Correlates of Physical Activity with Intrusive Thoughts, Worry and Impulsivity in Adults with Attention Deficit/Hyperactivity Disorder: A Cross-sectional Pilot Study

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ABSTRACT

Background: Physical exercise is known to produce numerous psychological beneficial effects in healthy and clinical populations. Nevertheless, little is known about the relationship between exercise and ADHD symptoms, let alone among adults with ADHD. This study examines the association between exercise and three ADHD symptoms: (1) behavioral impulsivity; (2) intrusive unwanted thoughts and (3) worry. The latter two are cognitive facets of anxiety, a prominent symptom of ADHD.

Methods: Physical activity was measured using a self-report questionnaire. Thirty participants with a diagnosis of ADHD were divided into two groups: Participants engaging in frequent aerobic activity ("high activity" group), and participants engaging in non-frequent physical activity ("low activity" group).

Results: Adults with ADHD engaging in frequent aerobic physical activity report significantly less behavioral impulsivity and experience significantly less worrisome and intrusive thoughts.

Conclusions: Our results reflect an association between physical activity and reduced symptoms of impulsivity and intrusive and worrisome thoughts in an adult ADHD sample. The results of this pilot study may encourage further investigations emphasizing the causal link between physical activity and ADHD symptoms. Suggested underlying neurobiological mechanisms, clinical implications and limitations are discussed.

INTRODUCTION

Attention Deficit/Hyperactivity Disorder is a neuro-developmental disorder characterized prominently by inattention, impulsivity and hyperactivity (1) that persist into adulthood (2-4). This debilitating and burdensome condition has a worldwide estimated prevalence of approximately 5.3% in children and adolescents (5) and 4.4% in adults (2).

Physical activity: psychological and cognitive correlates. Research indicates that together with improving physical health, physical activity reduces anxiety, depression and enhances general psychological functioning in clinical and non-clinical populations (6-11). Wipfli and colleagues (12) conducted a meta-analysis of randomized controlled trials examining the anxiolytic effects of exercise. The authors found that an overall significant reduction of anxiety was observed in exercise groups in comparison with non-treatment control groups. Moreover, the authors reported that the exercise groups demonstrated greater reduction in anxiety in comparison with other forms of anxiety-reducing treatments (12). Notably, research reveals that physical activity may be also associated with improvement of cognitive functioning (13).

In an attempt to elucidate the nature of the effects of physical activity, a growing body of literature suggests that physical activity may alter monoamines transmission (13, 14). In brief, physical exercise causes a change in the metabolism of the three monoamines: Serotonin, Dopamine and Norepinephrine. This alteration of monoamine metabolism may underlie the physiological mecha-

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nisms that are associated with psychological, behavioral and emotional effects of exercise (15-17).

Anxiety, intrusive thoughts and worry

Anxiety disorders and symptoms of anxiety are highly associated with ADHD in childhood as well as in adulthood (2, 18-20). Kessler and his colleagues (2) analyzed results from the U.S. national comorbidity survey replication and found that within the adult ADHD population, 47.1% were diagnosed with an anxiety disorder compared with only 19.5% in the non-ADHD group. However, investigations addressing the association between anxiety and ADHD typically focus on the affective facet of anxiety, either by examining anxiety disorders as a separate comorbid entity associated with ADHD (2, 21), or by examining symptoms of anxiety (22). Regardless of the methodology used, the majority of studies predominantly examined the affective aspect of anxiety in ADHD, but not its cognitive expression.

Worrisome and intrusive thoughts are two cognitive features of anxiety. Perrin and Last (23) compared three groups of children: a non-clinical group, a group diagnosed with anxiety disorder, and a group diagnosed with ADHD. The authors found a significant difference between the non-clinical group and both clinical groups in the total number of intense worries. No difference was found between the anxious group and the ADHD group (23).

Borkovec et al. (24) defined worry as "thoughts or images that generate a negative affect and are relatively uncontrollable." Wells (25) outlined three aspects of worry: meta-worry, social worry, and health worry. Meta-worry is defined by Wells as "worry about worry...worry about the controllability of thoughts and the appraisal of thoughts as intrusive." Similar to meta-worry, intrusive thoughts are associated with the cognitive aspect of anxiety (26).

