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Adolescents' Mental Health is Related to Physical Activity Operationalized in Different Ways

Lien entre la santé mentale des adolescents et diverses modalités de mesure de la pratique d'activité physique

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The relationship between multiple measures of physical activity (PA) and mental health among adolescents was examined. Adolescents (n = 460) in Toronto, Ontario completed four PA measures (assessing frequency of moderate PA, frequency of vigorous PA, frequency of moderate and vigorous PA, and metabolic equivalent (MET) hours/week) and the General Health Questionnaire - 12 (GHQ-12) scales. Participants who reported high PA had lower anxiety/depression and fewer problems in social functioning. Hierarchical regression results indicated that, in general, PA level operationalized in four different ways, along with selected demographic variables (age, sex and body mass index (BMI)), explained four to seven percent of the variance in mental health, with 2% typically and no more than 4% representing the additional variance contributed by the PA level. The negative relationship between mental health and various measures of PA is consistent, suggesting that policies and programs should promote mental health through PA.

Cette étude porte sur liens entre les nombreuses mesures de l'activité physique et la santé mentale chez les adolescents. Des adolescents (n = 460) de Toronto, en Ontario, se sont prêtés à quatre mesures de l'activité physique (évaluation de la fréquence d'une activité physique modérée, de la fréquence d'une activité physique vigoureuse, de la fréquence d'une activité physique modérée et vigoureuse, et équivalences métaboliques par heure/semaine) à l'aide des barèmes du Questionnaire sur la santé générale (General Health Questionnaire – 12). Les participants qui affirmaient avoir un haut niveau de pratique

d'activité physique avaient un taux d'anxiété et de dépression plus faible et moins de problèmes dans des contextes sociaux. Les résultats de l'analyse de régression hiérarchique indiquent qu'en général, le niveau d'activité physique, mesuré de quatre façons différentes, jumelé à certaines des variables démographiques (âge, sexe et indice de masse corporelle) peuvent expliquer de 4 % à 7 % des écarts en santé mentale, avec 2 % typiquement et pas plus de 4 % illustrant l'écart additionnel lié au niveau de pratique d'activité physique. La relation négative entre les problèmes de santé mentale et diverses mesures de l'activité physique est constante, ce qui porte à croire que les politiques et programmes devraient chercher à promouvoir la santé mentale par le biais de l'activité physique.

Introduction

The mental health benefits of participating in regular physical activity (PA) are often mentioned when promoting PA as a public health priority (Centers for Disease Control and Prevention (CDC), 2010, March 29; Health Canada, 2009, October 23; World Health Organization (WHO), 2011a). Some studies have shown that higher PA levels are associated with positive mental health among adolescents (Allison et al., 2005; De Moor, Beem, Stubbe, Boomsma, & De Geus, 2006; Kantomaa, Tammelin, Ebeling, & Taanila, 2008; Sagatun, Sogaard, Bjertness, Selmer, & Heyerdahl, 2007), whereas other research has found no relationship (Desha, Ziviani, Nicholson, Martin, & Darnell, 2007; Sanders, Field, Diego, & Kaplan, 2000). Comparing these inconsistent findings is difficult because PA is often operationalized differently. For example, PA has been operationalized as hours of exercise or PA per week (Sagatun et al., 2007; Sanders et al., 2000), hours of moderate and vigorous PA (MVPA) per week (Kantomaa et al., 2008), and frequency of at least 20 minutes of vigorous PA (VPA) (Allison et al., 2005). Other researchers used metabolic equivalent (MET) scores, which estimate the intensity for activities, to measure PA (De Moor et al., 2006; Desha et al., 2007). Also, mental health has been operationalized differently such as anxiety/depression (Allison et al., 2005; De Moor et al., 2006; Desha et al., 2007; Kantomaa et al., 2008; Sanders et al., 2000), problems in social functioning (Allison et al., 2005), somatic complaints (Kantomaa et al., 2008), and emotional symptoms and peer problems (Sagatun et al., 2007). The purpose of the current study was to examine the relationship between multiple measures of PA and mental health among adolescents.

