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ORIGINAL ARTICLE

The Moderating Effect of Physical Activity on the Association Between ADHD Symptoms and Peer Victimization in Middle Childhood

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Abstract Previous research has demonstrated that symptoms of attention-deficit/hyperactivity disorder (ADHD) are associated with higher levels of victimization, but little is known about protective factors. The purpose of the study was to examine whether physical activity attenuated the associations among ADHD symptoms and physical and relational victimization 1.5 years later. Participants included 168 s through fourth grade students (M age = 8.43; 52.4 % boys) who completed self-reports of physical activity and victimization; teachers provided ratings of ADHD symptoms. ADHD symptoms predicted subsequent increases in physical, but not relational, victimization among children who reported engaging in moderate/high levels of physical activity, especially out of the school context (moderate: $\beta = .26$, $p = .03$; high: $\beta = .55$, $p < .001$). Findings suggest that children with ADHD symptoms may benefit from being taught the skills necessary to appropriately engage in physical activity and from being monitored while engaging in activity in order to limit physical victimization that they might experience.

Keywords Attention-deficit/hyperactivity disorder (ADHD) symptoms · Physical activity · Physical victimization · Relational victimization · Middle childhood

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Introduction

Previous research has demonstrated that symptoms of attention-deficit/hyperactivity disorder (ADHD) are associated with higher levels of physical and relational forms of victimization in both male and female youth [e.g., 1, 2]. Given that children who exhibit high levels of ADHD symptoms are at increased risk for peer victimization, additional work is needed to identify protective factors that may buffer this link in order to inform the development of targeted interventions. Physical activity has been associated with a variety of favorable outcomes for children with ADHD symptoms in areas such as behavioral inhibition, executive functioning, social functioning, and motor control [3, 4]. Therefore, physical activity may help to buffer the effect of ADHD symptoms on children's subsequent risk for experiences of victimization. The purpose of the current short-term longitudinal study was to examine whether physical activity attenuated the associations among ADHD symptoms and physical and relational peer victimization 1.5 years later in a sample of elementary school-age children.

ADHD is a neurodevelopmental disorder characterized by symptoms of inattention, hyperactivity, and impulsivity [5]. Prevalence estimates for diagnoses of ADHD in children and adolescents converge around 4–7 %, and many more experience elevated levels of ADHD symptoms without meeting full criteria for the diagnosis (e.g., symptoms and functional impairment across settings/informants) [6]. Notably, children with "subthreshold" levels of symptomatology still experience marked psychosocial impairment compared to the majority of their peers, despite not having a diagnosis [e.g., 7]. As such, research focusing on symptoms in non-clinical samples is essential to understanding the factors that contribute to negative

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outcomes associated with attention problems and hyperactivity-impulsivity [8].

ADHD symptoms are primarily conceptualized to be a result of deficits in behavioral inhibition and, consequently, of four domains of executive functioning (i.e., working memory, self-regulation, internalization of speech, and reconstitution) [9]. These deficits make it difficult for children with ADHD symptoms to maintain information and problem-solve in order to choose an optimal action or to attain a later goal [10, 11]. Furthermore, these cognitive impairments often lead to deficits in motor control, ability, and syntax [9], which make it difficult for children with ADHD symptoms to execute the chosen goal or action and re-engage when disrupted. As a result of these impairments, children exhibiting ADHD symptoms often have functional impairments in multiple domains of their lives.

Children with ADHD symptoms have particular difficulty with peer relations, as evidenced by a sizeable literature on the links between ADHD symptoms and various aspects of impaired social functioning [12–15]. All of the major symptom domains (hyperactivity, impulsivity, and inattention) of ADHD are likely to constitute, cause, or exacerbate difficulties in getting along with peers [14]. For example, children with ADHD symptoms often have difficulties reading social cues, communicating problems, processing information, and monitoring their behavior during peer interactions [e.g., 16, 17], which lead to limited social competence, peer rejection and neglect, and fewer and lower-quality friendships [12, 14]. Relevant to the present study, ADHD symptomatology has been linked to both sides of aggressive conflicts among children; that is, compared to their peers, children with ADHD symptoms are more likely to be an aggressor, a victim, or both [2]. Although a great deal of research has investigated aggressive behavior in relation to ADHD symptoms [e.g., 18–20], considerably less is known about the connection between ADHD symptoms and peer victimization; thus, further research is needed to clarify the nature of these prospective relations.

Peer victimization refers to the receipt of aggressive acts, inflicted by one or more peers (the aggressors) upon another (the victimized) with an intent of causing harm [21, 22]. This conceptualization is somewhat broad, casting a net that includes children who are victims of different *forms* of aggression (e.g., physical and relational victimization); physical victimization is the experience of being physically attacked or intimidated or verbally threatened [23, 24], whereas relational victimization is the experience of having social relationships damaged through methods such as rumors, gossip, and exclusion [25]. Large-scale, nationally representative survey data [26] indicate that nearly one in three youth in the US report involvement in chronic peer victimization—either as an aggressor (13 %),

a victim (11 %), or an aggressive-victim (6 %). Considering the literature reviewed here, children with ADHD symptoms appear to represent a specific subgroup with a particularly high risk for victimization.