Unwanted intrusive thoughts are typically attributed to an internal origin and are defined as repetitive, unacceptable or unwanted thoughts, images or impulses (27). It has been argued that intrusive thoughts and worry are functionally similar and share common processes over much of a continuum (28), and are systematically associated (29). Turner et al. (30) suggest that there are some differences between the two phenomena. Among them are that worry is more ego-syntonic than intrusive thoughts, and that worry occurs as verbal thoughts, whereas intrusive thoughts occur as thoughts, images and impulses (30). To our knowledge, only one study examined worrisome and intrusive thoughts in adults diagnosed with ADHD. Abramovitch and Schweiger (31) compared healthy controls with a group of young adults with ADHD and found that the ADHD group experienced significantly more social and meta-worries, and a significantly greater frequency of intrusive unwanted thoughts. In the same study, individuals in the ADHD group were found to be significantly more disturbed and sad regarding the intrusive thoughts and images they experienced and showed significantly greater difficulty in removing those thoughts from their minds. The authors suggested that given the prominent inhibitory deficit characteristic of this syndrome, individuals with ADHD may experience difficulties inhibiting those thoughts (31).

Attention Deficit/Hyperactivity Disorder is considered a neuropsychiatric disorder, and extensive body of neurobiological research suggests that ADHD is characterized with a pattern of under-activity in prefrontal and striatal regions of the brain, as well as deficiencies in dopaminergic frontostriatal connectivity systems (32-36). An abundance of research also suggests that individuals with ADHD are characterized with impairments in tests of response inhibition (37, 38), defined as the ability to inhibit an already activated motor response (39). A common explanation for this deficit was motivated by neuroimaging research on ADHD, in which metabolic under-activity of specific prefrontal and striatal regions were identified (32, 34). Thus, behavioral impulsivity and deficient response inhibition in ADHD are thought to stem from metabolic under-activity of the inhibitory/executive control system (37, 40).

During the past twenty years, researchers and clinicians have been advocating physical activity for ADHD individuals as an adjunct treatment (41, 42). This fairly widespread notion has been usually supported by the combination of intuitive and scientific arguments (e.g., physical activity is scientifically proven to be healthy, and hyperactive individuals should exercise in order to dispose of excess energy). Nevertheless, even today, there is a dearth of research on the impact of physical activity in ADHD. In fact, to our knowledge only two studies investigated the correlates of physical activity in ADHD, and specifically the psychomotor and cognitive correlates. In an attempt to investigate the impact of physical activity in children with ADHD, Tantillo and her colleagues (43) examined the effect of treadmill walking on spontaneous and acoustic startle eye blink response and motor impersistence in 18 children diagnosed with ADHD. Whereas the authors reported mixed results, a significant effect of physical exercise was demonstrated, prompting the author's conclusion that physical activ-

ity has an impact on behavioral and cognitive function in children with ADHD. Interestingly, this effect was not found in non-ADHD matched controls (43). In the second study, Hopkins and his colleagues (44) examined the impact of physical activity on attentional orienting, social interactions and locomotor activity in a rat model of ADHD. Results points to an impact of physical activity on attentional orientation and social interaction. The authors of both studies conclude that their findings, while not without limitations, are significant as well as novel and should encourage additional research in this field. In sum, the existing data on the effects of physical exercise on depression and anxiety, along with evidence of the impact of exercise on dopamine and norepinephrine modulation and recent pioneering work on ADHD, increases the likelihood that exercise may have a positive impact on cognitive, behavioral and emotional symptoms in ADHD. Nevertheless, to our knowledge the association between physical activity and adult ADHD symptomatology has never been empirically investigated, let alone its impact on the cognitive aspects of anxiety (e.g., intrusive and worrisome thoughts). Therefore, this study aims at examining the association between physical exercise and impulsivity, intrusive unwanted thoughts and worrisome thoughts in adults with ADHD. We hypothesized that individuals diagnosed with ADHD that engage in frequent physical activity will report less behavioral impulsivity, intrusive and worrisome thoughts than individuals with ADHD that do not, or infrequently engage in physical activity.