Methods

Participants

Students in five Toronto high schools (n = 518) completed the measures. The analytic sample size was 460 based on removal of three individuals 18 years and over, removal of six outliers associated with the PA measure focusing on MET hours/week (see below), and listwise deletion to deal with missing data (n = 49). The mean age was 15.8 years (SD = 0.9), 58% were females, and 78% had a healthy weight, which represented the 5th percentile to less than the 85th percentile (CDC, 2009, January 27).

Measures

Demographic measures. Participants reported their age, sex, height, and weight. BMI-for-age (sex-specific) z-scores were identified using the CDC BMI-for-age growth charts (CDC, 2009, January 27).

PA measures. Three single-item measures from the 2005 Youth Risk Behavior Surveillance System Survey (CDC, 2006), which has good reliability (Brener, Collins, Kann, Warren, & Williams, 1995), was used to assess frequency of PA. The moderate PA (MPA) item requested how many of the past 7 days they participated in moderate-intensity activity (e.g., fast walking and slow bicycling), which makes them feel warmer and increases their breathing rate, for at least 30 minutes. The VPA item asked how many of the past 7 days they participated in vigorous-intensity activity (e.g., jogging and fast bicycling), which makes them sweat and breathe hard, for at least 20 minutes. The MVPA item requested how many of the past 7 days they participated in moderate- and vigorous-intensity activity for at least 60 minutes.

The Self-Administered Physical Activity Checklist (SAPAC), which has good validity (Ekelund, Neovius, Linne, & Rossner, 2006), was used as a more comprehensive measure of MVPA. Participants reported the number of days that 25 specific activities, such as soccer and dance, and 5 "other" activities were done in the past seven days (including physical education classes, school sports teams, and PA in non-school settings) and the average number of minutes that each activity was done. MET hours/week were computed by multiplying frequency (days), duration (hours), and MET values representing the intensity of each activity for youth (Ridley, Ainsworth, & Olds, 2008). One MET equals the rate of energy expended when at rest (WHO, 2011b). More than 500 MET hours/week was considered an outlier and removed (n = 2). More than 300 MET hours/week was truncated to 300 (n = 17).

General Health Questionnaire - 12 (GHQ-12). The GHQ-12, which has good validity (Allison et al., 2005; Politi, Piccinelli, & Wilkinson, 1994), was used to measure mental health: anxiety/depression and problems in social functioning. The measure has a 4-point Likert scale format.

Procedure

University and school board committees provided research ethics approval. Five high schools were conveniently selected and promotional flyers were circulated in schools. An information letter and parental consent form were sent home with interested students. In 2005, research staff administered the measures in the schools to students who returned a signed consent form.

Statistical Analysis

The data were logically and statistically examined to identify univariate outliers. Two participants who reported more than 500 MET hours/week and four participants with z-scores above ± 3.29 on this variable were excluded. There were no multivariate outliers, evaluated using Mahalanobis distance (Meyers, Gamst, & Guarino, 2006). Assumptions of correlation and regression analyses were examined. Except for MET hours/week, normality (assessed by examining histograms and skewness values for each predictor and outcome variable) was satisfactory. MET hours/week was positively skewed and therefore a square root transformation was used to obtain a normal distribution. Multicollinearity, which was assessed using correlations among predictors, the variance inflation factor, and the Durbin-Watson test, was not present in the data. Residual plots of variables showed that the assumptions of linearity and homoscedasticity were met.

To examine the bivariate relationship between PA and mental health, correlations were calculated and partial correlations that statistically controlled age, sex and BMI were computed. Hierarchical regression analyses were conducted to examine multivariate relationships when age, sex and BMI are statistically controlled. These three variables were entered first in the regression equation and therefore served as covariates (Meyers et al., 2006). They were statistically controlled because other researchers found that age is significantly associated with mental health (Allison et al., 2005) and sex is significantly related to mental health (Allison et al., 2005; Desha et al., 2007) and adjusted for BMI (Kantomaa et al., 2008) when examining the relationship between PA and mental health among adolescents.

Results

Participants reported between 3.5 and 3.9 days of moderate and/or vigorous PA (see Table 1). The median score for the non-transformed MET hours/week was 61.8. The GHQ-12 scales had good internal consistency reliability (Cronbach's alphas were .87 and .73, respectively) and were significantly, moderately correlated (.50, $p < .001$). The mean GHQ-12 scale scores were 2.0, which corresponds with the higher end of the psychological well-being continuum.