A limited but compelling body of evidence has documented an association between ADHD symptoms and peer victimization. For example, Wiener and Mak [2] found that children between the ages of 9 and 14 with ADHD symptoms experienced significantly greater levels of victimization than their peers without ADHD. Furthermore, these results were largely consistent across gender, form of victimization (physical and relational), and categorical versus dimensional measures of ADHD symptoms [2]. Another large study [16] found that approximately half of children with ADHD were identified as rejected by their peers; they were also lower on social preference, higher on social impact, had fewer friends, and had unfavorable patterns of friend imbalance. Further, results held even after controlling for grade and gender, and post hoc analyses revealed that the social deficits were due to the ADHD symptoms and not comorbid disorders (i.e., oppositional defiant disorder/conduct disorder or anxiety) [16]. Such broad patterns of social difficulties, while not including victimization specifically, are likely connected to peer victimization and share many of the same correlates. Similar conclusions regarding the connection between ADHD symptoms and peer victimization have been reached through qualitative research methods [1] as well as through studies using dimensional ratings of ADHD symptoms in school samples [e.g., 27, 28]. However, future research is needed to help clarify the nature of these associations and identify factors that contribute to this association so that more effective interventions strategies can be developed and implemented.

Because ADHD symptoms often emerge in childhood and last throughout adolescence and adulthood, the conceptualization of symptom management has shifted from a short-term to a life-long process, similar to that of chronic medical disorders such as asthma or diabetes [29]. With this shift in conceptualization, research has begun to examine nonpharmacological treatment options, including lifestyle changes, which could help manage symptoms over the life span. These lifestyle changes may be particularly helpful for youth with subthreshold ADHD symptoms in order to prevent the progression to full-syndrome ADHD [29]. One nonpharmacological lifestyle change that has shown some evidence for reducing ADHD symptoms in youth is physical activity. Physical activity, which refers to bodily movement that results in energy expenditure [30], may involve a variety of activities ranging from active play and aerobic exercise to competitive sports. In addition to health benefits, previous research indicates that youth who engage in regular

physical activity experience numerous psychological, social, and behavioral benefits [31, 32].

Although physical activity has positive physical and mental health benefits for all youth, there is evidence that it might be especially beneficial for those with cognitive, motor, and social deficits, such as youth with ADHD symptoms. For example, Smith and colleagues [3] reported that children ages 5–9 with ADHD symptoms who participated in a physical activity intervention demonstrated noticeable reductions in interruptions and unintentional aggression. Similarly, Verret et al. [4] found that children ages 7–12 with ADHD symptoms who engaged in a 10-week moderate- to high-intensity physical activity program showed improvements in motor skills, information processing, and behavior; parents reported less attention, thought, and social problems, while teachers reported less anxious/depressed symptoms and social problems. Overall, the literature suggests that physical activity buffers the negative psychosocial consequences associated with ADHD symptoms; therefore, it follows that physical activity may buffer the relationship between ADHD symptoms and peer victimization.

Despite the fact that the specific mechanisms by which physical activity helps reduce symptoms of ADHD and buffers the relationship with negative psychosocial consequences are unknown, there have been multiple hypotheses regarding both functional and structural changes within the brain. For example, it has been hypothesized that improved functioning of children with ADHD symptoms as a result of physical activity is due to increased capillary growth, blood flow, neural plasticity, and neurotransmitters [e.g., 33–36]. In addition, children with ADHD often have less tissue volume in the frontal regions of the brain, which are associated with executive functioning, and in the cerebellum and cortical regions, which are associated with motor control [34, 37]; however, physical activity has been shown to increase brain volume in these areas [36]. These changes in the function and structure of the brain are particularly relevant for children with ADHD symptoms because the changes alter the core deficits associated with ADHD (i.e., behavioral inhibition, executive functioning, and motor control) [9]. A reduction of these symptoms as a result of physical activity might make it less likely that these children would be victimized by their peers.

In addition to changes in brain structure and function, it has been suggested that engaging in physical activity may reduce risk for maladjustment "through a variety of mechanisms such as providing role models, peer networks, opportunities for teamwork, social development, problem solving, and effective outlets for energy" [38]. Because of the lack of attention to social cues and uninhibited and overbearing social interactions [12], children with ADHD symptoms are more likely to be rejected or neglected and have fewer opportunities to develop friendships and social skills. However, engagement in physical activity may provide opportunities for these children to improve social competence and problem-solving abilities and to increase chances to develop friendships; therefore, physical activity may be a protective factor against peer victimization.

Current Study

Extant research suggests that ADHD symptoms may predict subsequent increases in peer victimization among children and adolescents [e.g., 1, 2, 16, 27, 28], yet relatively little research has examined factors that may protect children with ADHD symptoms from such negative interpersonal experiences. Given that evidence that physical activity improves behavioral, social, and motor functioning in children with ADHD, it may be that children who have high levels of ADHD symptoms but are engaging in high levels of physical activity might be less likely to experience increases in peer victimization over time. Therefore, the primary goal of the current study was to examine whether physical activity attenuated the associations among ADHD symptoms and physical and relational victimization 1.5 years later in a sample of elementary school-age children. This age group was selected because, as mentioned previously, ADHD symptoms often emerge in childhood and last throughout adolescence and adulthood. Identifying lifestyle changes that may serve as protective factors for children with ADHD symptoms may be helpful in order to prevent the progression to full-syndrome ADHD [29].

