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## Prospective Reciprocal Relations between Physical Activity and Depression in Adolescent Females

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### Abstract

**Objective**—Although research has found an inverse correlation between physical activity and depression among adolescents, few studies have examined this relation prospectively. Thus, we tested whether physical activity reduces risk for future escalations in depression and whether depression decreases likelihood of future change in physical activity.

**Method**—Data from a longitudinal study involving annual assessments of 496 adolescent girls (M age = 13, SD 0.7) followed over a 6-year period were analyzed to address these questions.

**Results**—Physical activity significantly reduced risk for future increases in depressive symptoms and risk for onset of major/minor depression and depressive symptoms and major/minor depression significantly reduced future physical activity, controlling for several covariates, though predictive effects were modest.

**Conclusions**—Results support a bidirectional relation between exercise and depression and imply that interventions that increase physical activity may reduce risk for depression among this high-risk population.

## Prospective Reciprocal Relations Between Physical Activity and Depression in Adolescent Females

Major depression is a common psychiatric disorder during adolescence that increases risk for suicide, academic failure, interpersonal problems, unemployment, substance abuse, and delinquency (Klein, Torpey, & Bufferd, 2008). The prevalence of depression also increases dramatically for girls relative to boys during early adolescence (Garber, Keiley, & Martin, 2002), suggesting it is important to elucidate factors that increase risk for depression in this population.

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Cross-sectional studies have found that low physical activity is correlated with depression. There are several mechanisms by which physical activity may influence risk for depression. First, physical activity may increase monoamines (e.g., serotonin, norepinephrine, dopamine), leading to positive affect and reduced risk for depression (O'Neal, Dunn, & Martinsen, 2000). Physical activity may also serve as a distraction to negative affect, which reduces risk for other maladaptive coping strategies (e.g., rumination), thereby reducing risk for depression (Just & Alloy, 1997). Physical activity has also been shown to improve self-esteem, which could reduce the risk for depression (Ekeland, Heian, & Hagen, 2005).

Although it is possible that physical activity reduces risk for future onset of depression, it is also possible that depression results in a reduction in future physical activity. A cardinal feature of depression is anhedonia, which may cause individuals to discontinue physical activities that they used to find enjoyable. The vegetative symptoms of depression, including motor retardation and low energy, may also lead to reduced activity. Thus, a key gap in the literature is to test the prospective relation between physical activity and depression to shed light on these competing hypotheses.

Several cross-sectional studies have reported negative correlations between physical activity and depressive symptoms, ranging from  $r = -.15$  to  $-.19$  (Motl, Birnbaum, Kubik, & Dishman, 2004; Norris, Carroll, & Cochrane, 1992). Cross-sectional studies that have examined the association between physical activity and depressive symptoms in multivariate models involving other risk factors have typically observed significant negative relations of this magnitude (e.g., Field, Diego, & Sanders, 2001; Kirkcaldy, Shephard, & Siefen, 2002), but null findings have also emerged (e.g. Haarasilta, Marttunen, Kaprio, & Aro, 2004). Although cross-sectional studies establish an association between physical activity and depression, causality can not be inferred.

To our knowledge, only one study has longitudinally tested the bidirectional relationship between physical activity and depressive symptoms. Birkeland, Torsheim, and Wold (2009) examined prospective bidirectional relations between physical activity and depression over 10 years in an adolescent sample. Results showed no significant relationships between depressive symptoms and changes in physical activity nor vice versa. However, methodological issues such as the brief self-report measure of depression reduce our confidence in these findings.

Thus, this current study aimed to fill this gap in the literature by investigating the prospective bidirectional relations between physical activity and depressive symptoms among a large sample of adolescent girls followed over a 6-year period, using validated diagnostic interviews to assess depressive symptoms. We investigated whether prospective reciprocal relations were stronger when major depression diagnoses, or depressive symptoms were examined. Further, we tested whether physical activity reduces risk for future onset of major/minor depression. Given there are numerous known risk factors for depression, we wanted to assess the link between depression and physical activity in the context of 3 of those risk factors; social support, body dissatisfaction, and bulimic symptoms. (Seeley, Stice & Rohde, 2009). We also controlled for body mass given its strong association with a number of the variables.