METHOD

SUBJECTS

Thirty-seven male college students diagnosed exclusively with ADHD (the inclusion criterion) enrolled in a support center for students with learning disabilities and ADHD at a college in northern Israel volunteered to participate in this study. The preliminary screening process included the selection of participants for which a board psychiatrist formal diagnosis of ADHD was on file. Subsequently, all participants were pre-screened using a detailed semi-structured interview to rule out other comorbid psychiatric disorders. Exclusion criteria were as follows: 1) any formal diagnosis of any other DSM-IV psychiatric disorders, 2) any history of prescribed psychiatric medications and hospitalization, 3) any history of a neurological disorder or insult 4) any known or reported history of other learning disabilities. Only males were used in this study due to the relative small number and difficulty in recruiting adult females with ADHD (45). Of the original 37 participants, only 30 participants fulfilled the diagnosis of ADHD using DSM-IV criteria (and confirmed by the Continuous Performance Test II [46]), and met inclusion/exclusion criteria. This final group constituted the experimental group and all participants were not taking stimulant medication. Diagnoses were established additionally by the third author, an experienced clinical neuropsychologist. The mean age for the group was 27.29 (SD = 5.87). This study was approved by the Institutional Review Board. All participants signed an informed consent in accordance with the declaration of Helsinki.

MEASURES

A *DSM IV based questionnaire* (1) was created covering all the necessary diagnostic criteria for ADHD diagnosis. Participants were asked to indicate whether they exhibited each presented behavior in the past six months and/or in childhood (before the age of 7). Of note, research suggests that DSM-IV-based self-report measures have sound psychometric properties in terms of diagnostic validity, and do not differ significantly from structured ADHD rating scales (47).

The Conners' Continuous Performance Test, 2nd edition (CPT-II) (46) was used as a secondary assessment tool for the ADHD diagnostic process. The CPT-II is a computer based sustained attention test. Respondents are required to press the mouse button when any letter except the target letter "X" appears. The CPT-II was administered using a laptop personal computer and took approximately 14 minutes to complete. The CPT-II has adequate reported reliability (Split half coefficients on all measures ranging from 0.73 to 0.95[46]).

The *Distressing Thoughts Questionnaire (DTQ),* (48), measures 6 prominent anxious thoughts and 6 depressive thoughts, each along 5 dimensions; frequency, sadness, worry, removal and disapproval. The latter 5 are compiled by summing their values in each criterion (e.g., depressive and anxious). The DTQ subscales are reported to have internal consistency coefficients above .70 (48). The DTQ was found to correlate with State Trait Anxiety Inventory-State scale (*r's* from .23 to .62) (49), with the Cognitive and Somatic subscale of the Cognitive-Somatic Anxiety Questionnaire (*r's* from .33 to .57;(49)) and with the Beck Depression Inventory (*r's* from .31 to.79 [49]). In addition the DTQ correlated with the Eysenck Personality Questionnaire – Neuroticism Scale (*r's* from .36 to .59) (50).

The *Anxious Thoughts Inventory (AnTI,* Wells, 25) evaluates three dimensions of worry: social worry, health worry and meta-worry (i.e., worry about the controllability of thoughts and appraisal of thoughts as intrusive) (51). The AnTI which was translated into Hebrew, has 22 items; 9 items related to social worry, 6 items related to health worry and 7 items related to meta-worry. The responses are given on a 1 (almost never) to 4 (almost always) Likert scale. The AnTI was reported to have good psychometric properties (25). Cronbach alpha coefficients of the subscales reported by the authors were all .75 and above (25). All four subscales of the AnTI (e.g., social worry, health worry, meta-worry and total worry) were reported to have significant correlations with the Spilberger Trait Anxiety subscale, Eysenck Neuroticism subscale and the Self-Consciousness Inventory (25).