Table 1
Mean and Standard Deviation Scores for PA Measures and GHQ-12 Scales

Measure	Mean	SD
PA		
Frequency of MPA (at least 30 minutes)[a,b]	3.5	2.1
Frequency of VPA (at least 20 minutes)[a,b]	3.6	2.2
Frequency of MVPA (at least 60 minutes)[a,b]	3.9	2.0
Square root of SAPAC MVPA (MET hours/week)	8.3	3.7
GHQ-12[c]		
Anxiety/depression[d]	2.0	0.7
Problems in social functioning[e]	2.0	0.4

[a]Single item; [b]responses can range from zero to seven days; [c]scores can range from 1 (high psychological well-being) to 4 (low psychological well-being); [d]7-item scale; [e]5-item scale.

There were significant, positive, moderate Pearson correlations (.50 - .61, ps < .001) among the four PA measures. Therefore, high frequency of PA done at various intensities for different periods of time were interrelated and associated with high MET hours/week.

Bivariate Relationships

Table 2 shows significant, negative, low Pearson correlations between the PA measures and GHQ-12 scales. Participants who reported a higher frequency of moderate and/or vigorous PA and MET hrs/week had lower anxiety/depression and fewer problems in social functioning. The magnitude of the correlations were similar, ranging from -.11 to -.20 for the relationship

between PA and anxiety/depression and from -.18 to -.23 for the association between PA and problems in social functioning. The partial correlations showed a significant, negative relationship between PA and mental health. The exception was the non-significant relationship between MET hours/week and anxiety/depression.

Table 2
Correlations and Partial Correlations[a] Between PA Measures and GHQ-12 Scales

	Correlation		Partial correlation	
	GHQ-12 scale		GHQ-12 scale	
PA measure	Anxiety/ depression	Problems in social functioning	Anxiety/ depression	Problems in social functioning
Frequency of MPA (at least 30 minutes)[b,c]	-.14**	-.18***	-.10*	-.16***
Frequency of VPA (at least 20 minutes)[b,c]	-.20***	-.23***	-.16***	-.21***
Frequency of MVPA (at least 60 minutes)[b,c]	-.19***	-.18***	-.15***	-.15***
Square root of SAPAC MVPA (MET hours/week)	-.11*	-.19***	-.06	-.16***

[a]Age, sex and BMI-for-age (sex-specific) z-scores were statistically controlled.
[b]single item.
[c]responses can range from zero to seven days.
*p < .05, 1-tailed.
**p < .01, 1-tailed.
***p < .001, 1-tailed.

Multivariate Relationships

Table 3 shows the results of the regression analyses of the four PA measures predicting GHQ-12 anxiety/depression scores, while controlling for age, sex and BMI. In model 1, with age, sex and BMI in the equation, R^2 was significant ($F(3, 456) = 9.45$, $p < .001$, adjusted $R^2 = .05$). Entering frequency of MPA in model 2 in the first regression yielded a significant R^2 ($F(1, 455) = 5.00$, $p < .05$). Age, sex and frequency of MPA contributed significantly to the prediction of anxiety/depression. Six percent of the variance in anxiety/depression was explained by frequency of MPA while controlling for demographics, with 1% representing the additional variance contributed by frequency of MPA.

Table 3

Summary for Variables Predicting GHQ-12 Anxiety/Depression Scores in Four Hierarchical Regression Analyses: Standardized Beta and Standard Error (SE) of Beta (in parentheses)

Variable	Model 1		Model 2	
First regression				
Age	.11*	(.03)	.10*	(.03)
Sex (male = 1)	-.22***	(.06)	-.20***	(.06)
BMI z-scores	.01	(.03)	-.01	(.03)
Frequency of MPA (at least 30 minutes)			-.10*	(.01)
Adjusted R^2	.05		.06	
Second regression				
Age	.11*	(.03)	.09	(.03)
Sex (male = 1)	-.22***	(.06)	-.19***	(.06)
BMI z-scores	.01	(.03)	.01	(.03)
Frequency of VPA (at least 20 minutes)			-.16***	(.01)
Adjusted R^2	.05		.07	
Third regression				
Age	.11*	(.03)	.10*	(.03)
Sex (male = 1)	-.22***	(.06)	-.20***	(.06)
BMI z-scores	.01	(.03)	-.01	(.03)
Frequency of MVPA (at least 60 minutes)			-.15***	(.02)
Adjusted R^2	.05		.07	
Fourth regression				
Age	.11*	(.03)	.11*	(.03)
Sex (male = 1)	-.22***	(.06)	-.21***	(.06)
BMI z-scores	.01	(.03)	.01	(.03)
Square root of SAPAC MVPA (MET hrs/wk)			-.06	(.01)
Adjusted R^2	.05		.05	

*p < .05; **p < .01; ***p < .001.