## Method

### Participants and Procedures

Four hundred ninety six adolescent girls, aged 11 to 15 years (mean age = 13.0,  $SD = 0.73$ ) were recruited from 4 public (82%) and 4 private (18%) middle schools in a metropolitan city in the southwest United States. The participant distribution was representative of the population from which the sample was taken (Seeley, et al., 2009).

The study was described to parents and participants as an examination of adolescent physical and mental health. The local Institutional Review Board approved the study. The study utilized active parental consent, resulting in a participation rate of 56% of eligible girls, which is comparable to participation rates of other longitudinal studies that required active consent (Lewinsohn, et al., 1994). Girls completed a questionnaire, participated in structured interviews, and had their height and weight measured by female research assistants yearly over the 6-year follow-up. All participants received a \$15 gift certificate as compensation each assessment point.

## Measures

**Depression**—The Schedule for Affective Disorders and Schizophrenia for School-Age Children (Lewinsohn et al., 1994) collects information on the DSM IV criteria for Major Depressive Disorder on a monthly basis over the past year. Data from this structured interview was used to classify participants as having met diagnostic criteria for major depressive disorder or minor depression in the past year. Minor depression was diagnosed when girls met at least 5 of the criteria for a diagnosis of major depression, but endorsed a subclinical level of disturbance on at least one of the symptoms. The past year severity ratings for each symptom on the KSADS were also averaged to form a continuous depressive symptom composite at each assessment point. Response options ranged from 1 = not at all to 4 = severe symptoms. This measure has shown internal consistency, test-retest reliability, and discriminant validity (Ambrosini, 2000; Lewinsohn et al., 1994).

**Physical Activity**—A modified version of the Past Year Activity Scale (Aaron et al., 1995) was used to assess physical activity. Participants reviewed a list of 26 activities and checked those they had done more than 10 times in the past year outside of school physical education classes. The total number of physical activities indicated by each girl was used as the main physical activity variable in analyses. This scale has shown 1-month test-retest reliability ( $r = .79$ ) and convergent validity with team sport rosters (Aaron et al., 1995).

**Body dissatisfaction**—Eight items from the Satisfaction and Dissatisfaction with Body Parts Scale (Berscheid, Walster, & Bohrnstedt, 1973) assessed satisfaction with body parts that are often of concern to females (e.g., stomach, thighs, and hips). Response options range from 1 = *extremely satisfied* to 6 = *extremely dissatisfied* (scale range: 1–6). This scale has shown internal consistency ( $\alpha = .94$ ), 3-week test-retest reliability ( $r = .90$ ), and predictive validity for bulimic symptom onset (Stice, Shaw, Burton, et al., 2006).

**Bulimic symptoms**—The diagnostic items from the Eating Disorder Examination (EDE; Fairburn & Cooper, 1993), a semi-structured investigator-based interview, assessed DSM-IV bulimia nervosa symptoms. Items assessing the symptoms in the past month were summed to create an overall bulimic symptom composite for each assessment point. The adapted symptom composite showed internal consistency ( $\alpha = .92$ ), 1-week test-retest reliability ( $r = .90$ ), sensitivity to detecting intervention effects, and predictive validity for future onset of depression in studies of adolescent and young adult females (Stice, Burton et al., 2004).

**Social support**—Perceived social support was measured with items adapted from the Network of Relationships Inventory (Furman & Buhrmester, 1985) assessing companionship, guidance, intimacy, affection, admiration, and reliable alliance from parents and peers using 5-point scales ranging from 1 = *strongly disagree* to 5 = *strongly agree*. The internal consistency ( $M \alpha = .89$ ), test-retest reliability ( $M r = .69$ ), and convergent and criterion validity of this measure have been documented (Furman & Buhrmester, 1985). This scale had an  $\alpha = .85$  at T1.

**Body Mass**—Body mass index was calculated by dividing weight in kilograms by height and meters squared. For these analyses, we converted BMI values to age and sex specific percentiles based on Center for Disease Control published values (Kuczmarski et al., 2002).