Consistent with existing literature, it was first hypothesized that ADHD symptoms would be positively associated with both physical and relational victimization. Moreover, it was hypothesized that ADHD symptoms would be less strongly associated with physical and relational victimization at high levels of physical activity. Lastly, because preadolescent children attending the same school likely get similar amounts of physical activity during school hours, it was hypothesized that high levels of out-of-school, rather than in-school, physical activity would be driving the interaction; specifically, it was hypothesized that ADHD symptoms would be less strongly associated with both physical and relational victimization at high levels of out-of-school physical activity.

Method

Participants

Participants included 168 youth, ages 7–10 ($M = 8.43$, $SD = 1.02$; 52.4 % boys), who were enrolled in the second

($n = 57$), third ($n = 29$), and fourth ($n = 82$) grades at an elementary school located in a small, rural Midwestern community in the United States, and their primary classroom teachers. Children were deemed eligible for the current study if: (a) they were enrolled in second through fourth grade at the designated elementary school, (b) they were not receiving special education services, and (c) their parents or guardians provided written consent for participation. According to census data, the lower middle-class community in which the school was located had an average per capita income of $25,369. Additionally, school records indicated that 35 % of students at the school were eligible for free or reduced-price lunch and the majority (approximately 90 %) identified as Caucasian.

The current sample was a part of a larger project that evaluated various developmental outcomes for preadolescent youth.[1] A total of 384 consent forms were distributed to all caregivers of second through fourth grade students for the larger project, and 74.7 % of caregiver consent forms were returned ($n = 287$). Of these, 87.5 % of caregivers ($n = 251$) gave consent for their child's participation in the study (65.4 % of all eligible students). All of the students' teachers ($n = 14$; 100 %) also consented to participate in the study by providing information on the participating students. In total, data were collected on 88 boys and 80 girls at Time 1 after excluding those students who (a) were absent on the day of data collection ($n = 12$), (b) had moved out of the school district prior to data collection ($n = 2$), (c) declined to provide assent ($n = 4$), or (d) were not able to complete measures of interest in the current study during the allotted time ($n = 65$). A total of 131 students participated again at Time 2, which occurred approximately 1.5 years later. Follow-up data were missing for students (a) who had moved out of the district in between school years ($n = 12$), (b) whose caregivers did not return the consent forms ($n = 20$), and (c) whose caregivers declined to provide consent again for their participation ($n = 5$). The final sample consisted of the 168 participants who provided complete data at Time 1; missing data from the 37 participants who did not participate at Time 2 were accounted for in analyses.

Procedure

The study procedures were approved by the researchers' Institutional Review Board and the elementary school's administrators prior to data collection. All second through

fourth grade students at the school were recruited for participation by distributing information letters and consent forms to parents during school enrollment days prior to the beginning of school. Parental consent and child assent were collected before data were collected. Self-report data from children were collected in group format in the schools in order to accommodate all students while reducing the burden on the school and disruptions to the school schedule. Research assistants read questions aloud to students to ensure that children's participation was not restricted by reading comprehension. Data collection occurred during 30 min sessions in each classroom; as a result of the short testing session, some of the second and third grade students were unable to complete the self-report measures in the allotted time. Time 1 student data collection occurred about 2 months after the beginning of the fall semester, and Time 2 student data collection occurred about 1.5 years later in the spring semester. The same procedures were followed at both time points. Regardless of levels of class participation, all classrooms received a $75 gift card at Time 1 and a $50 gift card at Time 2 for school supplies as compensation for their time and effort.

All second through fourth grade primary classroom teachers were recruited for participation by distributing information letters and consent forms during school staff meetings. Teacher-reported data were collected at Time 1 via a secure online survey during the same month in which the in-school data collection with the students occurred. Teachers received $7 as compensation for each survey they completed.

Measures

ADHD and ODD Symptoms

The Disruptive Behavior Disorder rating scale (DBD) [41] was used to measure teacher reports of ADHD and ODD symptoms at Time 1. The Disruptive Behavior Disorder rating scale is a 26-item measure with 18 items that assess hyperactive-impulsive (e.g., "Is often on the go or often acts as if driven by a motor.") and inattentive (e.g., "Often does not seem to listen when spoken to directly.") symptoms of ADHD and 8 items that assess ODD symptoms (e.g., "Is often spiteful and vindictive."). Teachers were instructed to report how much each item described the child on a 4-point Likert scale from 1 ("Not at all") to 4 ("Very Much"). Mean scores for the ADHD and ODD subscales at Time 1 were calculated and used for analyses, with higher scores indicating higher levels of symptoms. The ADHD ($\alpha = .97$) and ODD ($\alpha = .94$) subscales demonstrated excellent internal consistency in the current sample.

