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The association between past and current physical activity and depressive symptoms in young adults: a 10-year prospective study

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ABSTRACT

Purpose: The objectives of this study were to assess (1) the longitudinal associations of past moderate-to-vigorous physical activity (MVPA) and involvement in team sports during secondary school with depressive symptoms in early adulthood, and (2) the cross-sectional associations of current MVPA and involvement in team sports with depressive symptoms during young adulthood.

Methods: Data were drawn from the Nicotine Dependence in Teens study, which is an ongoing prospective cohort study of 1293 adolescents aged 12–13 years at baseline (52% female). Data analyses involved latent growth curve modeling and multiple hierarchical linear regression models.

Results: Current MVPA ($\beta = -0.12$), but not past MVPA, participation was significantly negatively related to depressive symptoms during young adulthood ($P < .05$). Both current and past involvement in team sports were significantly negatively related to depressive symptoms ($\beta = -0.09$; $P < .05$); however, these associations were no longer significant ($P = .08$) when covariates were controlled for.

Conclusions: Findings provide insight about the unique associations between the timing and type of physical activity and depressive symptoms, suggesting that physical activity within team sport contexts should be encouraged so that young adults may experience less depressive symptoms.

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Depression is a significant contributor to the burden of disease in developed countries [1]. It is estimated that 2%–9% of adolescents will suffer from a major depression disorder (MDD; [2–4]), and that more than 50% of depressed adolescents will continue to experience MDD into adulthood [5]. Moreover, almost one in five adolescents experience subthreshold depression (i.e., a temporary affective state or cluster of symptoms that fail to meet the diagnostic criteria; [6]). Adolescents with MDD or subthreshold depression report poorer quality of life and more difficulty in carrying out daily living functions than asymptomatic adolescents [7–10]. Identifying modifiable factors that relate to depression early in life is necessary to inform the development of optimal preventive interventions.

Previous research suggests that physical activity may be one modifiable factor that affects MDD and depressive symptoms. In

numerous cross-sectional studies, physical activity has been inversely associated with these states [11–18]. There are also a growing number of longitudinal studies in which researchers have indicated that physical activity may protect against the development of MDD and depressive symptoms [19–24]. Sagatun et al. [21] reported that physical activity at 15–16 years of age was inversely associated with negative emotional symptoms at 18–19 years of age, but only in boys. Jerstad et al. [19] found that higher levels of physical activity at 13 years of age reduced the risks for depressive symptoms and the onset of major depression at 19 years of age in girls. Motl et al. [20] showed that both girls and boys who were more active at 13–14 years of age reported lower levels of depressive symptoms 2 years later. In addition, change in physical activity was negatively related to change in depressive symptoms. In contrast, Rethon et al. [25] found a negative association between physical activity and depressive symptoms at baseline in 11- to 12-year-old boys and girls; however, change in physical activity from baseline to follow-up at 13–14 years of age was not statistically significantly associated with depressive symptoms at follow-up.

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Similarly, Clark et al. [26] observed that physical activity levels at 11–12 years of age were not associated with depressive symptoms at 13–14 years of age.

These inconsistent findings may be attributed, in part, to differences in the assessment of the exposure and outcome variables, as well as to variations in study design. Light intensity activities are frequently used in the calculation of physical activity scores despite evidence that light physical activity can be positively associated with depression, whereas vigorous activity is negatively associated with depression [27] and that physical activity at moderate and vigorous intensities may have the greatest effect on depression [28–30]. Also, most prior studies have combined different types of physical activities providing an aggregate score for physical activity, and thus, there are few data regarding how involvement in certain types of physical activity (e.g., organized team sports) relates to depressive symptoms [31]. Physical activity performed in the context of team sports can offer adolescents and young adults opportunities to receive social support and interact with adult role models, become involved with peers in a prosocial context, develop and master skills, and enhance their self-esteem [32], which may in turn inversely relate to depressive symptoms. Accordingly, moderate-to-vigorous physical activity (MVPA) and involvement in team sports might have unique associations with depressive symptoms. In addition, most longitudinal studies have included few physical activity assessments over time (e.g., one per year for 2 or 3 years; [19–22]). As a result, the analyses have been limited to change in physical activity scores, which can mask the heterogeneity in physical activity patterns during adolescence. Furthermore, some investigators have focused on the associations between *current* levels of activity and depression, whereas others have focused on *past* activity, but few have included both within a single study (e.g., [33]), which would allow for an examination of the independent associations of past and current activities with depression. Last, the scoring of depression measures has varied across studies despite recommendations to use a continuous approach in community-based studies [34] when participants are drawn from population-based samples where the prevalence of major depression is relatively low [2–4]. Specifically, some researchers have used categorical scoring methods based on current taxonomies [35], whereas others have used continuous scoring methods that reflect a continuum of severity [14,19,33,36].

