

The effects of cardio and non-cardio exercise on the symptoms of inattention and impulsivity on adults with attention deficit hyperactivity disorder

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Abstract

There is some evidence for the usefulness of cardio and non-cardio exercise in reducing ADHD symptoms, however, prior research has focused on children and employed observational study designs. Due to the conflicting research, no definitive conclusion can be reached, as some studies discovered both significant (Hoza, Martin, Pirog, & Shoulberg, 2016) and non-significant results (Farcas, Szabó, Orbán, & Batiz, 2019). To obtain a better understanding of the subject matter, we collected data from healthy adults and adults with ADHD (n = 20). We attempted to extend this area by integrating non-cardio exercises on adults and employing objective behavioural tests. Participants were recruited using a purposive sampling technique, and their data were obtained through a series of tests (Test of Variables of Attention, Delay-Discounting Task, Iowa Gambling Task). The data were analyzed using a 3x2x2 factorial design with mixed measures. We discovered that exercise alone was unable to reduce symptoms of impulsivity ($F(1,16)=0.28$, $p=0.599$, $\eta_p^2=0.01$) and inattention ($F(1,16)=1.32$, $p=0.266$, $\eta_p^2=0.07$). Overall, both cardio and non-cardio exercises were not enough to reduce ADHD symptoms.

Keywords: ADHD, cardio, non-cardio, exercise, impulsivity, inattention

The effects of cardio and non-cardio exercise on the symptoms of inattention and impulsivity on adults with attention deficit hyperactivity disorder

Attention deficit hyperactivity disorder (ADHD) can affect both children and adults. According to research, around 7.2% of children and 2.5% of adults suffer from ADHD (Simon, Czobor, Bálint, Mészáros, and Bitter, 2009; Thomas, Sanders, Doust, Beller, and Glasziou 2015). It is most frequently diagnosed in childhood but can occur at any age (Moffitt et al., 2015; Simon et al., 2009). ADHD is characterized by inattention, hyperactivity, and impulsivity. Long-term issues include behavioural and learning difficulties, emotional problems, lower socioeconomic status, and other physical and psychological problems (Doggett, 2004). According to Hinshaw (2002), ADHD is a severe, persistent, long-lasting, and impairing condition that affects six domains of competence (academic/school performance, family and home life, peer relationships, self-esteem, presence of accidental injuries, and overall adaptive functioning). According to a ten-year follow-up study of children with ADHD, even though 65 per cent of subjects no longer met DSM-IV criteria for ADHD, 78 per cent of subjects still had psychiatric comorbidity, were familiar with mood disorders, or had higher levels of impairment in educational and interpersonal domains (Biederman, Petty, Evans, Small, & Faraone, 2010). Due to ADHD's high prevalence and devastating effects, we need to develop a treatment that works for both adults and children (Parekh, 2017).

Amphetamine and methylphenidate are two of the most often prescribed and effective treatments. These medications have been shown to effectively treat ADHD symptoms in around 80% of people (Barkley, DuPaul, and McMurray 1991; Dittmann, et al., 2014; Milich, Balentine, and Lynam, 2006). However, these medications are not without risks. According to a case study conducted by Lakić (2012), increasing the dosage of methylphenidate resulted in the appearance of clinical depressive symptoms, which resolved with discontinuation of

medication treatment. Numerous children discontinue their ADHD medication during the first year because of psychological side effects or a feeling that the medication was ineffective (Toomey, Sox, Rusinak, & Finkelstein, 2012). Alternative treatments, such as physical exercise, may assist to prevent such issues by minimizing the adverse effects of medications.

