Physical activity and depressive symptoms

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CHAPTER III

Physical Activity and Onset of Depression in Adolescents: A Prospective Study in the General Population Cohort TRAILS

"Living with depression is like trying to keep your balance while you dance with a goat—it is perfectly sane to prefer a partner with a better sense of balance"

Andrew Solomon, *The Noonday Demon*, 2001

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ABSTRACT

Purpose: Although it has often been suggested that physical activity and depression are intertwined, only few studies have investigated whether specific aspects of physical activity predict the incidence of major depression in adolescents from the general population. Therefore the aim of this study was to investigate the effects of nature, frequency, duration and intensity of physical activity during early adolescence on the onset of a major depressive episode in early adulthood.

Methods: In a population sample of adolescents (N = 1396), various aspects of physical activity were assessed at early adolescence (mean age = 13.02, SD = 0.61). Major depressive episode onset was assessed using the Composite International Diagnostic Interview. A Cox regression model was performed to investigate whether physical activity characteristics and their interactions with gender predicted a major depressive episode onset up until mean age 18.5 (SD = 0.61).

Results: The individual characteristics of physical activity (nature, frequency, duration and intensity) or their interactions with gender did not predict a major depressive episode onset (p-values>0.05).

Conclusion: So far, there is no prospective evidence that physical activity protects against the development of adolescent depressive episodes in either boys or girls.

INTRODUCTION

Physical activity (PA) has been shown to improve both physical and mental health, especially depression, in adults (Deslandes et al., 2009; Dunn, Trivedi, & O'Neal, 2001; Penedo & Dahn, 2005). The possibility that PA can reduce the risk of depression is particularly relevant in adolescence, a period of life characterized by a high incidence of depression (Hankin et al., 1998). However, only few studies have investigated the association between PA and depression in adolescents, and the results have been inconsistent so far (for a detailed review see: Biddle & Asare, 2011). A possible reason for these inconsistencies is that various aspects of PA affect the development of depression in diverse ways (Allison et al., 2005; Johnson & Taliaferro, 2011; Tao et al., 2007). To our knowledge, there are no studies on the specific effects of nature, duration and frequency of PA on depression in adolescents. A few studies have investigated the effects of PA intensity on depressive symptoms in adolescents, but their results are equivocal (Allison et al., 2005; Brand et al., 2010; Goldfield et al., 2011; Johnson & Taliaferro, 2011; Tao et al., 2007). Allison et al. (2005) found that vigorous PA was inversely associated with problems in social functioning, but it was not related to depression or anxiety after adjustment for age, gender and socioeconomic status (SES). Tao et al. (2007) found that light to moderate PA protected against the development of depressive symptoms, whereas high intensity PA was a risk factor for suicidal ideation and psychological distress. However, Tao et al.'s (2007) findings might be explained by cultural differences, since the population target was on Chinese adolescents. In contrast, Goldfield et al. (2011) found that light to moderate intensity PA was not related to depressive symptoms, whereas high intensity PA was associated with reduced depressive symptoms in boys. Goldfield's findings suggest that gender differences might be a source of heterogeneity in effects as well (Goldfield et al., 2011). Finally, Brand et al. (2010) found that adolescent athletes who exercised vigorously reported improved sleep and psychological functioning, including lower depressed mood than non-athletes. Another reason for the lack of clarity regarding the influence PA may have on adolescent depression is that most associations tested were cross-sectional (see reviews: Biddle & Asare, 2011 and Johnson & Taliaferro, 2011). One study found an inverse association between childhood PA and depression in late adulthood (Jacka et al., 2011) but this finding was based on retrospective reports of childhood PA and did not involve specific aspects of PA. Therefore, it remains to be elucidated whether specific aspects of PA have the potential to prevent depressive episodes in adolescents, and whether this preventive potential is equal for boys and girls.

Aim

The aim of this study was to investigate the prospective association of the nature (leisure-time PA), frequency, duration and intensity of PA during early adolescence with the onset of major depression during adolescence, and gender differences therein. We hypothesized that the amount of leisure-time PA, frequency, duration and intensity would be negatively associated with the probability to develop a major depressive episode (MDE) and that the associations would be stronger in boys than in girls.