### Analytic Methods

Descriptive statistics were calculated for demographic characteristics of the sample and for all relevant variables in the study. Pearson and Spearman correlation coefficients with t-tests or Fisher's exact tests were used to describe and test the significance of the associations between total number of activities, depression status, BMI percentile, social support, body dissatisfaction and bulimic symptoms.

All longitudinal analyses were adjusted for baseline status of the outcome of interest, BMI percentile, social support, body dissatisfaction and bulimic symptoms (hereafter referred to as the covariates). For the binomial outcomes (e.g., major and minor depression), generalized linear models with a binomial distribution and a log link (Lipsitz, Kim, & Zhao, 1994) adjusted for covariates to evaluate the temporal association between number of physical activities in the previous year and the risk for onset of either minor or major depression. For the count outcomes (e.g., depressive symptoms and number of physical activities), a generalized linear model with a Poisson distribution and a log link (Diggle, Liang, & Zeger, 1994) adjusted for covariates were used to determine if depression symptoms in the previous year impacted future number of physical activities and vice versa. Results are reported as risk ratios with 95% confidence intervals. SAS version 9.1 was used for all analyses (SAS Institute, 1999).

### Results

Of the initial sample of 496 girls, 2% did not provide T2 data, 2% did not provide T3 data, 1% did not provide T4 data, 2.6% did not provide T5 data, and 3.6% did not provide T6 data for the variables studied in this report. Attrition analyses confirmed that girls who dropped out of the study did not significantly differ from girls who remained in the study on any of the study variables, suggesting attrition should not bias parameter estimates.

#### Incidence rates and correlations of depression and physical activity

The proportion of girls experiencing both major and minor depression overall was near 13%, which is consistent with rates reported in the literature (Angold, Erkanli, Silberg, Eaves, & Costello, 2002; Lewinsohn et al., 1994). The incidence rates of major and minor depression among the participants from time 1 to time 6 were as follows: 8%, 10%, 7%, 11%, 11%, and 6%. On average, adolescent girls participated in 3 to 4 physical activities over 10 times in the last year. Table 1 presents the overall means, standard deviations, and pair wise correlations between the variables. Overall means show a steady decline in the total number of physical activities over the six years of the study. Pearson correlations showed that the predictors had weak to moderate covariation, implying that have enough unique variance to be examined simultaneously.

#### Prospective associations between physical activity and major and minor depression

Table 2 displays the results from the generalized linear models evaluating risk for depression based on previous involvement in physical activities. The first model used depressive symptoms as the outcome, the second with major or minor depression as the outcome, and the third with only major depression as the outcome. All analyses adjusted for covariates. Results are presented as risk ratios. All predictive effects were statistically significant. Baseline physical activity predicted less increase in depressive symptoms over time. With regard to the onset models, for each additional physical activity, the relative risk of later depression

decreased by 1 percent for depressive symptoms, by 8 percent for major or minor depression and by 16 percent for major depression.

Table 3 displays results from the generalized linear models evaluating likelihood of participation in physical activities based on previous year depression status. After adjusting for covariates girls who had major depression were 35% less likely to participate in 1 additional physical activity a year later ( $p=.04$ ). Minor depression in one year decreased the likelihood of participation in 1 additional physical activity by 18 percent in a subsequent year. An increase by 1 depressive symptom over a year decreased the likelihood of participation in 1 additional physical activity in a subsequent year by 21%. Again, all predictive effects were statistically significant.

## Discussion

Prospective analyses showed that regular physical activity offers some protective effect for the onset of major/minor depression in adolescent girls and that major/minor depression influences the number of physical activities in which adolescent girls participate. Similar relations emerged when depressive symptoms were examined. These results extend prior cross-sectional studies that have reported a modest correlation between physical activity and depressive symptoms (e.g., Field, et al., 2001; Kirkcaldy et al., 2002; Motl et al., 2004). The present results also suggest that physical activity reduces risk for future depression. Involvement in physical activity may provide social connectedness, efficacy, and enjoyment, contributing to lower risk of depression onset. In the other direction of association, depression decreases the probability of later participation in physical activity. Anhedonia and psychomotor retardation may explain the lack of participation in activities. Also, low self-esteem that often accompanies depression might raise doubt in girls about their ability to play a sport. Clearly there are other risk factors for depression as many other studies have concluded (e.g., Lewinsohn et al., 1994; Seeley et al., 2009) which might explain the modest association found in the current study. However even when adjusting for several of those risk factors, physical activity still emerged with a modest association. Although the magnitude was not strong, the present data support the theory depression and physical activity are linked bidirectionally.