Cardio exercises increase heart rate (HR) and breathing intensity and are often performed at a moderate to intense speed for 20 to 60 minutes (Bumgardner, 2020). This form of exercise includes jumping rope, swimming, cycling, and rowing. Continuous cardio exercises are found to be effective in terms of reducing ADHD symptoms and improving social, emotional, and behavioural functioning (Hoza et al., 2016). However, the data did not support the use of exercise as a stand-alone treatment for ADHD. Zang (2019) discovered that exercise significantly reduced depression, anxiety, aggressive behavior, as well as social and cognitive problems in children with ADHD. With non-significant findings, symptoms of hyperactivity and inattention were also shown to be reduced. In research conducted by Silva et al. (2015), the effects of physical activity on children's attention were assessed using a computer game. The findings indicated that intensive physical exercise improves attention and provides stronger impulse control in children and adolescents with ADHD symptoms. Another study examined participants for half an hour each day while they engaged in various physical exercises such as running, jogging, and cycling. The study's findings were not statistically significant, indicating that no improvement in attention or hyperactivity/impulsivity symptoms was found (Farcas et al., 2019). Den Heijer (2017) conducted a systematic review to determine whether exercise can be used to treat children and adults with ADHD. Cardio workouts seemed to be a feasible alternative for those with ADHD, as they demonstrated promising results in terms of reducing impulsivity, response time, and other physical symptoms. However, these findings came from research with

methodological flaws (absence of control group and condition, logistical problems). Due to inadequate experimental designs and a lack of theoretical support, the effects of non-cardio exercise remains questionable.

Non-cardio exercises include walking, yoga, and tai-chi. Due to a scarcity of research in this area, there is insufficient evidence to support the impact of non-cardio exercises on ADHD. However, a few studies shed light on potential benefits. An analysis of the literature shows a study that examined the effect of tai chi on adolescents with ADHD (Hernandez-Reif, Field, & Thimas, 2002). After engaging in tai chi lessons, adolescents with ADHD exhibited decreased levels of anxiety and hyperactivity. Taylor and Kuo (2019) discovered that children with attentional difficulties were able to concentrate better after taking a stroll in the park. According to a case study (Azrin, Ehle, & Beaumont, 2016), playground exercise reduced hyperactivity in children with ADHD; however, this effect may be attributable to the reinforcing nature of the surroundings rather than the physical activity.

Statement of Relevance

ADHD is one of the most prevalent disorders, particularly in children, and is associated with serious long-term impairments in nearly every aspect of life. While medications are the first line of treatment for people with ADHD, they are frequently discontinued due to adverse effects. As a result, we need to discover viable solutions to medication or adjunct treatments. The purpose of this study was to determine whether exercise provides a viable answer to this problem. While the evidence supporting exercise as an additional treatment for ADHD is limited, it is a promising and growing field of research. However, the majority of prior studies focused on children and cardio exercises and had flaws in their design. Our research is particularly important since it examined the effects on adults, took into account non-cardio exercises, and included objective behavioural tests.

According to previous studies, the outcomes in this area remain unclear. There are both significant and non-significant findings. Additionally, given the lack of research in this field, more extensive studies are required to have a better understanding of the subject. The lack of studies in this field focusing just on children or adolescents, and mostly on cardio-only activities, bolstered this idea. Additionally, the bulk of studies is limited to one or two ADHD symptoms and cardio-only activities. Another critical aspect is that prior research has been conducted mostly on uncontrolled groups and has lacking objective measurements of symptoms. As a result, our research will examine whether non-cardio activities can be beneficial, as well as the concurrent investigation of several ADHD symptoms utilizing a variety of instruments. This enables us to monitor changes in ADHD symptoms across a range of conditions. Following exercise, we anticipate that these symptoms will subside or improve. The following is our research question:

- 1.) Are cardio and non-cardio exercises beneficial in the reduction of symptoms of impulsivity and attention in medicated adults with ADHD in comparison to healthy controls?

Method

Participants

The study involved ten male and ten female participants between the ages of 18 and 35. We limited our age range to those under the age of 35 to avoid the danger of age-related cognitive decline (Salthouse, 2009). Purposive sampling was used to select participants, and we used several recruitment strategies to reach our target group (King's College London's institutional recruiting network, the UK Adult ADHD network, fliers and posters around campus, and social media advertisements). The study consisted of two groups: healthy controls (HC) and adults with ADHD who are currently using psychostimulants (AD+).