METHODS

Design

This study is part of the Tracking Adolescents' Individual Lives Survey (TRAILS), a Dutch prospective cohort study of adolescents. The Dutch Central Committee on Research Involving Human subjects approved the study to be undertaken. Data collection for the first measurement wave (T1) started in 2001, while for the remaining waves data collection took place at intervals of approximately 2.5 years. Previous TRAILS publications (de Winter et al., 2005; Huisman et al., 2008; Ormel et al., 2012) provide extensive description(s) of TRAILS main design, data collection and sample selection. Informed consent was collected from the parents at T1, while for the second (T2) and third wave (T3) informed consent was obtained from both parents and participants. In the fourth wave (T4), the participants had reached the age of 18 and parental consent was not requested (Ormel et al., 2012). In this study we used data from T2 and T4.

Participants

At baseline, 2935 adolescents were requested to participate, of whom 2230 (response rate 76.0%; 51% girls, mean age = 11.1, SD = 0.55) agreed to do so. The response rates at T2 and T4 were 96.4% (N = 2149; 51% girls, mean age = 13.65, SD = 0.53), and 84.3% (N = 1881; 52.3% girls, mean age 19.1, SD = 0.60) respectively.

Procedure

During T2 questionnaires were sent through the mail to the parents or guardians, while the adolescents completed questionnaires at school. During T4, the adolescents filled out a web-based questionnaire, and were interviewed at home by a trained test assistant (for more information on recruitment procedures for all waves see: Nederhof et al., 2012).

Measures

Physical Activity

At T2, adolescents were asked to rate how often they engaged in PA during an average week: "How many days in an average week do you take part in physical activities?". These questions were rated on an eight-point scale ranging from 0 = never, up to 7 = 7 days per week. Furthermore, they could indicate the frequency and amount of time spent on up to four specific sports. Additional questions concerned the frequency and duration of walking or cycling to school or work and walking or cycling in free time. The percentage of leisure time PA (% LTPA) was calculated as a percentage of time spent in leisure time compared to the time spent on walking and cycling to school or work. Frequency was defined as the number of times the participant engaged in PA and duration (in minutes) of the PA per time, regardless of the nature of the PA. If participants reported walking or cycling both as a sport and in their free time, we only used the sports information to calculate the frequency and duration to avoid duplicate answers. Based on visual inspection of the duration data, participants who reported spending more than 225 minutes on a single activity were considered outliers and excluded from the analyses. The intensity of PA was expressed in metabolic equivalent of task (MET) scores, which were assigned to each sport using the MET score 2011 compendium (Ainsworth et al., 2011). Based on these scores we created two intensity measures: the peak MET score (the highest MET score) and the mean MET score across all activities. In case a participant did not report any sport, the MET scoring of cycling or walking in leisure time was used.

Depression

Depression was operationalized as a DSM-IV MDE and assessed using the World Health Organization Composite International Diagnostic Interview (CIDI) version 3.0 (Kessler & Ustun, 2004), which was administered at T4. The CIDI is a structured diagnostic interview, which yields the occurrence and age at onset of psychiatric disorders according to DSM-IV criteria, and has been shown to have good reliability and validity (Kessler et al., 2004). Because we aimed to investigate the effect of PA on the incidence of depression, adolescents who had developed an MDE before T2 (n = 103) were excluded from the analyses.

Socioeconomic Status

A measure of SES was obtained by averaging five standardized variables, describing the educational attainment and professional occupation of both parents and household income.

Statistical Analysis

All analyses were conducted using the Statistical Package for the Social Sciences (SPSS Inc., Chicago, IL.) version 20. Two-tailed tests with an alpha-level of 0.05 were performed. Cox regression analysis was used to investigate whether the T2 PA measures (%LTPA, frequency, duration and intensity) predicted the onset of an MDE between T2 and T4. SES and gender were included as covariates. The proportional hazards (PH) assumption was tested using the Schoenfield residuals. In case this test was significant for any of the predictor variables an extended Cox model was used to examine whether that variable interacted significantly with the time variable. If the interaction was not significant a normal Cox regression model was used. First, we tested a model including the main effects of the PA measures (%LTPA, frequency, duration, intensity) and covariates as predictors. After that, we added interactions of each of the PA measures with gender one by one. If the interaction term was significant, it was kept in the model. Finally, we examined to what extent the exclusion of adolescents due to outliers had influenced the results by repeating the analyses including these cases.

RESULTS

Descriptive Statistics

Of all T4 participants (n = 1881), 408 were excluded because they either did not complete the CIDI interviews or had developed an MDE before T2. A further 18 participants were excluded from the final analysis because the values reported for the average duration per activity were considered outliers. Finally, 59 participants had missing values on the PA and SES questions and therefore were also excluded from the analysis. The final sample consisted of 1396 participants (mean age at T2 = 13.02, SD = 0.61; mean age at T4 = 18.53, SD = 0.61).