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[1] In the larger project, peer victimization has been examined as a predictor of various outcomes, including forms of aggression [39] and academic performance [40]; however, no studies have yet examined risk factors for peer victimization. Additionally, the current project was the first from the larger project to examine physical activity and its relations to children's developmental outcomes.

Physical Activity

A modified version of the Self-Administered Physical Activity Checklist (SAPAC) [42, 43] was used to measure child reports of frequency of physical activity at Time 1. The original SAPAC is a self-report measure that assesses children's engagement in 21 different physical activities (e.g., bicycling, basketball, soccer, running) before, during, and after school. The SAPAC was developed for use with preadolescent children, and it has demonstrated good reliability and validity based on objective measures of physical activity, including heart rate monitors and accelerometers [42]. The SAPAC was adapted for use in the present study by combining before and after school activity engagement into one category (i.e., out-of-school physical activity) and eliminating spaces for reporting additional activities as well as items assessing sedentary activities (e.g., playing video games). Children were asked to rate how often they participated in each activity for more than 5 min over a three-day period (i.e., 1, 2, 3 days, No days). Consistent with previous research [42], an overall score was generated by averaging the number of days that children engaged in each of the physical activities over a 3-day period at Time 1. Mean scores for in-school and out-of-school physical activity at Time 1 were also calculated and used for analyses.

Physical and Relational Victimization

A modified version of the Victimization of Self (VS) scale from the Peer Experiences Questionnaire (PEQ) [44] was used to measure child reports of peer victimization at both Time 1 and Time 2. The VS scale was modified to accommodate the reading level of the sample (at or below third grade level) [45]. The current VS scale included four items that assessed physical victimization (e.g., "A kid said he or she was going to hurt me or beat me up.") and five items that assessed relational victimization (e.g., "A kid told lies about me so other kids wouldn't like me."). Children were instructed to report the frequency of victimization since the start of school on a 5-point Likert scale ranging from 1 ("Never") to 5 ("A few times a week"). Mean scores for the physical and relational victimization subscales at Time 1 and Time 2 were calculated and used for analyses, with higher scores indicating greater frequency of the forms of victimization. The physical victimization (Time 1 $\alpha = .68$; Time 2 $\alpha = .87$) and relational victimization (Time 1 $\alpha = .76$; Time 2 $\alpha = .88$) subscales demonstrated marginal to good internal consistency across both time points in this sample.

Data Analytic Plan

The moderating effect of physical activity on the prospective links between ADHD symptoms and forms of peer victimization was examined by estimating two series of path analysis models using Mplus statistical software (Version 7) [46]. An initial series of models was estimated to examine whether the total amount of physical activity that children engaged in influenced the longitudinal associations between ADHD symptoms and forms of peer victimization. Subsequently, a second series of models was estimated to examine whether these links differed according to the location in which the physical activity occurred (i.e., inside or outside of the school context). Consistent with previous research indicating the high rates of comorbidity (35–60 %) between ADHD and oppositional defiant disorder (ODD) [47], ODD symptoms were controlled for in each model. Previous research has also shown that in middle childhood, there are gender and grade level differences in peer victimization [e.g., 48–50], that physical and relational victimization are distinct yet overlapping constructs [51, 52], and that, on average, self-report of victimization is stable [48]; therefore, gender, grade level, the alternate form of victimization, and the stability in the victimization form over time were accounted for in analyses. A hierarchical model-building approach was employed, whereby both physical and relational victimization were simultaneously regressed on all covariates (e.g., Time 2 physical victimization was regressed on gender, grade level, Time 1 physical victimization, Time 1 relational victimization, Time 1 ODD symptoms, Time 1 ADHD symptoms, and Time 1 physical activity; Model 1). Model 1 also included a covariance between each of the predictors and a covariance between the residuals of the outcomes; accordingly, this path analysis model was fully saturated (i.e., 0 degrees of freedom), which resulted in a perfect fit to the data. Next, paths from the cross-product term(s) between ADHD symptoms and physical activity to the victimization forms were added to Model 1 (Model 2).

Both Time 2 physical victimization (skewness = 2.67; kurtosis = 8.30) and Time 2 relational victimization (skewness = 2.16; kurtosis = 4.65) met the assumptions of normality recommended by Kline [53]. All continuous variables were standardized prior to analyses in order to aid in the interpretation of effects, and grade level was centered such that students in the second grade were treated as the reference group. According to standard procedures [54], significant interactions were probed when the model was conditioned to represent associations at low (-1 SD), moderate (mean), and high ($+1$ SD) levels of the physical activity. Full information maximum likelihood estimation (FIML) was used to accommodate the missing data at Time

2 (22 %), as this approach has been shown to provide less biased parameter estimates compared to other methods of handling missing data such as listwise and pairwise deletion [55]. In contrast, participants with missing data at Time 1 were excluded from analyses given that FIML cannot accommodate for exogenous variables with missing values.