Before the start of the test, all participants were asked to complete a brief online screening survey to determine their eligibility and to assist us in grouping them. The Physical Exercise Readiness Questionnaire (PAR-Q; Cardinal and Cardinal, Esters, 1996) was used to assess participants' fitness for activity. Those that were ready were asked to complete the following forms: 1.) Demographic information (age, gender, ethnic origin, handedness, and years of post-compulsory education); 2.) The Godin-Leisure Time Exercise survey (Sikes et al., 2019). They indicated how frequently they exercised for at least 15 minutes at a light, extreme, or moderate-intensity during their free time throughout the week. 3.) A single question about ADHD diagnosis was used in combination with the standardized Adult ADHD Self-Report Scale (ASRS; Kim, Lee, & Joung, 2013) to validate the presence of ADHD in all participants. Those who stated they had ADHD were asked about their medication (dose, duration of use, the type used). We ensured that our medicated patients adhered to their medications at a rate of at least 80%, as this is the most often reported level of medication adherence (Safren, Duran, Yovel, Perlman, & Sprich, 2007).

Inclusion/Exclusion criteria

All groups. Recruited via the institutional recruitment network at King's College London, the UK Adult ADHD network, social media, and posters. Ages 18–35, fitness for exercise as determined by the PAR-Q (participant answering "no" to all seven questions), and blood pressure (bp) of 140/90mmhg. Exclusion criteria: The screening questionnaire and blood pressure readings indicated that the individual was physically unfit for exercise.

Healthy controls (HC). The absence of a diagnosis of ADHD is a requirement for inclusion. The ASRS (score < 17) will be used to validate this (Kessler et al., 2005, Adler, et al., 2006).

Medicated ADHD group (AD+). Inclusion criteria: existing ADHD diagnosis confirmed by the ASRS (score > 17), medication adherence of at least 80% (Safren et al., 2007), and medication information. Exclusion criteria: haven't had medication in over 6 months.

Design

This was a quantitative study using a 3x2x2 factorial design with mixed measures. The first factor is referred to as "ADHD status," and it is a between-subjects factor made up of two distinct participant groups (HC, AD+). The second factor is "Exercise," which is also a between-subjects factor and is consisting of two conditions: 1.) 10 minutes of moderate-intensity cycling on an exercise bike at 80-90 RPM; 2.) 10 minutes of non-cardio yoga accompanied by an instructional video. The last factor is "Time," which will be assessed within-subjects before and after exercise.

Measures

The tasks evaluate impairments in temporal, cognitive, motor impulsivity, and attention. The Test of Variables of Attention (TOVA; Grane, Endestad, Pinto, & Solbakk, 2014; Wu et al., 2007) is a 22-minute test that is longer than the average duration of alertness for people with ADHD, making it a more sensitive test for this group than shorter tasks (Vaurio, Simmonds, & Mostofsky, 2009). Participants must press a letter on a keyboard in response to a target stimulus while suppressing responses to the non-target stimuli. The work is separated into two phases, each of which contains distinct information: i) Phase 1: target signals are uncommon, occurring in only 22.5% of trials; ii) Phase 2: target signals are common, occurring in 77.5% of trials. There are several parameters available in both phases, but for this study, we have focused on omission errors in the first phase (failure to respond to a target signal), which indicate impaired attention, and commission errors in the second

phase (responding to a non-target signal), which indicate motor impulsivity (Grane et al., 2014; Adams, Roberts, Milich, & Fillmoore).

The Delay-Discounting Task (DDT) was used to measure temporal impulsivity (Hurst, Kepley, Mccalla, & Livermore, 2010). Participants must select between hypothetical awards now or in the future over a range of periods, including one week, two weeks, one month, three months, six months, and one year. The task takes less than 15 minutes to complete. The area under the curve (AUC) is a method that is used to obtain the results of this task. This is accomplished by graphing the values of indifference points acquired at various delays, with the value plotted on the y-axis and the delay plotted on the x-axis. On both axes, the potential values are modified to range from 0 to 1. The AUC for a segment of the discounting curve (D1, D2) is calculated using the size of the trapezoid formed by two temporally contiguous indifference points (V1, V2) and their associated delays (Yoon et al., 2017). The AUC is a frequently used metric for assessing the DDT task (Myerson, Green, & Warusawitharana, 2001). Smaller AUC values indicate more impulsivity, whereas larger AUC values indicate reduced impulsivity. We anticipate that exercise will reduce symptoms of impulsivity.