To address these limitations, the objectives of the present study were to examine (1) the longitudinal associations of past MVPA and involvement in team sports during secondary school with depressive symptoms in early adulthood, and (2) the cross-sectional associations of current MVPA and involvement in team sports with depressive symptoms during young adulthood. It was hypothesized that negative associations of weak and moderate magnitudes would be observed for (1) and (2), respectively.

Methods

The Nicotine Dependence in Teens study is an ongoing prospective cohort study initiated in 1999 that investigates the natural course of early cigarette use and nicotine dependence in novice smokers. Details of the study design are presented elsewhere [37]. Briefly, 1293 students (52% girls) initially aged 12–13 years from all grade 7 classes in 10 secondary schools in Montreal, Quebec, were enrolled in the study. Schools were selected to represent a range of socioeconomic status (low, medium, and high), geographic locations (urban, suburban, and rural), and languages (French and English). Participants provided assent, and a parent/guardian provided written informed consent. The study was approved by the following ethics review boards: Montreal Department of Public Health, McGill University, and the Centre de

Recherche du Centre Hospitalier de l'Université de Montréal, and procedures were in accord with the ethical standards outlined in the Helsinki Declaration of 1975, as revised in 2004.

In-school self-report questionnaires were administered every 3 months during the 10-month school year throughout the 5 years of secondary school, resulting in 20 survey cycles. The retention proportion at each survey cycle was approximately 94%. Around 2 years after survey cycle 20, additional data were collected from 880 participants when they were 18–24 years of age in 2007–2008 (survey cycle 21) using mailed self-report questionnaires.

Measures

Past MVPA and involvement in organized team sports

MVPA was assessed from survey cycles 1 through 20 using a past 7-day recall activity checklist [38] that was adapted to reflect 29 physical activities commonly engaged in by adolescents living in Montreal, Quebec, Canada. Participants reported the number of days on which they participated in any of the physical activities for at least 5 minutes. Its 2-week test–retest reliability has been tested ($r = 0.73$; [39]), and scores on the adapted checklist have been associated with energy intake measures [40]. For the current analysis, moderate (3.0–5.9 metabolic equivalent of task units) and vigorous (>5.9 metabolic equivalent of task units) intensity activities were retained [41]. These were bicycling, swimming/diving, basketball, baseball/softball, football, soccer, racket sports, ice/hockey, jumping rope, downhill skiing, cross-country skiing, ice skating, rollerblading/skateboarding, exercise/physical conditioning, ball-playing, track and field, playing games, jazz/classical ballet, outdoor play, karate/judo/tai chi, boxing/wrestling, mixed walking, and running/jogging. Number of sessions per week engaged in MVPA was calculated by summing the number of days in which the participants engaged in moderate and/or vigorous activities. These scores measured through the 20 survey cycles were used to estimate MVPA trajectories expressed as intercepts and slopes. The main analyses were based on these continuous intercept and slope scores.

In addition, participation in organized team sports was measured by asking participants to report if they belonged to 12 common sports teams in or outside of school from survey cycles 1 through 20. Past involvement was categorized as “never involved” (i.e., participants who responded “no” to each sport across the 20 survey cycles), “sporadic involvement” (i.e., participants who responded “yes” at least once to belonging in at least one sports team across the 20 survey cycles), and “sustained involvement” (i.e., participants who responded “yes” to belonging to at least one sports team at each of the 20 survey cycles).