First regression: $p < .001$ for adjusted R^2 (model 1) and $p < .05$ for Δ adjusted R^2 (model 2).

Second regression: $ps < .001$ for adjusted R^2 (model 1) and Δ adjusted R^2 (model 2).

Third regression: $ps < .001$ for adjusted R^2 (model 1) and Δ adjusted R^2 (model 2).

Fourth regression: $p < .001$ for adjusted R^2 (model 1) and $p > .05$ for Δ adjusted R^2 (model 2).

Entering frequency of VPA in model 2 in the second regression yielded a significant R^2 (F (1, 455) = 11.87, $p < .001$). Sex and frequency of VPA contributed significantly to the prediction of anxiety/depression. Seven percent of the variance in anxiety/depression was explained by frequency of VPA while controlling for demographics, with 2% representing the additional variance contributed by frequency of VPA.

Entering frequency of MVPA in model 2 in the third regression yielded a significant R^2 (F (1, 455) = 10.78, $p < .001$). Age, sex and frequency of MVPA contributed significantly to the prediction of anxiety/depression. Seven percent of the variance in anxiety/depression was explained by frequency of MVPA while controlling for demographics, with 2% representing the additional variance contributed by frequency of MVPA.

Entering MET hours/week in model 2 in the fourth regression yielded a non-significant R^2 (F (1, 455) = 1.66, $p > .05$, adjusted $R^2 = .05$). Age and sex contributed significantly to the prediction of anxiety/depression but MET hours/week did not make a significant contribution.

Table 4 shows the results of the regression analyses of the four PA measures predicting GHQ-12 problems in social functioning scores, while controlling for age, sex and BMI. In model 1, with age, sex and BMI in the equation, R^2 was significant (F (3, 456) = 3.48, $p < .05$, adjusted $R^2 = .02$). Entering frequency of MPA in model 2 in the first regression yielded a significant R^2 (F (1, 455) = 11.58, $p < .001$). Sex and frequency of MPA contributed significantly to the prediction of problems in social functioning. Four percent of the variance in problems in social functioning was explained by frequency of MPA while controlling for demographics, with 2% representing the additional variance contributed by frequency of MPA.

Table 4
Summary for Variables Predicting GHQ-12 Problems in Social Functioning Scores in Four Hierarchical Regression Analyses: Standardized Beta and Standard Error (SE) of Beta (in parentheses)

Variable	Model 1		Model 2	
First regression				
Age	.10*	(.02)	.09	(.02)
Sex (male = 1)	-.12*	(.04)	-.10*	(.04)
BMI z-scores	-.01	(.02)	-.02	(.02)
Frequency of MPA (at least 30 minutes)			-.16***	(.01)
Adjusted R^2	.02		.04	
Second regression				
Age	.10*	(.02)	.06	(.02)
Sex (male = 1)	-.12*	(.04)	-.08	(.04)
BMI z-scores	-.01	(.02)	-.01	(.02)
Frequency of VPA (at least 20 minutes)			-.21***	(.01)
Adjusted R^2	.02		.06	
Third regression				
Age	.10*	(.02)	.07	(.02)
Sex (male = 1)	-.12*	(.04)	-.10*	(.04)
BMI z-scores	-.01	(.02)	-.02	(.02)
Frequency of MVPA (at least 60 minutes)			-.16***	(.01)
Adjusted R^2	.02		.04	
Fourth regression				
Age	.10*	(.02)	.08	(.02)
Sex (male = 1)	-.12*	(.04)	-.08	(.04)
BMI z-scores	-.01	(.02)	-.02	(.02)
Square root of SAPAC MVPA (MET hrs/wk)			-.17***	(.01)
Adjusted R^2	.02		.04	

*p < .05; **p < .01; ***p < .001.
All four regressions: $p < .05$ for adjusted R^2 (model 1) and $p < .001$ for Δ adjusted R^2 (model 2).