The Iowa Gambling Task (IGT) is a commonly used and well-validated assessment of cognitive impulsivity where participants are presented with four decks of cards labelled A, B, C, and D and they must choose 100 times from the decks (Kovács, Richman, Janka, Maraz, & Andó, 2017). The test takes 15 minutes to complete. Each time a participant picks a card, they can gain or lose virtual money. While decks A and B generate greater earnings and losses and are thus less favourable, decks C and D generate smaller profits and losses but are more advantageous. Selecting just from Decks C and D results in a net score of 100, whereas selecting exclusively from Decks A and B results in a net score of -100. Subtracting Decks A and B from Decks C and D are used to reach the score. Higher net scores are associated with

improved performance, which results in less impulsivity. Decks A and B are riskier cards because they win more in the short term but lose in the long term. Selecting from decks A and B more frequently indicates a high degree of impulsivity. Individuals with ADHD performed differently on this test (Groen, Gaastra, Lewis-Evans, & Tucha, 2013), with those with ADHD making more risky decisions (Toplak, Jain, & Tannock, 2005). We expect that risky decisions will be more prevalent in ADHD groups and less prevalent in exercise groups. The experiment is expected to last two hours per participant.

Procedure

Ethical approval has been obtained from King's College London before the commencement of this study. All participants before and upon arrival were briefed about the study's aim and procedures, as well as how their personal information will be kept private, and they were requested to sign an informed consent form. We double-checked that our screening survey did not include any offensive language or prejudice. Participants were given the choice to stop at any moment regardless of their reason. They were informed not to consume coffee, alcohol or cigarettes up to 2-3 hours before coming into the study. This was to ensure that the participant was not under the effects of these substances as they can affect their performance during the tasks. The blood pressure of every participant was taken before the start of the study to ensure that they were healthy enough to participate. They were then assigned to one of the two workout conditions at random. Following that, the participants completed 30 minutes of the previously described cognitive tests. We assessed the participants' HR before they began their allocated exercise condition. We made certain to give additional help to anyone who wasn't feeling well physically or psychologically during the exercise. Following the exercise, we measured the participant's HR once more and instructed them to complete the cognitive tests for the second time.

Results

After checking for normality, data will be analyzed using parametric methods such as mixed measures ANOVA.

Table 1.

Demographic data of the study population.

		Group								
		HC			ADHD Med			Total		
		Mean	Count	Row N %	Mean	Count	Row N %	Mean	Count	Row N %
Age		26.60			24.30			25.45		
Gender	Male		5	50.0%		5	50.0%		10	100.0%
	Female		5	50.0%		5	50.0%		10	100.0%
	Total		10	50.0%		10	50.0%		20	100.0%
Handedness	Left		0	0.0%		1	100.0%		1	100.0%
	Right		10	52.6%		9	47.4%		19	100.0%
	Total		10	50.0%		10	50.0%		20	100.0%
Activity levels	Active		8	47.1%		9	52.9%		17	100.0%
	Insufficiently active		2	66.7%		1	33.3%		3	100.0%
	Total		10	50.0%		10	50.0%		20	100.0%
Post-compulsory education (years)		6.20			5.75			5.98		

Based on our sample the expected mean difference of the age of the participants between HC and ADHD medicated groups was 2.3 (95% CI: [-2.00, 6.60]). This difference was not statistically significant ($t=1.12$, $df=18$, $p=0.277$). According to Fisher's exact test (exact $p=1.000$), no significant differences were found between handedness and group. The results were the same between activity levels and study groups (exact $p=1.000$). Based on our sample the expected mean difference in ASRS score between HC and ADHD medicated group was -22.6 (95% CI: [-31.99, -13.20]). This difference was statistically significant ($t= -5.05$, $df=18$, $p<0.001$). We expected participants to have a higher HR after the cardio exercise and a stable HR after the non-cardio exercise. For both HC's ($t= -4.08$, $p<0.015$) and ADHD

medicated ($t = -5.94, p = 0.004$) participants their HR after the cardio exercise has increased and for both HC ($t = -0.57, p = 0.596$) and ADHD medicated ($t = -0.38, p = 0.721$) participants their HR after the non-cardio exercise remained stable.