Current MVPA and involvement in organized team sports

MVPA was assessed in survey cycle 21 using two open-ended questions from the International Physical Activity Questionnaire, which has been validated against accelerometer data [42]. Participants reported the number of days in the last week in which they engaged in moderate and vigorous physical activities for at least 10 minutes. Number of sessions per week engaged in MVPA was calculated by summing responses to both questions. In addition, participation in organized team sports was measured by asking participants to report the number of organized sports team they belonged to in the past 12 months. The International Physical Activity Questionnaire scores were treated as continuous in the analyses, whereas current team sport involvement was dichotomized as “not involved” (response = 0) or “involved” (response ≥ 1).

Depressive symptoms

The Major Depression Inventory (MDI [43]) was used in survey cycle 21 to assess depressive symptoms. Participants rated the

frequency with which they experienced 10 depression symptoms in the past 14 days using a six-point Likert scale ranging from 0 (*at no time*) to 6 (*all the time*). The MDI score was created by summing the 10 items, where scores ranged from 0 to 50. Of note, for items 8 and 10, each of which have two alternatives (a and b), only the highest of the two scores was used. Scores on the MDI are valid and reliable in adults [43,44].

Covariates

Potential confounders of the longitudinal relationship between the physical activity variables and depressive symptoms included self-reported age, sex, and depressive symptoms assessed at baseline, whereas those for the cross-sectional relationships included self-reported age and sex assessed at survey cycle 21. Baseline depressive symptoms were measured using a six-item depressive symptoms scale at survey cycle 1 [45] that was developed based on the depressive mood subscale of the Hopkins Symptom Checklist [46]. Participants indicated the frequency with which they (1) “felt too tired to do things,” (2) “had trouble going to sleep or staying asleep,” (3) “felt unhappy, sad, or depressed,” (4) “felt hopeless about the future,” (5) “felt nervous or tense,” and (6) “worried too much about things” in the past 3 months, using a modified four-point Likert scale ranging from 1 (*never*) to 4 (*often*). The scale has good test–retest reliability (i.e., intraclass correlation coefficients >0.76 over 6 months), acceptable internal consistency coefficients (Cronbach $\alpha > 0.72$), as well as face validity in adolescent populations [45,47]. Also, scores on this scale and the depression subscale of the Hopkins Symptom Checklist were highly related ($r = 0.72$) in a clinical sample of youths aged 14–16 years, providing evidence of construct validity [45]. Parental university education was considered a potential confounder of the longitudinal and cross-sectional associations. Parental education status was dichotomized as “no university education” or “one or both parents have some university education” using data reported by parents themselves in 2009–2010. If data were missing, data reported by participants in survey cycles 17 and 13 were used, respectively.

Data analyses

The data analyses occurred in several stages and were performed in SPSS (version 20.0, IBM SPSS Inc., Chicago, IL, USA) and STATA (version 9.2, Stata Corporation, College Station, TX, USA). First, descriptive statistics were computed for the study variables. Second, latent growth curve modeling using the repeated assessments of MVPA collected from survey cycles 1 through 20 was used to determine a single growth trajectory of MVPA for each participant characterized by an intercept (i.e., estimate of initial level) and slope (i.e., rate of change over time [48]). The mean of the intercept across participants represents the average starting values for MVPA, and the mean of the slope represents the average rate of change in MVPA, whereas the variance for the intercept and slope represents the individual variation around the means of the intercepts and slopes of MVPA, respectively. Maximum likelihood estimation was used to account for missing data because this method does not require that data to be missing completely at random and results are less biased than other methods [49]. In the last step, multiple hierarchical linear regression models were tested to examine the associations between (1) MVPA trajectories during secondary school and depressive symptoms in early adulthood, (2) involvement in team sports in secondary school and depressive symptoms in early adulthood, (3) early adulthood MVPA and depressive symptoms, and (4) early adulthood organized team sport involvement and depressive symptoms. The depressive symptoms scores were first regressed on the physical activity variables in unadjusted models and then in adjusted models controlling for confounders. Of

note, separate models were tested for MVPA and involvement in team sports to avoid double-counting activity sessions because it could not be assumed that the MVPA measure did not capture activities performed within team sport contexts, and thus, represent overlapping behaviors. Also, an initial set of analyses were conducted to test whether the relationships between the physical activity variables (i.e., MVPA and involvement in team sports) and depressive symptoms differed between the sexes by including two-way interaction terms in the linear regression models. No significant sex-by-physical activity interactions were observed, so sex-stratified analyses were not conducted.