The Eysenck Impulsivity-Venturesomeness-Empathy questionnaire (IVE) (52) is a 63 item questionnaire designed to assess impulsivity venturesomeness and empathy. The items from the latter scale were added in order to be used as buffer items (52), and were not included in our statistical analyses. The IVE has reported reliability coefficients of .79 and .85 for venturesomeness and impulsivity, respectively (52). Investigation of this scale's construct validity was conducted by the authors and showed that impulsivity correlated moderately with psychotism (r =.52), and venturesomeness with extraversion (r = .46) of the Eysenck Personality Scale.

MEASURE OF PHYSICAL ACTIVITY

In order to assess physical activity, a leisure time activities questionnaire was constructed. Our decision to create a novel questionnaire was due to the fact that a similar published questionnaire did not use buffer items and was very explicit in terms of its face validity (53). We considered this explicit nature of the questionnaire as being a potential bias, producing undesirable demand characteristics for the participants. This questionnaire contained 30 items compiled into 4 subcategories: sport and physical activities, general leisure time activities, book reading preferences and movie preferences. The latter three subcategories were used as filler and distracter items in order to conceal the true focus of the study on physical activity, and thus minimizing the potential response bias. The physical exercise subscale contained seven common physical activities with a major aerobic component (e.g. walking, jogging, competitive sports and bicycling). All activities were defined as lasting at least 30 minutes each time it was performed. Participants were asked to select the average number of times each activity was performed each week for the past six months.

The IVE, DTQ and the AnTI questionnaires were administered to a group of Hebrew native speakers, age-matched normal controls, to ensure the equivalence of the translations. When comparing this group's results to the original and other control samples published in the scientific literature, no significant differences were found.

PROCEDURE

Participants completed initially the DTQ, AnTI, and the DSM questionnaire, following careful instructions. They were told that no time limit is imposed on completion of the questionnaires. All subjects subsequently completed the CPT-II individually. The completion of the five questionnaires took approximately 35-45 minutes. Next, participants were given a 10 minute break, and then were directed to another secluded classroom where they completed the CPT-II. Each participant was seated in front of a computer and was given instructions concerning the test completion. The completion of the CPT-II took an average of 14 minutes.

STATISTICAL ANALYSIS

Using the physical activity section of the leisure-time activity questionnaire, we divided the participants into two main groups: "high (physical) activity" and "low activity." Low activity was defined as engaging in any physical activity up to once a week. High activity was defined as engaging in any aerobic physical activity at least twice a week. This cut off is based on studies demonstrating that substantial psychological improvement was found to occur in study groups engaging in physical activity for at least twice a week (54, 55). In fact, research suggests that even lower doses of physical activity may improve psychological well-being, depressive and anxious symptoms (10, 56, 57). A univariate analysis of Variance (ANOVA) was performed in order to examine differences in years of age between the groups. A Multivariate Analysis of Variance (MANOVA) was conducted in order to examine the overall difference between the ADHD participants in the "high activity" group and "low activity" group on the IVE, AnTI and DTQ subscales (e.g., impulsivity, venturesomeness, social worry, health worry, meta-worry, total worry, frequency of intrusive thoughts, sadness about intrusive thoughts, feeling disturbed regarding the thoughts, removal difficulty, disapproval, overall index of intrusive thoughts with anxious content and the overall index of intru-

sive thoughts with depressive content). Subsequently, a multivariate discriminant function analysis (DFA) was performed to assess the relative partial association between the target variables and the extent to which they differentiate the two groups. Since the empathy scale was originally used in order to provide buffer items in the IVE questionnaire and was not relevant to the present study, it was removed from all statistical analyses. Alpha level of 0.05 was used throughout the study.