Inattention

The results of the Three-Way Mixed ANOVA showed that there was no significant main effect of group ($F(1,16) = 1.02, p = 0.326, \eta_p^2 = 0.06$) on omission errors in phase 1 of the TOVA task, with HC (mean = 1.74, sd = 0.62) and ADHD medicated participants (mean = 2.64, sd = 0.62) performing similarly overall. In addition, there was also no significant main effect of time ($F(1,16) = 1.32, p = 0.266, \eta_p^2 = 0.07$) on omission errors in phase 1 of the TOVA task, with participants showing similarities for before (mean = 1.80, sd = 0.43) and after (mean = 2.57, sd = 0.65) exercise. Also, there was no significant main effect of exercise on omission errors in phase 1 of the TOVA task ($F(1,16) = 3.22, p = 0.091, \eta_p^2 = 0.16$), with cardio (mean = 2.98, sd = 0.62) and non-cardio (mean = 1.39, sd = 0.62) scoring similarly overall. On the contrary, there was a significant interaction effect of group and exercise condition ($F(1,16) = 6.73, p = 0.020, \eta_p^2 = 0.29$). Descriptive statistics showed that while HC's in the cardio condition made fewer errors of omission compared to HC's in the non-cardio condition, ADHD_med's showed the opposite pattern (Table 2).

Table 2.

Means, standard deviations and confidence intervals on the measure of errors of omission in the first half of the TOVA task.

Group	Exercise condition	Mean	Std. Error	95% Confidence Interval	
				Lower Bound	Upper Bound

HC	Cardio	1.389	.886	-.489	3.267
	Non-cardio	2.097	.886	.219	3.975
ADHD_Med	Cardio	4.585	.886	2.707	6.463
	Non-cardio	.694	.886	-1.183	2.572

Note. Greater values represent more inattention.