Results

A total of 860 participants provided data on physical activity from survey cycles 1 to 21 and on depressive symptoms at survey cycle 21. Of these, 44 self-reported a clinically diagnosed mood disorder by a physician currently and/or at some point during the course of the study. These participants were excluded from all analyses because the association between physical activity and depressive symptoms is attenuated for individuals with past experiences of MDD [24]. Although participants retained for analysis were younger than those not retained (mean at baseline = 12.7, SD = 0.5 vs. 13.0, SD = 0.8; $F = 55.41$, $df = 1$, $P < .001$), there were no significant differences in the baseline depressive symptoms scale scores ($F = 0.02$, $df = 1$, $P = .90$). The descriptive statistics for the sample retained for the analyses are presented in Table 1. In addition, these 816 participants were divided into tertiles based on their depressive symptoms scores at survey cycle 21. Descriptive statistics for each tertile are also presented in Table 1. Baseline and current depressive symptoms were significantly and positively related ($r = 0.24$, $P < .05$). Current and past team sport involvements were also significantly and positively related ($r = 0.32$, $P < .05$). Current MVPA was significantly and positively related to MVPA intercept ($r = 0.13$, $P < .05$), but not slope ($r = 0.01$, $P > .05$).

Longitudinal results

The latent growth curve model estimating growth trajectories and individual variability in change over time in MVPA from survey cycles 1 to 20 indicated that, in general, participants' MVPA levels decreased during secondary school ($M_{\text{intercept}} = 15.22$, SD = 12.81; $M_{\text{slope}} = -1.38$, SD = 1.96; Table 1). Furthermore, 10.2% were never involved in team sport in secondary school, 51.9% were sporadically involved, and 37.9% were always involved. There were no statistically significant associations between the MVPA slope in secondary school and depressive symptoms in young adulthood in the unadjusted or adjusted linear regression models (Table 2). In contrast, involvement in team sports was significantly and negatively related to depressive symptoms in the univariate model ($P < .05$), and although not attaining the level of statistical significance, there was a trend toward significance observed for the MVPA intercept in the univariate model and for involvement in team sports in the adjusted model. In addition, sex (reference category: males) and baseline depressive symptoms were significantly and positively related to depressive symptoms assessed during young adulthood in the adjusted linear regression model ($P < .05$).

Cross-sectional results

At survey cycle 21, current MVPA scores ranged from 0 to 14 times per week with a mean of 4.04 (SD = 3.84), 24% of the participants were involved in at least one organized team sport within the past 12 months, and the depressive symptoms scores

Table 1
Descriptive statistics for the main study variables and covariates for the total sample and stratified by tertile of depressive symptoms in survey cycle 21

Variables	Depressive symptoms			
	Total sample	Lowest tertile	Middle tertile	Highest tertile
Female (%)	53.2	41.2	55.7	61.6
Baseline age (y), mean (SD)	12.71 (0.51)	12.72 (0.53)	12.69 (0.48)	12.70 (0.50)
Age at survey cycle 21 (y), mean (SD)	20.39 (0.39)	20.43 (0.79)	20.35 (0.71)	20.38 (0.77)
Parents with no university education (%)	55.9	58.4	50.2	57.6
Baseline depressive symptoms, mean (SD)	2.07 (0.58)	1.91 (0.53)	2.04 (0.54)	2.23 (0.61)
Past MVPA intercept, mean (SD)	15.22 (12.81)	15.88 (12.46)	15.45 (13.49)	14.51 (12.63)
Past MVPA slope, mean (SD)	−1.38 (1.96)	−1.47 (2.00)	−1.44 (2.14)	−1.28 (1.79)
Past team sport involvement, %				
Never	10.2	11.1	7.4	11.3
Sporadic	51.9	50.2	47.2	56.6
Sustained	37.9	38.7	45.4	32.2
Current MVPA weekly sessions, mean (SD)	4.04 (3.84)	4.45 (4.21)	4.32 (3.81)	3.50 (3.45)
Current team sport involvement (% yes)	24.3	27.7	26.9	19.5
Current depressive symptoms, mean (SD)	9.34 (7.48)	2.65 (1.84)	7.41 (1.16)	16.33 (6.94)

ranged from 0 to 50.0 with a mean of 9.34 (SD = 7.48; Table 1), which reflects low depressive symptoms [44]. A significant negative association between current physical activity (i.e., both MVPA and involvement in team sports) and depressive symptoms during young adulthood was observed in the unadjusted linear regression models ($P < .05$), but the association between involvement in team sports and depressive symptoms was no longer significant at the $P < .05$ level in the adjusted model Table 3).