Results

Preliminary Analyses

Descriptive statistics and correlations among study variables are presented in Table 1. Overall, 8.3 % of children had ADHD symptoms in the clinically significant range based on teacher-report, which corresponds to the average prevalence rates of ADHD in community-based samples of children and adolescents (5–10 %) [56]. Approximately 81 % of children reported engaging in physical activity on at least one occasion during the prior three days at school, and 91.7 % of children reported engaging in physical activity at least once outside of the school context. In terms of initial exposure, 38.7 % of children reported having been physically victimized and 57.1 % reported having been relationally victimized at least once since the beginning of the school year at Time 1. In- and out-of-school physical activity were strongly correlated at Time 1, sharing approximately 27 % of their variance. Further,

both physical and relational victimization showed some stability, sharing approximately 31 and 7 % of their variance between Time 1 and Time 2, respectively. ADHD symptoms were significantly and positively associated with physical and relational victimization at Time 1 and Time 2, as well as out-of-school, but not in-school, physical activity at Time 1. Additionally, out-of-school physical activity was positively associated with physical, but not relational, victimization at Time 2.

Total Physical Activity Path Models

Physical Victimization

Results from Model 1 (see Table 2) indicated that both ODD and ADHD symptoms predicted subsequent increases in physical victimization 1.5 years later. After taking into account other variables in the path model, physical victimization was not stable from Time 1 to Time 2. Further, Time 1 relational victimization, gender, grade level, and Time 1 total physical victimization were not uniquely related to physical victimization over time. This main effects model resulted in a total $R^2 = .36$.

When the cross-product term between ADHD symptoms and total physical activity was included in Model 2 (see Table 2), a significant interaction emerged and accounted for an additional 2 % of the residual variance. As illustrated by simple slope analyses (see Fig. 1), ADHD symptoms predicted subsequent increases in physical

Table 1 Descriptive statistics and correlations among study variables

	1	2	3	4	5	6	7	8	9	10	11
1. Gender	–										
2. Grade	−.09	–									
3. T1 ODD symptoms	−.26*	.09	–								
4. T1 ADHD symptoms	−.30*	.09	.71*	–							
5. T1 total physical activity	.06	.17*	.16*	.19*	–						
6. T1 in-school physical activity	.07	.14	.11	.05	.82*	–					
7. T1 out-of-school physical activity	.03	.16*	.16*	.25*	.92*	.52*	–				
8. T1 physical victimization	−.21*	−.11	.58*	.64*	.17*	.07	.20*	–			
9. T1 relational victimization	−.10	.07	.77*	.73*	.24*	.16*	.24*	.54*	–		
10. T2 physical victimization	−.14	−.06	.49*	.52*	.23*	.12	.26*	.56*	.36*	–	
11. T2 relational victimization	−.03	.06	.28*	.30*	.16	.10	.17	.20*	.26*	.60*	–
Mean	–	3.15	1.22	1.41	.53	.38	.69	1.29	1.43	1.38	1.48
SD	–	.90	.47	.61	.41	.40	.55	.54	.65	.64	.74
Minimum	–	2	1.00	1.00	.00	.00	.00	1.00	1.00	1.00	1.00
Maximum	–	4	3.88	4.00	3.00	3.00	3.00	4.00	4.20	4.50	4.60

T1 = Time 1 (Fall 2012); T2 = Time 2 (Spring 2014); Gender (0 = Male, 1 = Female); The number of participants included in correlation analysis ranged from 168 to 127

* $p < .05$

Table 2 Total physical activity path models predicting Time 2 physical and relational victimization

	T2 physical victimization						T2 relational victimization					
	Main effects			Interactive effects			Main effects			Interactive effects		
	β	SE	p	β	SE	p	β	SE	p	β	SE	p
T1 physical victimization	.09	.11	.42	.08	.11	.46	.12	.13	.37	.11	.13	.39
T1 relational victimization	.10	.10	.35	.10	.10	.31	.04	.12	.72	.05	.12	.69
Gender	−.02	.15	.92	−.03	.15	.87	.14	.18	.44	.13	.18	.46
Grade	−.09	.08	.27	−.08	.08	.35	.06	.09	.51	.07	.09	.44
T1 ODD symptoms	**.24**	**.11**	**.04**	**.22**	**.11**	**.05**	.17	.13	.20	.16	.13	.22
T1 ADHD symptoms	**.39**	**.12**	**.001**	**.31**	**.12**	**.009**	.20	.14	.13	.15	.14	.29
T1 total physical activity	.11	.07	.13	**.16**	**.08**	**.03**	.06	.09	.46	.10	.09	.26
ADHD × Total physical act	–	–	–	**.19**	**.09**	**.03**	–	–	–	.14	.11	.20

T1 = Time 1 (Fall 2012); T2 = Time 2 (Spring 2014); Gender (0 = Male, 1 = Female); Grade (0 = 2nd Grade, 1 = 3rd Grade, 2 = 4th Grade); Bold estimates represent statistically significant paths

victimization at moderate to high levels of total physical activity. Time 1 ADHD symptoms were unrelated to Time 2 physical victimization when levels of Time 1 total physical activity were low.