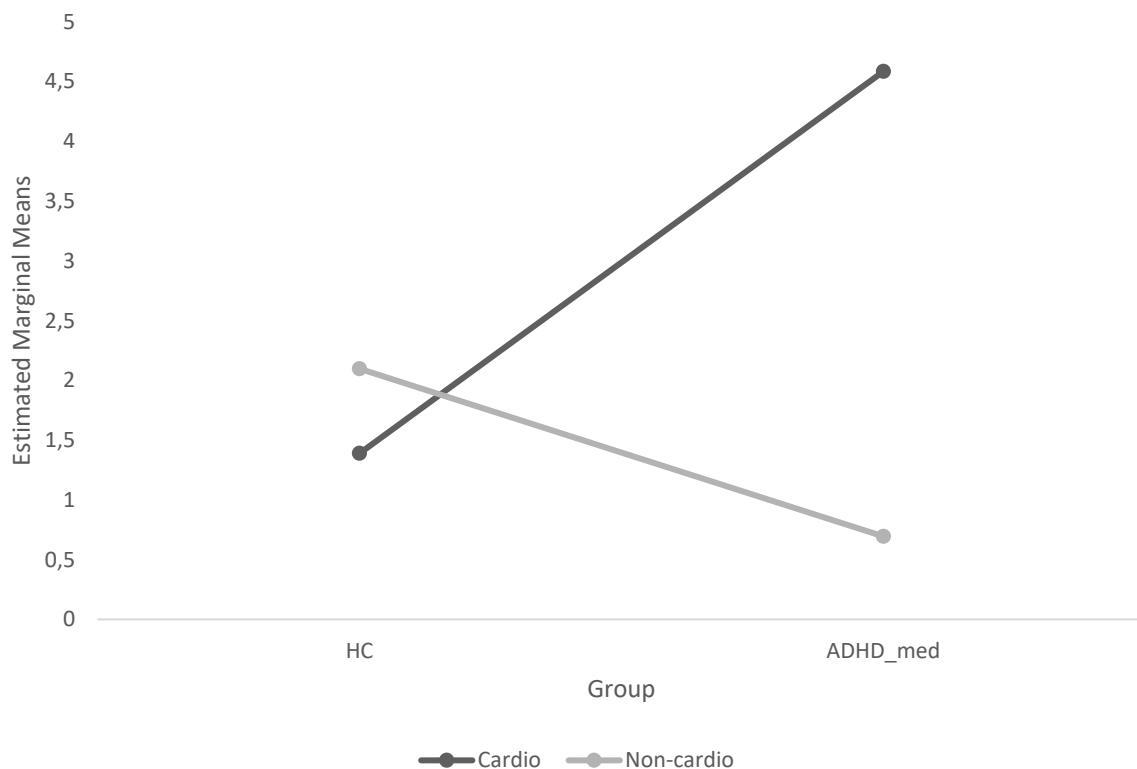


Figure 1. Represents the baseline differences between HC and ADHD medicated group on the means of omission errors in phase 1 of the TOVA task.

Upon further inspection, we found that this interaction effect was due to the baseline differences of ADHD medicated participants in the cardio group having a much higher level of errors (mean=5.0, sd=2.88) than the non-cardio group (mean=0.83, sd=1.24). For HC's cardio group (mean=1.66, sd=2.28) and non-cardio (mean=2.80, sd=4.33). No other interactions were significant.

Motor Impulsiveness

The results of the Three-Way Mixed ANOVA showed that there was no significant main effect of group ($F(1,16)=1.98$, $p=0.178$, $\eta_p^2=0.11$) on commission scores on phase 2 of the TOVA task with HC (mean=3.62, sd=0.97), ADHD_med (mean=5.56, sd=0.97) performing similarly overall. There was no main effect of time ($F(1,16)=0.28$, $p=0.599$, $\eta_p^2=0.01$) on phase 2 of the TOVA task with participants showing similarities for before (mean=4.82, sd=0.87) and after (mean=4.36, sd=0.71) exercise. Also there was no main effect of exercise ($F(1,16)=1.30$, $p=0.270$, $\eta_p^2=0.07$) on phase 2 of the TOVA task with cardio (mean=3.80, sd=0.97) and non-cardio (mean=5.38, sd=0.97) scoring similarly. Also, there was not a significant interaction effect of group and exercise condition ($F(1,16)=0.18$, $p=0.670$, $\eta_p^2=0.01$). No other interaction effects were found.

Temporal Impulsivity

The results of the Three-Way Mixed ANOVA showed that there was no significant main effect of group ($F(1,15)=0.87$, $p=0.364$, $\eta_p^2=0.05$) on temporal impulsivity, with HC (mean=0.31, sd=0.05) and ADHD_med (mean=0.39, sd=0.06) performing similarly overall. In addition, there was also no significant main effect of time on temporal impulsivity ($F(1,15)=0.43$, $p=0.521$, $\eta_p^2=0.02$), with participants showing similar scores for before (mean=0.34, sd=0.04) and after (mean=0.37, sd=0.04) exercise. Also, there was no significant main effect of exercise on temporal impulsivity ($F(1,15)=1.83$, $p=0.196$, $\eta_p^2=0.10$), with cardio (mean=0.30, sd=0.05) and non-cardio (mean=0.41, sd=0.06) showing similarities overall. In contrast there was a significant interaction effect of group and exercise condition ($F(1,15)=11.78$, $p=0.004$, $\eta_p^2=0.44$). Descriptive statistics showed that while HC's scored higher for the cardio condition compared to non-cardio condition, ADHD_med's showed the opposite pattern (Table 3).

Table 3.

Means, standard deviations and confidence intervals on the measure of the AUC in the DDT task.

Group	Exercise condition	Mean	Std. Error	95% Confidence Interval	
				Lower Bound	Upper Bound
HC	Cardio	.405	.080	.234	.576
	Non-cardio	.233	.080	.062	.404
ADHD_Med	Cardio	.198	.080	.027	.369
	Non-cardio	.594	.090	.403	.786

Note. Smaller values represent greater temporal impulsivity.