RESULTS

A univariate analysis of variance revealed a significant difference in years of age between the "high activity" (*M* =30.63, *SD* =8.00) and the "low activity" (*M* =25.62, *SD* =3.68) groups, F(1,28)= 5.621, *p* =.025. Accordingly, we controlled the age variable on subsequent analyses. A MANOVA was conducted to assess overall difference between the two groups of participants with ADHD. We used 14 variables (impulsivity, venturesomeness, social worry, health worry, meta-worry, total worry, intrusive thoughts' frequency, sadness, worry, removal difficulty, disapproval, total anxiety and total depressive) as dependent variables. Controlling for age, the MANOVA results revealed an overall significant difference between the "high activity" and the "low activity" groups, Wilks' Lambda = .332, F(12, 16)= 2.686, *p* = .034). The univariate analyses presented in Table 1 reveal that the group reported to frequently engage in aerobic physical activity, scored significantly lower than the low physical activity group on the meta-worry scale (*p* =.012), as well as on the impulsivity scale (*p* =.033). Subjects from the "high activity" group also scored significantly lower on most of the DTQ subscales: the "sadness about unwanted thoughts" scale (*p* =.013), the "worry about intrusive thoughts" scale (*p* =.022), on "difficulty in removal of intrusive thoughts" scale (*p* =.037), and on the "total anxious intrusive thoughts" scale (*p* =.005). No significant differences between the groups were found on the social worry, health worry, total worry, venturesomeness, the frequency of intrusive thoughts scale and on total depressive intrusive thoughts scale.

In order to examine the relative weight of the dependent variables' association with physical activity, a subsequent Discriminant Function Analysis (DFA) was performed. In this analysis, only variables found to significantly differ between the groups were entered. As expected, a significant overall discriminant effect was found between the groups, Wilk's Lambda= .342, Chi-Square (8) = 25.764, *p* =.001). The DFA standardized discriminant function coefficients of each variable entered are presented in Table 2.

Table 1. *Means and standard deviations of the AnTI, IVE and the DTQ questionnaire subscales for the ADHD physical activity groups*

		Low Activity (N=20)		High Activity (N=10)				
	Variable	M	SD	M	SD	F (1,28)	Sig.	Adjusted R^2
AnTI	Social worry	21.5	6.9	17.9	6.53	1.032	N/S	.001
	Health worry	9.1	3.5	8.7	3.33	0.039	N/S	-.069
	Meta-worry	17.2	5.2	11.7	4.49	7.231	.012	.170
	Total worry	47.8	13	38.3	12.12	2.693	N/S	.051
IVE	Impulsivity	15.7	3.4	12.3	3.5	5.081	.033	.163
	Venturesomeness	13.8	3.3	12.1	3.2	0.553	N/S	-.026
DTQ	Frequency	49.4	14.8	37.4	17.2	2.378	N/S	.072
	Sadness	54.3	17.8	34.8	16.5	7.105	.013	.174
	Worry	50.8	17.1	33.5	16.8	5.920	.022	.140
	Removal difficulty	49.1	16.9	31.4	18.3	4.816	.037	.142
	Disapproval	49.6	18.1	33.3	16.3	3.678	N/S	.119
	Total anxious [a]	126.3	28.3	81.1	36.6	9.454	.005	.300
	Total depressive [b]	127.2	50	86.3	45.7	3.521	N/S	.081

AnTI= Anxious Thoughts Inventory; IVE= Eysenck's Impulsivity-Venturesomeness-Empathy Questionnaire; DTQ= Distressive Thoughts Questionnaire. [a]Total rating of six anxious intrusive thoughts. [b]Total ratings of six depressive intrusive thoughts.

Table 2. *Discriminant function analysis of the IVE, DTQ and AnTI subscales*

Variable[a]	DFA coefficients
DTQ Total Anxious IT	.510
DTQ Sadness	.394
AnTI Meta Worry	.388
IVE Impulsivity	.374
DTQ Worry	.358
DTQ Removal Difficulty	.357
DTQ Disapproval	.325
DTQ Total Depressive IT	.295

[a] Only variables that significantly differ between the groups were included in this analysis. IT = Intrusive Thoughts; AnTI= Anxious Thoughts Inventory; IVE= Eysenck's Impulsivity-Venturesomeness-Empathy Questionnaire; DTQ= Distressive Thoughts Questionnaire.