Entering frequency of VPA in model 2 in the second regression yielded a significant R^2 ($F (1, 455) = 20.47$, $p < .001$). Only frequency of VPA contributed significantly to the prediction of problems in social functioning. Six percent of the variance in problems in social functioning was explained by frequency of VPA while controlling for demographics, with 4% representing the additional variance contributed by frequency of VPA.

Entering frequency of MVPA in model 2 in the third regression yielded a significant R^2 ($F (1, 455) = 11.03$, $p < .001$). Sex and frequency of MVPA contributed significantly to the prediction of problems in social functioning. Four percent of the variance in problems in social functioning was explained by frequency of MVPA while controlling for demographics, with 2% representing the additional variance contributed by frequency of MVPA.

Entering MET hours/week in model 2 in the fourth regression yielded a significant R^2 ($F(1, 455) = 12.61$, $p < .001$). Only MET hours/week contributed significantly to the prediction of problems in social functioning. Four percent of the variance in problems in social functioning was explained by MET hours/week while controlling for demographics, with 2% representing the additional variance contributed by MET hours/week.

Discussion

The correlations showed a significant, negative, albeit not strong relationship between adolescent PA, operationalized in four different ways, and both anxiety/depression and problems in social functioning. Thus, the nature of the relationship was consistent when PA was operationalized differently. The partial correlations revealed that this significant, negative relationship remained when the effects of age, sex and BMI were held constant, except for the association between MET hours/week and anxiety/depression, which provides some support for a non-spurious relationship between PA and mental health. The regression results indicated that, in general, PA level operationalized in four different ways and the selected demographics explained four to seven percent of the variance in mental health, with 2% typically and no more than 4% representing the additional variance contributed by the PA level.

The present results are consistent with findings from previous studies (Allison et al., 2005; De Moor et al., 2006; Kantomaa et al., 2008; Sagatun, 2007). Allison et al. (2005) found negative, weak correlations between VPA and mental health and reported that VPA and demographics explained only 3% of the variance in problems in social functioning. They measured VPA and mental health the same way as in the current study and therefore our results replicated findings from previous research using the same measurement approach. Also, De Moor et al. (2006) found that regular PA was associated with lower depression and anxiety. Similar to our study, they used MET scores to assess PA. In addition, the negative relationship between PA and mental health was consistent even when PA was measured differently across studies. Sagatun et al. (2007) found that regular PA was associated with lower depression and anxiety and Kantomaa et al. (2008) found that physical inactivity was associated with an increased likelihood of having several emotional and behavioural problems such as anxiety/depression, withdrawal/depression, and social and attention problems. Whereas we measured the number of days (frequency) of specific types of PA, Sagatun et al. (2007) and Kantomaa et al. (2008) assessed the number of hours (duration) of PA per week. Thus, there is a consistent negative relationship between PA and mental health among adolescents.

This study has some limitations. The cross-sectional study does not allow causality to be inferred. PA participation might lead to increased mental health or mental health might lead to increased PA participation, which can be examined by longitudinal research. Also, the results are based on self-reported data. PA and mental health may be influenced by accuracy of recall and social desirability. For example, participants may have overestimated their PA levels which would yield less accurate results and may have reported lower bodyweights which would result in a lower, healthier BMI and less valid findings. An objective PA measure such as an accelerometer could be utilised in future research and actual height and weight could be assessed. Further, the results cannot be generalized

beyond the convenience sample of self-selected students, with 11.2% of the sample removed to deal with some outliers and missing data. In terms of strengths, by focusing on students with complete data, we were able to examine relationships between measures among the same sample of students. The sample size was good with adequate representation of sex and age, and valid and reliable PA and mental health measures were used.

Considering the consistent relationship between mental health and various PA measures, policies and programs designed to promote mental health through PA should be developed, implemented and evaluated. The results support education and public health approaches to promote mental health through physical education, school intramural activities and sports teams, and other types of PA. Individuals responsible for developing and providing PA programs, such as physical education teachers and coaches, and mental health professionals should espouse the psychological health benefits of being physically active. While these strategies or activities should not be seen as a panacea for improving individual and population levels of mental health, it can be considered a potentially useful approach to dealing with this important public health issue.

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