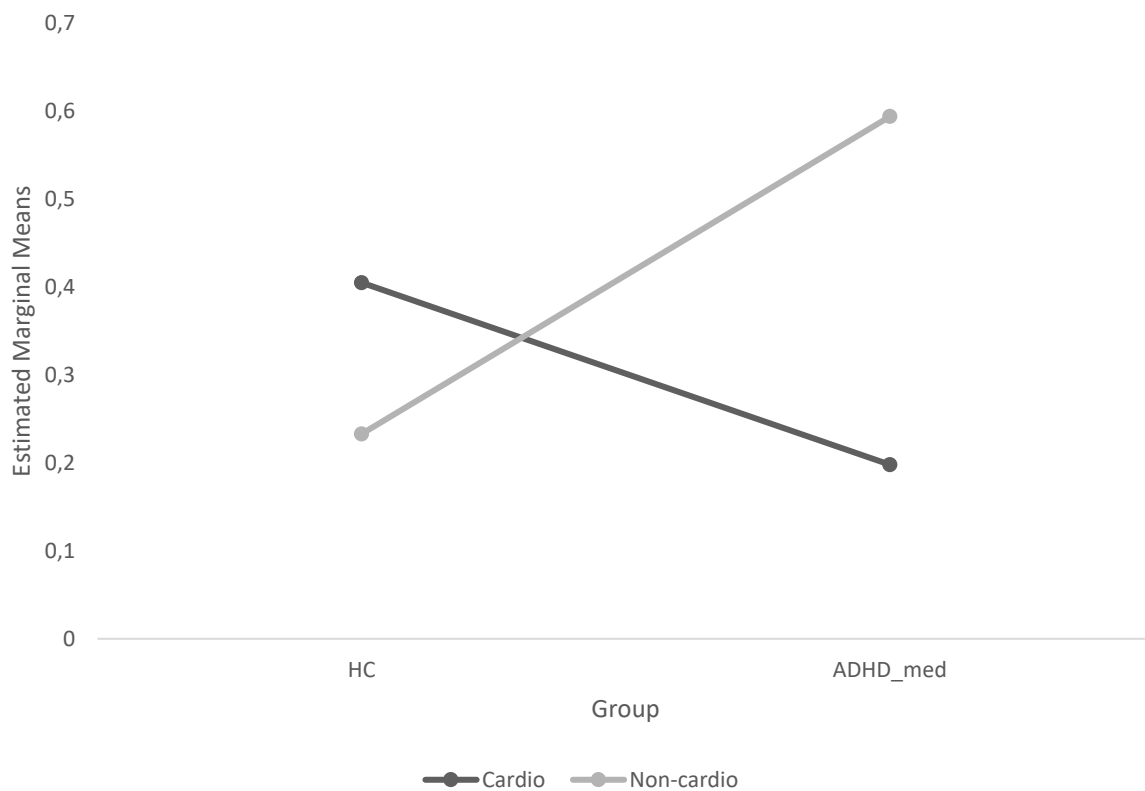


Figure 2. Represents baseline differences between HC and ADHD medicated group on the means of the AUC.

Upon further inspection, we found that this was due to the baseline differences between the two groups with ADHD_med's in the cardio group having a significantly lower level of temporal impulsiveness (mean=0.24, sd=0.233) than the non-cardio group (mean=0.65, sd=0.16). For HC's in the cardio group (mean=0.43, sd=0.259) and non-cardio (mean=0.16, sd=0.11). No other interactions were found.

Cognitive Impulsivity

The results of the Three-Way Mixed ANOVA showed that there was no significant main effect of group ($F(1,16)=0.04$, $p=0.841$, $\eta_p^2=0.003$) on cognitive impulsivity, with HC (mean= -2.10, sd=6.59) and ADHD_med (mean= -0.20, sd=6.59) performing similarly throughout. There was also no main effect of time ($F(1,16)=0.30$, $p=0.589$, $\eta_p^2=0.01$) on cognitive impulsivity with participants not showing differences for before (mean= -3.20, sd=5.72), after (mean=0.90, sd=6.31) exercise. Additionally there was no main effect of exercise ($F(1,16)=0.17$, $p=0.681$, $\eta_p^2=0.17$) on cognitive impulsivity with cardio (mean= -3.10, sd=6.59) and non-cardio (mean=0.80, sd=6.59) scoring similarly. Finally, there was not a significant interaction effect of group and exercise condition ($F(1,16)=0.25$, $p=0.621$, $\eta_p^2=0.01$). No other interreaction effects were significant.