DISCUSSION

In a previous study, Abramovitch and Schweiger (31) found that young adults diagnosed with ADHD experience significantly more intrusive and worrisome thoughts than normal controls. In the present study we compared two groups of adults with ADHD engaging in frequent and infrequent physical activity. Our results reveal that adult individuals diagnosed with ADHD engaging in frequent aerobic physical activity reported significantly less meta-worry (e.g., worry about worry), less worry about the experienced intrusive thoughts, less difficulty in removing intrusive thoughts, less sadness about experiencing intrusive thoughts and generally less overall anxious intrusive thoughts. Another important finding was that ADHD participants in the "high physical activity" group reported significantly less behavioral impulsivity, one of the most prominent symptoms of ADHD. Our results also suggest that the experience of anxious content intrusive thoughts has the strongest relative association with physical activity. This was as opposed to intrusive thoughts with depressive content which showed to hold the weakest association. Moreover, it appears that physical activity is not associated with lower frequency of intrusive thoughts, but more with meta-perceptions about them (e.g., sadness regarding the experience of intrusive thoughts and meta-worry). Finally, we found that lower rates of behavioral impulsivity are associated with physical activity more than with other intrusive thoughts subscales (e.g., worrisome intrusive thoughts, removal difficulty and disapproval with intrusive thoughts).

Physical activity is known to alter monoamine transmission (13, 14, 16, 17) and converging scientific evidence suggests that aerobic physical exercise causes structural as well as functional changes in the brain that are associated with improvement in the cognitive, emotional, behavioral and physical domains (58). As discussed above, research provides evidence for therapeutic effects of exercise on depression and anxiety disorders and recently with regards to ADHD (6, 8, 10, 12, 43, 44, 56, 58). In light of the above, it is plausible that our findings reflects positive effects of exercise on the overall symptoms of ADHD in a fashion that mimics (or perhaps even adds to) the effect of medication therapy. Administration of stimulants and other prescription drugs for ADHD individuals generates improvement in cognitive functioning and positive behavioral changes. Studies examining the impact of methylphenidate treatment on ADHD adult individuals found that compared with placebo, medicated ADHD individuals exhibited significant reduction of inattentive, hyperactive and impulsive symptoms (59, 60). Stimulants also reduce impulsivity in adults with and without ADHD (61, 62). It is plausible that the combined effect of modulation of monoamine neurotransmitters associated with physical activity would result in the reduction of worry, intrusive thoughts and impulsivity.

No significant differences were found between the "high activity" and "low activity" groups in health and social worry and venturesomeness. The non-significant difference in venturesomeness might stem from the fact that the items examining this property are based on future intention or hypothetical declarations (e.g., "would you enjoy parachute jumping"; "would you like to go scuba diving," etc.). Thus, ADHD individuals that engage in frequent physical activity may *declare* they will act in a certain way, but in real life this may be different. We suspect that a direct measurement of this variable will yield different results. We also suspect that the non-significant difference in social worry and the "frequency of intrusive thoughts" variables might stem from the small sample size

Notably, our findings are correlational and do not reflect causation. An alternative explanation to our result may be that individuals with ADHD that are able to maintain a continuous stable physical activity regime, are able to do so due to a more moderate preexisting symptom severity.

LIMITATIONS

This exploratory study is not without limitations. First, the small sample used in this research requires cautious interpretation. Second, the difference in group

sizes seems to be problematic. This is usually due to the assumption that smaller groups will produce inflated variance. However, in this study, both groups show strikingly similar variance on most variables. Furthermore, in examining ADHD undergraduate students, there is an inherent limitation that is almost unavoidable because of the relatively low prevalence of young adults with full-blown ADHD symptoms who attend and graduate from college. Finally, this cross-sectional pilot study is based on self-reports.

CONCLUSION

Research suggests that together with improving general health, physical exercise promotes psychological well-being in a variety of ways in clinical as well as non-clinical populations. As mentioned above, clinicians, educators and researchers believe that physical activity may be beneficial specifically to individuals diagnosed with ADHD. The results of this pilot study demonstrate this association in an adult sample. However, in light of the correlational nature of our findings and the small sample size, interpretation should be approached with caution. Nevertheless, the results of the current exploratory study, together with reports of the beneficial effect of physical exercise in other psychiatric populations, give rise to the possibility that physical exercise may contribute to the overall psychological well-being of adult individuals with ADHD. Future research using larger samples is warranted in order to investigate the causal relationship between physical activity and ADHD symptoms as well as the specific underlying mechanisms.

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