Relational Victimization

Results from Model 1 (see Table 2) indicated that none of the predictor or control variables were uniquely associated with increases in relational victimization 1.5 years later. This main effects model resulted in a total $R^2 = .13$. Further, ADHD symptoms did not significantly interact with total physical activity to influence Time 2 relational victimization in Model 2 (see Table 2).

In- and Out-of-School Physical Activity Path Models

Physical Victimization

Results from Model 1 (see Table 3) indicated that both ODD and ADHD symptoms predicted subsequent

increases in physical victimization 1.5 years later. No other predictor or control variables were uniquely related to Time 2 physical victimization. This main effects model resulted in a total $R^2 = .36$.

When the cross-product terms were added to the model, ADHD symptoms significantly interacted with out-of-school (but not in-school) physical activity to influence Time 2 physical victimization; the inclusion of these effects accounted for an additional 4 % of the residual variance. As illustrated by simple slope analyses (see Fig. 2), ADHD symptoms predicted subsequent increases in physical victimization at moderate to high levels of out-of-school physical activity. Time 1 ADHD symptoms were unrelated to Time 2 physical victimization when levels of Time 1 out-of-school physical activity were low.

Relational Victimization

Results from Model 1 (see Table 3) indicated that none of the predictor or control variables were uniquely associated with increases in relational victimization 1.5 years later.

Fig. 1 Interaction between ADHD symptoms and total physical activity in the prediction of Time 2 physical victimization
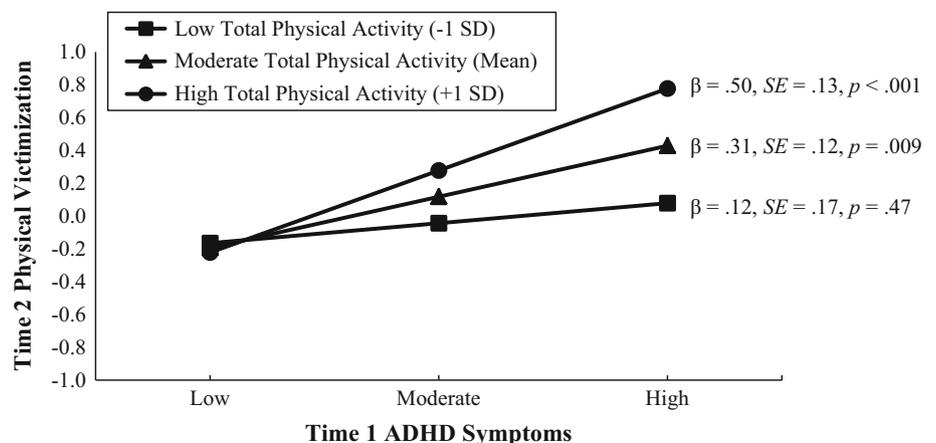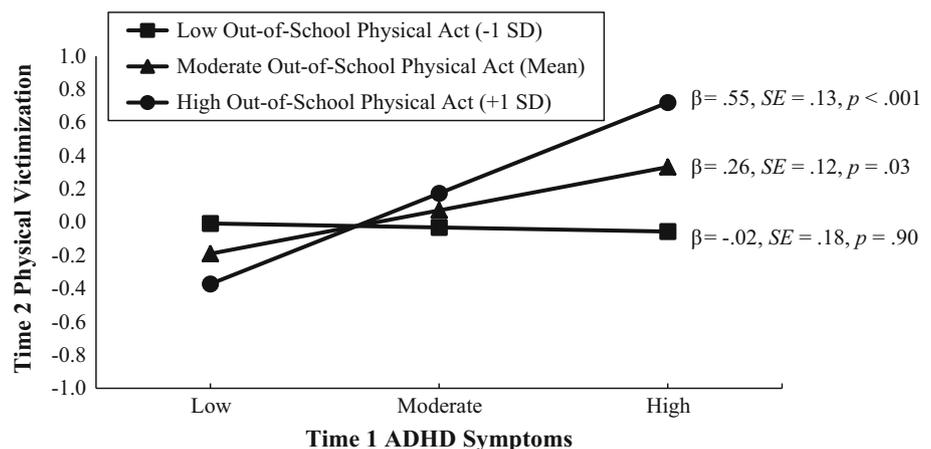
Table 3 In- and out-of-school physical activity path models predicting Time 2 physical and relational victimization

	T2 physical victimization						T2 relational victimization					
	Main effects			Interactive effects			Main effects			Interactive effects		
	β	SE	p	β	SE	p	β	SE	p	β	SE	p
T1 physical victimization	.09	.11	.43	.05	.11	.67	.12	.13	.37	.09	.13	.49
T1 relational victimization	.09	.10	.36	.13	.10	.18	.04	.12	.72	.07	.12	.57
Gender	−.02	.15	.91	−.05	.15	.75	.14	.18	.43	.12	.18	.50
Grade	−.09	.08	.27	−.06	.08	.48	.06	.09	.51	.08	.09	.37
T1 ODD symptoms	**.24**	**.11**	**.04**	.20	.11	.07	.17	.13	.20	.15	.13	.27
T1 ADHD symptoms	**.38**	**.12**	**.001**	**.26**	**.12**	**.03**	.20	.14	.14	.12	.15	.39
T1 in-school physical activity	.04	.08	.63	.03	.09	.71	.04	.10	.71	.04	.11	.72
T1 out-of-school physical activity	.09	.09	.32	.10	.09	.23	.04	.10	.72	.05	.10	.65
ADHD × In-school physical act	–	–	–	−.12	.12	.32	–	–	–	−.07	.15	.65
ADHD × Out-of-school physical act	–	–	–	**.29**	**.10**	**.005**	–	–	–	.19	.12	.12