739 (52.9%) girls and 657 boys, of whom 101 (13.6%) and 39 (5.9%) respectively, reported an MDE onset between T2 and T4. Table 1 shows the total number of minutes spent on PA per week, by gender, SES category, and MDE. The percentage spent on LTPA, the weekly frequencies of PA, the duration in minutes spent per activity, and the mean and peak intensity of activities for boys and girls are shown in table 2.

Prediction of Depression Onset by Physical Activity

The PA frequency variable violated the proportional hazards assumption (Schoenfield residual = 0.17, $p<0.05$), but the extended Cox regression model indicated that the interaction effect of frequency and time was not significant (p-value = 0.18), so we performed a regular Cox regression analysis. The results can be seen in Table 3. The main effect of gender was significant (with adolescent girls being more likely to develop an MDE than boys) but neither

Table 1. Minutes per week PA, by Gender, SES, and MDE.

Variables (N)	**Minutes per week of General PA** (Median and Interquartile range)
Gender	
Female (N = 739)	360 (210-735)
Male (N = 657)	410 (245-815)
SES	
Low SES (N = 262)	350 (190-752)
Interm. SES (N = 701)	375 (225-775)
High SES (N = 433)	420 (245-763)
MDE after T2	
Yes (N = 140)	380 (200-774)
No (N = 1256)	385 (226-765)

PA = physical activity, SES = socioeconomic status, MDE = major depressive episode.

Table 2. PA Nature (LTPA), Frequency, Duration and Intensity according to Gender and in the Total Sample.

Sample size	**LTPA** (%)	**PA Frequency** (times per week)	**PA Duration** (time)	**PA Intensity** (peak)	**PA Intensity** (mean)
Males (n = 657)					
Median	88	11	40	7	3
Interq. Range	73-95	8-15	26-59	6-8	2-4
Females (n = 739)					
Median	84	10	37	6	3
Interq. Range	67-94	8-14	23-55	4-7	2-4
Total (n = 1396)					
Median	86	11	38	7	3
Interq. Range	69-94	8-14	24-58	5-7	2-4

PA = physical activity, %LTPA = percentage of time spent on leisure time physical activities.

Table 3. Relationship of PA and MDE.

	B	SE	p-value	Hazard Ratio	95% CI
%LTPA	-0.16	0.11	0.12	0.85	0.69-1.05
PA Frequency	0.08	0.12	0.50	1.09	0.86-1.38
PA Duration	-0.02	0.10	0.81	0.98	0.81-1.18
PA MET Peak	-0.20	0.13	0.11	0.82	0.64-1.05
PA MET Mean	0.21	0.16	0.19	1.23	0.90-1.68
Gender[1]	-0.84	0.19	<0.001	0.43	0.30-0.63
SES[2]	-0.07	0.11	0.53	0.93	0.75-1.16

n = 1396, all PA variables were z-transformed prior to analysis.
PA = physical activity, %LTPA = percentage of leisure-time physical activity, MDE = major depressive episode, MET = metabolic equivalent of tasks, SES = socioeconomic status, SE = standard error, CI = confidence intervals.
[1] males are the reference group.
[2] SES was used as a continuous variable in analyses.

any of the PA measures nor their interactions with gender (p-value between 0.13 and 0.74) significantly predicted MDE onset.

As mentioned earlier, 18 subjects were excluded from the analysis because their average duration per activity was considered unrealistic (over 4 hours per activity). Including these subjects in the analyses did not change the results (data upon request).

DISCUSSION

To our knowledge, this is the first study on the prospective relationship between specific aspects of PA and the risk of developing an MDE in adolescents. Contrary to our expectations we did not find an effect of any of these aspects, nor interaction effects between PA aspects and gender.