Discussion

The purpose of this study was to determine if exercise can aid in the reduction of ADHD symptoms in adults. This was accomplished through the use of a variety of objective behavioural tests. Additionally, we sought to determine whether non-cardio exercise was beneficial, given there was minimal research in this area. However, our findings indicated that both cardio and non-cardio workouts were ineffective at reducing ADHD symptoms, as no significant main effect was observed. We discovered significant interaction effects between group and exercise condition on inattention ($F(1,16)=6.738$, $p=0.020$, $\eta_p^2=0.296$)

and temporal impulsivity ($F(1,15)=11.785$, $p=0.004$, $\eta_p^2=0.440$), however, this was attributed to substantial baseline differences in data due to our study's small sample size. The remainder of our data indicated that ADHD symptoms were reduced following exercise, although this was not statistically significant and was inconsistent with exercise type. For example, when symptom kinds were considered, non-cardio proved to be more beneficial than cardio, whereas the reverse was seen for another symptom type. This is comparable to Zang's (2019) meta-analysis, in which hyperactivity, impulsivity, and inattention were all decreased with non-significant results. While the majority of studies concentrating on cardio or non-cardio exercise have indicated that it generally improves ADHD symptoms, the results of our study contradict some prior research. In agreement with Hoza et al. (2016), our data also does not support cardio or non-cardio as a stand-alone treatment for ADHD. That is not to suggest, however, that it is useless, as Taylor and Kuo's (2019) study discovered substantial effects in children with attentional issues who improved their concentration following a walk in the park. This discrepancy in findings might be the result of differences in methodology. As a result of our findings, we may conclude that both cardio and non-cardio exercise do not necessarily result in an improvement in ADHD symptoms.

Limitations

First of all, this study only included a total of 20 participants. A sample size this small may have resulted in insufficient analysis. Second, there was no variation in the sort of physical exercise employed in the study. Previous studies looking at the effects of cardio exercises included a mix of activities (Farcas et al., 2019). Our exercise conditions consisted entirely of a single form of exercise. Thirdly, exercise intensity may have contributed to our study's lack of significance, since Silva et al. (2015) included a relay race that involved a 5-minute intense run and tai-chi was employed as a non-cardio exercise that is more physically demanding than yoga (Hernandez-Reif et al., 2002). The results of both of these studies are

significant. Additionally, the homogeneity of variance in some variables indicated that the assumptions had been violated which puts bias in our results. Another aspect that might have impacted our results was that participants were instructed to maintain a specified RPM range during the cardio condition, but they were not monitored throughout the exercise. As a result, if they became fatigued, they may not have maintained a steady RPM between the intervals as requested. We excluded a participant group since we were unable to achieve the necessary number of participants due to the population being more difficult to reach than anticipated. Additionally, the study's lengthy duration may have impacted the participants' performance, since they were observed to be bored and drowsy towards the end of the study.

Recommendations

Given the encouraging findings in this area, further study will be required to establish a definitive response to this subject. To determine the most efficient kind of exercise, it is necessary to distinguish between the type, duration, and intensity of the activity.

Additionally, we propose that non-cardio exercises be studied in more controlled trials to allow for more conclusive findings. Furthermore, studies should examine the short and long term benefits of exercise by adding suitable control groups and conditions, as well as adjusting for confounding variables. Research should also employ a broader range of measures and larger sample sizes. Future research should combine qualitative and quantitative data on the same or a similar issue to arrive at a more objective, valid, and accurate conclusion. It is also recommended that future research examine which activities are most helpful for treating a given symptom and whether certain symptoms are more impacted by exercise than others (Den Heijer et al., 2017). Finally, to increase generalizability, additional recruitment methods are recommended to reach the desired demographic.

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