Discussion

The unique associations of past and current physical activity with depression have received little empirical attention in young adults. Using data from a large population-based cohort study, the current results extend the literature on the cross-sectional and longitudinal associations between physical activity and depression by showing that current physical activity participation (i.e., both MVPA and involvement in team sports) and past involvement in team sports, but not past MVPA, were related to depressive symptoms in early adulthood.

The hypothesis that current MVPA and involvement in team sports are associated with current depressive symptoms was supported in this study. These results corroborate the findings from previous cross-sectional studies [11–18]. However, it is important to note that the associations observed herein and across studies are generally weak as is the proportion of variance explained in depressive symptoms. Thus, research is needed to understand other

modifiable factors that may influence depressive symptoms, as well as the mechanisms through which physical activity may relate to depressive symptoms to explain a greater proportion of variance in depressive symptoms. Although, the focus was on *quantity* of physical activity in the present study, *quality* of physical activity experiences should be considered in future studies. It might be that perceptions of enjoyment, interest, feelings of belonging, valuing of activity, and/or skill mastering while participating in MVPA and team sports are more strongly related to depressive symptoms than participation per se. Also, the context in which physical activity and team sports occur may be relevant. Participants may have engaged in activities and sports that offered varying opportunities for social support and interaction with adult role models, involvement with peers in a prosocial context, skill mastery, and esteem enhancement, and thus, these aspects may be some of the mechanisms through which physical activity is related to depression [50]. Assessing and understanding the context and quality of the physical activity experiences in future studies may help explicate a greater proportion of the variance in depressive symptoms and illuminate under which circumstances physical activity and depression may be most strongly related. Nevertheless, the current findings provide an empirical basis for intervention studies investigating the effectiveness of physical activity, both within and outside the context of organized team sports, in reducing the burden of depression in young adults.

The hypothesis that past MVPA is associated with later depressive symptoms was not supported in this study. These results regarding MVPA concord with some cross-sectional and longitudinal studies

Table 2
Regression analysis testing the association of past (survey cycles 1–20) MVPA (model A) and team sport participation (model B) with depressive symptoms during young adulthood (survey cycle 21)

Variables	Unadjusted model				Adjusted model			
	R^2	β (95% CI)	B (SE)	P	R^2	β (95% CI)	B (SE)	P
Model A								
Block 1*					0.10			
Sex						0.20 (1.88 to 3.96)	2.92 (0.53)	<.001
Age						−0.002 (−1.05 to 1.00)	−0.02 (0.52)	.96
Parental education						0.05 (−0.30 to 1.79)	0.75 (0.53)	.16
Baseline depressive symptoms						0.22 (1.95 to 3.71)	2.83 (0.45)	<.001
Block 2	0.01				0.10			
Initial MVPA (intercept)		−0.08 (−0.11 to 0.01)	−0.05 (0.03)	.12		0.01 (−0.06 to 0.06)	0.004 (0.03)	.90
Rate of MVPA decline (slope)		0.001 (−0.40 to 0.41)	0.004 (0.21)	.98		0.05 (−0.23 to 0.57)	0.17 (0.20)	.42
Model B								
Block 2	0.01				0.11			
Team sport involvement		−0.09 (−1.83 to −0.22)	−1.02 (0.41)	.01		−0.06 (−1.60 to 0.09)	−0.74 (0.42)	0.08

β = standardized coefficient; B = unstandardized coefficient; 95% CI = 95% confidence interval; SE = standard error.

To interpret the standardized regression coefficients: for every SD change in the independent variable, the dependent variable changes by “ β ” units (controlling for the other independent variables in the equation).

* Block 1 is the same for models A and B.