Rates of depression in the current study showed increases during adolescence, as has been observed in previous prospective studies (Lewinsohn et al., 1994). The decline in physical activity for girls during adolescence also replicates previous findings (i.e. Pratt, Macera, & Blanton, 1999). Given that physical activity reduces risk for depression onset, it is concerning that physical activity decreases at the same time depression rates are increasing. The decline in physical activity might contribute to the increased incidence of depression during adolescence for this group.

## Strengths and Limitations

Although this study had several strengths, including the large sample, prospective 6-year follow-up, low attrition rate, use of a multi-item measure of physical activity, and use of a diagnostic interview to assess depression, there were also important limitations. First, the measure of physical activity used was limited in its validity because it only assessed number of regular activities participated in, as opposed to a more detailed assessment of hours or MET levels. Second, the recruitment rate was moderately low, raising concerns about bias. Third, because the sample only included adolescent girls, with relatively few ethnic minority groups, the results cannot be generalized to adolescent boys or to other ethnic minorities.

## Implications and Directions for Future Research

The results offer a number of clinical implications. Providers who treat adolescent girls, particularly those who have a family history of depression or a personal history of previous episodes should encourage families to participate in activities together and decrease sedentary activities starting at young age as one component of prevention. Findings also have implications for future research. Given the modest protective effect of physical activity on depression found in this study, it would be beneficial to include it as a component of treatment and prevention studies. A randomized controlled trial (RCT) that includes physical activity with adolescent girls among other variables would be an excellent way of assessing treatment effects. Future studies should also investigate the factors that mediate the relation between physical activity and depression.

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**Table 1**

Overall pair wise correlations among variables, means, and standard deviations

	1	2	3	4	5	6	M	SD
1. Total number of activities (range = 1 – 10)	1.0	-.07**	-.01	-.09**	.08**	.08**	3.67	2.47
2. Major or Minor Depression		1.0	.05*	.16**	.11**	-.09**	.09	.28
3. BMI Percentile			1.0	.49**	.15**	-.11**	55.32	27.02
4. Body Dissatisfaction				1.0	.36**	-.18**	2.86	1.06
5. Bulimia Symptoms					1.0	.01	.58	1.22
6. Social Support						1.0	4.17	.81

\* p < .05

\*\* p < .01



**Table 2**

Results from generalized linear model evaluating the impact of previous year's number of physical activities on depressive symptoms, minor and major depression.

Variable	Risk Ratio	95% Confidence Interval	p-value
<i>Depression Symptoms</i>			
Number of activities previous year	0.99	0.98, 1.00	0.002
Baseline depression symptoms	1.17	1.08, 1.27	<0.001
<i>Minor Depression</i>			
Number of activities previous year	0.90	0.85, 0.96	0.002
Baseline depression	8.03	4.34, 14.86	<0.001
<i>Major Depression</i>			
Number of activities previous year	0.86	0.77, 0.95	.005
Baseline depression	14.92	6.89, 32.34	<0.001

Note: N = 496 for all analyses.

Analyses adjusted for baseline depression, body satisfaction, bulimic symptoms, social support, and previous year BMI percentile.

**Table 3**

Results from generalized linear models evaluating the impact of previous year's depression status or depressive symptoms on number of physical activities.

Variable	Risk Ratio	95% Confidence Interval	p-value
Depression as predictor			
Baseline physical number of physical activities	1.08	1.07–1.10	<0.001
Major depression previous year	0.68	0.57, 0.81	<0.001
Minor depression previous year	0.83	0.73, 0.94	0.005
Major or minor depression previous year	0.75	0.67, 0.84	<0.001
Depressive symptoms as predictor			
Baseline physical number of physical activities	1.08	1.07,1.10	<0.001
Previous year depression symptoms	0.80	0.73–0.88	<0.001

Note: N = 496 for all analyses.

Analyses adjusted for baseline depression, body satisfaction, bulimic symptoms, social support, and previous year BMI percentile.