T1 = Time 1 (Fall 2012); T2 = Time 2 (Spring 2014); Gender (0 = Male, 1 = Female); Grade (0 = 2nd Grade, 1 = 3rd Grade, 2 = 4th Grade); Bold estimates represent statistically significant paths

Fig. 2 Interaction between ADHD symptoms and out-of-school physical activity in the prediction of Time 2 physical victimization

This main effects model resulted in a total $R^2 = .13$. Further, ADHD symptoms did not significantly interact with in- or out-of-school physical activity to influence Time 2 relational victimization in Model 2 (see Table 3).

Discussion

Previous research has demonstrated that ADHD symptoms are associated with higher levels of physical and relational victimization [e.g., 1, 2]; however, there is a paucity of research examining factors that attenuate these relationships. Physical activity has been shown to be associated with a variety of positive outcomes for children with ADHD symptoms [3, 4]; therefore, the current short-term longitudinal study was designed to examine whether physical activity attenuated the associations among ADHD symptoms and physical and relational victimization 1.5 years later in a sample of elementary school-age children.

First, it was hypothesized that ADHD symptoms would be positively associated with both physical and relational victimization 1.5 years later; this hypothesis was partially supported. Results showed that ADHD symptoms at Time 1 were uniquely associated with higher levels of physical, but not relational, victimization at Time 2. Although ADHD symptoms and relational victimization were significantly associated at the bivariate level, ADHD symptoms were not uniquely associated with relational victimization at Time 2 after taking into account the other variables in the path model. The lack of a unique association between ADHD symptoms and relational victimization was contrary to expectations and previous research demonstrating that ADHD symptoms are positively

associated with both forms of victimization [e.g., 1, 2, 28]. It should be noted that the mean age of the current sample ($M = 8.43$) was lower than the samples of the previous studies that have examined the relations between ADHD and victimization ($M > 11$) [e.g., 1, 2, 28]. As established in previous research, physical aggression and victimization peak during early childhood and decline throughout later childhood and adolescence [57]. On the other hand, relational aggression and victimization tend increase from middle childhood through adolescence [58, 59]. Therefore, physical victimization may be more common in the current sample of elementary school-age youth than relational victimization. Furthermore, children with ADHD symptoms can be thought of as "provocative victims" because they often annoy their peers with hyperactive, impulsive, or inattentive symptoms [1, 60]. Perhaps elementary school-age children who exhibit these symptoms are more likely to irritate and provoke their peers to a point that would result in being physically attacked or threatened (i.e., physical victimization) instead of having social relationships damaged through rumors and gossip (i.e., relational victimization).

Second, it was hypothesized that physical activity would attenuate the associations among ADHD symptoms and physical and relational victimization; however, results did not support this hypothesis. On the contrary, results showed that moderate to high levels of total physical activity exacerbated the association between symptoms of ADHD and subsequent increases in physical victimization. Total physical activity did not impact the relational victimization associated with ADHD symptoms. Furthermore, as hypothesized, out-of-school, rather than in-school, physical activity drove the interaction with ADHD predicting physical victimization. However, as with total physical activity, the moderation worked in the opposite direction than expected. Instead of attenuating the relationship as hypothesized, ADHD symptoms were more strongly associated with physical victimization at high, as compared to low, levels of out-of-school physical activity.

Although surprising and contrary to initial predictions, there is some evidence that could explain why children with ADHD symptoms who are engaging in physical activity are more likely to be victimized by their peers. As mentioned previously, children with ADHD symptoms have impairments in motor control, ability, and syntax [9]. These children likely have difficulties executing goals and actions and re-engaging when disrupted. Beyond that, compared to children without ADHD, research shows that children with ADHD spend less time learning and practicing the skills necessary to perform physical activities appropriately [61]. Further, Harvey et al. [61] found that boys with ADHD do not use specific terminology about the sport that is required in order to communicate during the

physical activity. In general, having difficulties with motor control, spending less time learning and developing skills relevant to physical activities, and lacking specific knowledge of physical activity terminology might result in lower athletic performance. Lopez-Williams et al. [62] found that athletic performance predicted peer acceptance in youth with ADHD, and Harter [63] found that athletic competence is an important domain of competence among elementary school-age children; therefore, it could be that lack of athletic performance demonstrated while engaging in physical activity might make children with ADHD symptoms more likely to be victimized. Although the current study did not examine athletic competence, future studies should explore how it might be related to peer victimization for children with ADHD symptoms.

