks, number of stressful life events, number of chronic conditions, smoking status, and body mass index.

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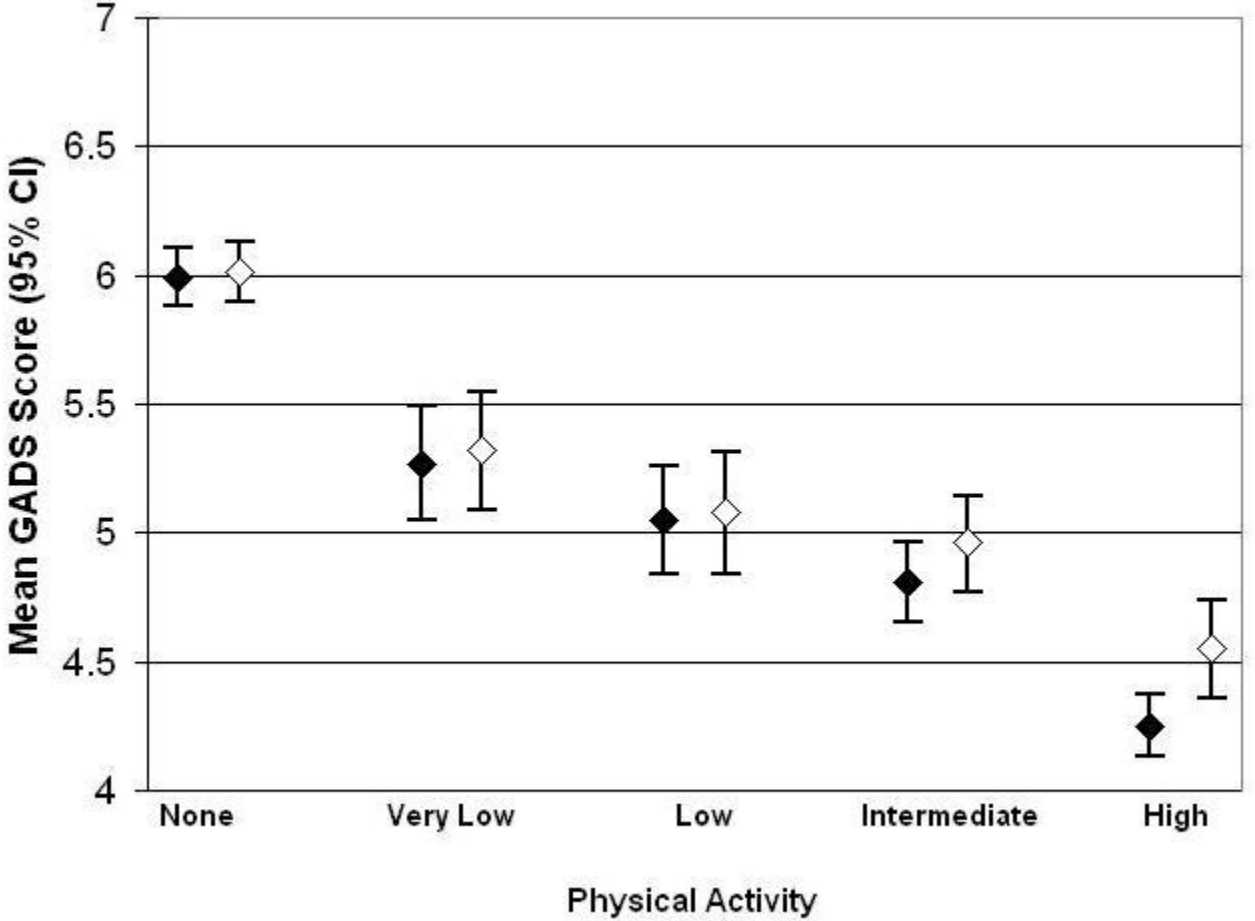
7
6.5
6
5.5
5
4.5
4
Mean GADS Score (95% CI)
None
Very Low
Low
Intermediate
High
Physical Activity