Studies in adults suggest that PA may help prevent depression (Farmer et al., 1988; Kritz-Silverstein, Barrett-Connor, & Corbeau, 2001; Strawbridge, Deleger, Roberts, & Kaplan, 2002), but only few studies investigated the preventive role of PA in adolescents. Adolescence is a critical period with a high incidence of psychiatric disorders (Hankin et al., 1998). Prospective studies with assessments before the onset can help to understand the mechanisms that

lead to the development of mental health problems. In a previous study involving the same sample (Stavrakakis, de Jonge, Ormel, & Oldehinkel, 2012), we studied prospective relationships between general levels of PA and depressive symptoms between age 11 and 16, and found weak but significant negative associations, in both directions. In the present study, we focused on onset of depressive disorder and specific aspects of PA, and we did not find evidence of such effects. This might indicate that the association between PA and depressive symptoms found is mainly caused by the potential of PA to reduce symptoms in those suffering from depression (Mota-Pereira et al., 2011; Pilu et al., 2007; Silveira et al., 2013), or that PA is more strongly associated with sub-threshold depressive symptoms than with clinical depression. However, it is still possible that PA can prevent an onset of MDE in late adulthood, as reported by Jacka et al. (2011), even though we did not find an effect on adolescent depression. Alternatively, the different results of these two studies might be due to methodological differences between the two. Although Jacka et al.'s study (2011) had a larger sample than ours (n = 2152 vs. n = 1396), they only used self-reports for defining depression and not a validated and reliable measure such as the CIDI. Furthermore, they used a sample of older persons (median age for males = 55; median age for females = 57) who were asked to retrospectively calculate their PA levels at the age of 15. This might have introduced error in their results, since activity levels across the lifespan have been reported to be only weakly correlated (Friedman et al., 2008). In general, the relationship between PA and depression or depressive symptoms is a complex one. Networks of genetic and biological factors, personality, SES, and lifestyle habits interact and jointly affect depressive symptoms. In combination with specific other factors, PA might prevent the onset of a depressive episode.

Although there are indications that males and females benefit differently from different levels of PA participation (Asztalos, De Bourdeaudhuij, & Cardon, 2010; Mikkelsen et al., 2010), we did not observe an interaction between PA aspects and gender on MDE onset. For adults, gender differences in depression risk have been suggested with regard to the intensity of PA; women have been reported to benefit more from low intensity activities and men benefit more from higher intensity activities. In our study, PA intensity did not prevent the onset of depression in either gender.

It is important to elucidate the true role of PA on depression, since its effect may have been overestimated in the literature (Daley & Jolly, 2012). Reviews have suggested that PA is beneficial in alleviating depression (Dunn et al., 2001; Penedo & Dahn, 2005) but most of the reviewed findings concerned cross-sectional associations in observational studies, small samples of clinically depressed patients, short follow-up periods or non-clinical volunteers in intervention studies (Daley & Jolly, 2012). In other words, far-reaching conclusions have been drawn concerning the ability of PA to treat and prevent depression, while in fact the empirical basis is less firm than often thought. Our study by no means excludes the

possibility that PA can help to reduce depressive symptoms in healthy individuals as shown previously (Brand et al., 2010; Sigfusdottir, Asgeirsdottir, Sigurdsson, & Gudjonsson, 2011; Stavrakakis et al., 2012), but clearly suggests that PA cannot prevent or postpone the development of incident depressive episodes in adolescents.

A strength of this study is its large sample size, which provides sufficient power to detect relevant differences and avoid type II errors. A further advantage is the young age of the sample; the probability of confounding by prior depressive episodes or somatic conditions is relatively low in adolescence; and the (retrospective) dating of first MDE onsets is less liable to recall bias than in older samples. Furthermore, the longitudinal design, with a follow-up period of over 5 years, made it possible to investigate prospectively whether early PA engagement may protect against MDE onset. Finally, the use of the CIDI interviews, administered by trained test assistants, provided standardized measures of DSM-IV depression and its onset.

However, the results of this study have to be interpreted with some caution due to several limitations. First, all PA measures were based on self-reports. Although self-reports can provide an accurate measure of an individual's engagement in PA (Haskell, 2012; Milton, Clemes, & Bull, 2012), more objective measures such as accelerometers are preferred when possible. Self-reports can lead to an over-estimation of the levels of PA (due to social pressures) in some participants and therefore partly explain the lack of associations found. Second, we did not use a validated questionnaire, such as the International Physical Activity Questionnaire (IPAQ), and therefore cannot be certain on the trustworthiness of the responses. Finally, the measure of the nature of PA (%LTPA) is quite difficult to be used accurately in adolescence, since engagement in occupational PA is not that clear compared to adulthood. This measure was broad and only measured approximately the percentage of time spent on leisure-time compared to non-leisure time activities (commuting in this case). Therefore, conclusions about differential associations of PA nature (leisure-time vs. occupational activities) on depression onset should be tentative.

CONCLUSION

We did not find any evidence that the nature, frequency, duration or intensity of PA influenced the probability to develop a depressive episode in adolescence in neither boys nor girls.

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