The results of several studies have also revealed that children are victimized while taking part in sports both within [64] and outside of the school context [65]. However, during school hours, children with ADHD symptoms are likely to be supervised while engaging in physical activity and may also receive direct instruction on how to perform the physical activities appropriately, which could increase athletic competence, as well as adult supervision, which prevents peer victimization. On the other hand, outside of school, children with ADHD symptoms may be engaging in less supervised play without the knowledge of skills that are required to appropriately perform the activities. Furthermore, it is posited that outside of school, aggressors have more opportunities to victimize their peers and coaches or supervisors may interfere less or are less aware of such incidents than teachers might be in the school setting [65]. Based on this information, it appears that supervision and instruction on how to engage in physical activity appropriately might be key to helping reduce the physical victimization associated with ADHD symptoms. Future intervention studies for children with ADHD (especially those that take place outside of the school context) should incorporate increased supervision and instruction into their protocols in order to limit the amount of physical victimization that the children might experience.

There are multiple examples of ADHD treatments that incorporate physical activity and provide appropriate skill-based learning and monitoring. For example, the summer treatment program (STP) [66] for children with ADHD is an 8-week evidence-based treatment for improving peer interactions for children with ADHD. One of the core components of the STP is sports skills training, in which children receive intensive training and coaching on the rules and skills necessary to participate in physical activities. During these activities, children are monitored by counselors and reinforced through a point system to increase appropriate behaviors (e.g., following the rules of the sports) and reduce

inappropriate behaviors (e.g., using hands in soccer) [67]. The STP is ideal for children with ADHD because it provides direct supervision of physical activity as well as instruction on how to appropriately engage in the sport. Similarly, the COACHES program [68] is a treatment program for children with ADHD and their fathers. For eight weeks, fathers learn parent management skills, children learn skills necessary to engage in sports, and fathers and children engage in physical activity together. Again, children with ADHD in this treatment program receive direct instruction on skills necessary for physical activity and also engage in sports in an organized and supervised manner. Although considered well-established interventions for children with ADHD [69], it is not clear which of the components of the interventions result in the significant effects [67]. Future research is needed to determine the active components of the interventions, as well as to determine the effect on peer victimization specifically.

The interpretation of these findings must be considered in the context of several limitations of the study. First, characteristics of the sample limit the generalizability of findings. For example, the current sample included elementary school-age students who were primarily Caucasian and middle-class. Consequently, the current findings may not generalize to children from other demographic groups. In addition, the current study included the examination of diagnostic symptoms of ADHD from a dimensional perspective within a community sample, which may limit the generalizability of results to clinical samples. Future studies should examine the relationships between ADHD symptoms, physical activity, and victimization in older age groups, as well as in minority and clinical samples. An additional limitation of the current study is the single-informant method of measuring ADHD symptoms (i.e., teacher-report). Because teachers are only able to provide information about children's behaviors in the school context, future studies should also collect parent-report data of ADHD symptoms to better understand children's behaviors in the home context. There are also limitations associated with the retrospective self-report measure of physical activity that was utilized in the current study. First, as previously noted, the time constraints of data collection prevented several groups of students (approximately 25 % of our sample) from completing the measure of physical activity, which may have impacted the accuracy of the activity estimates. Additionally, as noted by Prince and colleagues [70], individuals both over- and under-report levels of physical activity, which limits the reliability and validity of self-report measures of physical activity. Future research would benefit from using more precise, objective measures of physical activity, such as accelerometry. Future investigations may also benefit from examining participation in individual (e.g., running, bicycling) and group-based activities (e.g., football, soccer) separately, as

the mechanisms by which physical activity confers protection may differ according to extent to which one is involved with peers. For example, group-based activities may provide opportunities for social development and problem solving [38], whereas the benefit of individual activities may be attributed to their tendency to alter brain structure and function [33–36].

Despite these limitations, the current study has several strengths. First, the current study is a short-term longitudinal study that spans over 1.5 years. Therefore, stringent tests allow for the prediction of future victimization as a result of initial levels of ADHD symptoms and physical activity while controlling for baseline victimization. In addition to the longitudinal design, the current study employed a multi-informant method, which reduces the risk of response bias and shared method variance. Furthermore, the current study examined the relationships among ADHD symptoms and physical and relational victimization over and beyond the effects of ODD symptoms. Fite and colleagues [28] previously found that ODD symptoms had a stronger association with victimization than ADHD symptoms in an adolescent sample. However, the current study advances the field by providing evidence that ADHD symptoms are associated with physical victimization over time in middle childhood, over and beyond the effects of ODD symptoms.

Summary

The current study provides evidence that children with ADHD symptoms who are engaging in physical activity, especially outside of school, are likely to experience increases in physical, but not relational, victimization over time. Given the importance of regular physical activity in maintaining physical and mental health [32], additional research is needed to address the increased likelihood for victimization for children with ADHD symptoms. Although it is not recommended that children with ADHD symptoms refrain from engaging in physical activity as a way to reduce physical victimization, the findings from the current study suggest that children with ADHD symptoms might benefit from being taught the skills necessary to appropriately engage in physical activity and from being monitored while engaging in the activity in order to limit the amount of physical victimization that they might experience.

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