Table 3

Regression analysis testing the association of current (survey cycle 21) MVPA (model A) and team sport participation (model B) with depressive symptoms during young adulthood (survey cycle 21)

Variables	Unadjusted model				Adjusted model			
	R ²	β (95% CI)	B (SE)	P	R ²	β (95% CI)	B (SE)	P
Model A								
Block 1*					0.05			
Sex						0.24 (2.56 to 4.60)	3.58 (0.52)	<.001
Age						0.03 (−0.55 to 1.51)	0.48 (0.52)	.34
Parental education						0.04 (−0.52 to 1.57)	0.52 (0.53)	.33
Block 2	0.01				0.06			
Current MVPA		−0.12 (−0.36 to −0.10)	−0.23 (0.07)	.001		−0.08 (−0.29 to −0.02)	−0.15 (0.07)	.03
Model B								
Block 2	0.01				0.06			
Team sport involvement		−0.10 (−2.93 to −0.55)	−1.74 (0.61)	.004		−0.06 (−2.25 to 0.12)	−1.07 (0.61)	.08

β = standardized coefficient; B = unstandardized coefficient; 95% CI = 95% confidence interval; SE = standard error.

To interpret the standardized regression coefficients: for every SD change in the independent variable, the dependent variable changes by “ β ” units (controlling for the other independent variables in the equation).

* Block 1 is the same for models A and B.

that have reported nonsignificant associations [25,26,51,52]. There are several possible explanations for the lack of significant association between past MVPA and depressive symptoms. First, approximately 2 years elapsed between the assessment of depressive symptoms and the last physical activity assessment during secondary school. Accordingly, it is possible that an association between MVPA and depressive symptoms was attenuated over time because participants did not sustain an active lifestyle [28]. There is indirect evidence to support this tenet from previous studies [25,36]. Birkeland et al. [36] reported that changes in physical activity were related to the changes in depressive symptoms from 13 to 23 years of age but that baseline levels of physical activity did not predict later changes in depressive symptoms. Another possible explanation is that depressive symptoms were assessed during a period of life during which participants likely had to make multiple choices in different life domains (e.g., residential, employment, marital, and education) and adjust to the changes brought about by these choices [53]. The participants' attitudes toward these normative life changes and coping styles may have affected their mental health status, regardless of past MVPA patterns. Accordingly, the association between past MVPA and depression could be masked for those who experience the transition between secondary school and adulthood as negative and resulted in an underestimation of the longitudinal association between MVPA and depressive symptoms in this study.

In contrast, the hypothesis that past involvement in team sports is associated with later depressive symptoms was supported in this study. Although this association was weak and the proportion of variance explained in depressive symptoms was limited, it should not be dismissed because it reflects a relationship that was observed in a naturalistic observational study, which makes it difficult to isolate the association between physical activity and depressive symptoms. Researchers have shown that depression may coexist with other psychological morbidities such as anxiety [54], and thus, it is possible that the association observed is moderated by factors that were not controlled for. Notwithstanding this observation, the current finding, albeit weak, highlights the need to differentiate between the different types of physical activities that are assessed in future research. Team sports can be a source of a sense of accomplishment and progress in one's life, especially if other life domains are in transit or changing. They can also provide a healthy distraction to whatever other life circumstances may be happening concurrently. At minimum, this means less time to use unhealthy coping behaviors, such as overeating, oversleeping, rumination, and substance use, which are behaviors that have been related to reports of depressive symptoms in nonclinical samples of adolescents [13,47].

Limitations of this study include the use of self-report measures of depressive symptoms and physical activity that differed at survey cycle 21 from survey cycles 1 to 20, and possible misclassification of physical activities into moderate and vigorous intensity activities for past MVPA using the compendium of physical activities developed for use in adults [41]. In addition, the results are based on cohort from Montreal, which may limit generalizability of the findings to other settings. Nonetheless, strengths include a relatively large population-based sample of individuals who were assessed on 21 occasions over a 10-year period as they transitioned from early adolescence to adulthood. This allowed for a latent growth model approach to examine the association of both baseline MVPA and changes in MVPA in adolescence, an important period in the development of lifelong behaviors [55], as well as current MVPA.

In conclusion, the findings from this study provided insight about the unique associations between different types of physical activity (i.e., overall MVPA and team sports) and depressive symptoms, suggesting that activities that are done within team sport contexts should be encouraged so that young adults experience less depressive symptoms. An important avenue for future research is to identify distinctive aspects within a range of team sports that may result in decreased depressive symptoms.

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