

## The Effects of Physical Activity on Impulse Control, Attention, Decision-making and Motor Functions in Students with High and Low Impulsivity

Mohamad Hosein Ghahramani<sup>1</sup>, Mehdi Sohrabi<sup>2\*</sup>,  
Alireza Saberi Kakhki<sup>2</sup> and Mohamad Ali Besharat<sup>3</sup>

<sup>1</sup>PhD student in Motor Behavior, Ferdowsi University of Mashhad, Mashhad, Iran.

<sup>2</sup>Department of Motor Behavior, Ferdowsi university of Mashhad, Mashhad, Iran.

<sup>3</sup>Department of Clinical Psychology, Tehran University, Tehran, Iran.

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Impulsivity as a symptom cuts across a number of psychiatric disorders and results have shown that it as an antipode of certain components of executive functions and consistently associated with lower grades and academic achievement. The objective of this study was to explore the effects of physical activity on impulse control, attention, decision-making and motor functions in school students with high and low impulsivity. The subjects were forty elementary school students that represented the top and bottom 33% of the distribution of impulsivity scores as high and low impulsivity in the Impulsivity Rating Scale (IRS) and were peer in IQ. They were randomly assigned in training and wait-list control groups in both levels of impulsivity (10 subjects in each group, for a total of 40 subjects). Before and after a 54-week training or control period, impuls control, attention, decision-making and motor functions were assessed by Go/no-go test, Continue Performance Test (CPT), The Balloon Analogue Risk Task (BART) and Linklon - Oseresky Motor Development Scale (LOMDS), respectively. The results showed that impulsivity scores decreased in high and low impulsivity groups compared to control groups. Also, attention, decision-making and motor functions were improved in both levels of impulsivity compared with their control groups. But comparative analysis between high and low impulsivity groups showed that effect of physical activity with low impulsivity group was significantly more than with high impulsivity group ( $p < 0.05$ ). on the basis of this results, it can be concluded that physical activity program reduce the impulsivity and furthermore, it improves attention, decision-making and motor functions in students with different levels of impulsivity, specially in low impulsivity.

**Key words:** Attention function, decision-making, motor impulsivity. Physical activity.

Impulsivity is important dimension of personality traits and various hypotheses. It is related to neuropsychological functions<sup>1</sup>. Impulsivity has been defined as the inability to withhold or stop a response in the face of negative consequences; acting without forethought or before all necessary information is available<sup>2,3</sup>. In social approach, impulsivity has been thought of

as a learned behavior, coming from a family environment and in the biological approach, researchers have found that individuals who planned impulsive acts have larger evoked potential amplitudes and higher CSF serotonin metabolite levels than those who did not plan similar acts<sup>4,5</sup>. On the other hand, various studies have shown that the core subcomponents of impulsivity are considered to include impaired impulse control, poor decision-making, risk-taking, motor hyperactivity and general inattentiveness<sup>6</sup>. In this dimension, Patton, Stanford and Barratt (1995) separated impulsivity into three components:

\* To whom all correspondence should be addressed.  
Tel.: +98 051 38805000, Fax: +98 051 38803454;  
E-mail: sohrabi@um.ac.ir

attention (not focusing on the task at hand), decision-making (lack of planning) and motor impulsivity (acting on the spur of the moment)<sup>7</sup>. With this framework, over the last decades, many studies on impulsivity have highlighted the importance of attention, decision-making and motor functions on various psychiatric disorders, especially those linked to the lack of impulse control, such as aggression, substance abuse, etc.<sup>1,3,5</sup>. Also, several studies have examined the relationship between impulsivity and academic achievement in children with different level of impulsivity<sup>8</sup>. even within the learning and studying domain, researchers have found that children rated high on impulsivity have been demonstrated to achieve lower grades than their peers with low impulsivity ratings<sup>9</sup>. Further, impulsivity is consistently associated with lower grades and achievement scores, even when IQ is partialled out<sup>10,11</sup>. So, the importance of impulsivity during childhood and adolescence has been established related to a wide variety of learning problems. For this reason, treatment and reduce impulsivity is very important. Many treatment strategies for reducing impulsive behaviors have been reported<sup>12</sup>. In treatment methods, complementary medicine techniques such as physical therapy, physical activity and physical exercise used along with current treatments<sup>13,14</sup>. Physical Activity (PA) is any body movement that works your muscles and requires more energy than resting. Walking, running, dancing, swimming, and yoga are a few examples of physical activity<sup>15</sup>. The empirical literature has suggested that PA could be of benefit for a number of cognition-related variables<sup>16</sup> and it can alter brain functions underlying cognition and behavior<sup>17</sup>. The potential of PA as a treatment has been found to positively impact many of the same neurobiological factors that are implicated. For example, in animal studies, recent study showed that PA results in increased cerebral blood flow<sup>18</sup>. Further, there is evidence that PA results in changes in cerebral structure that are expected to be important for cognitive performance<sup>19</sup>. Given the probably impact of impulsivity on a child's ability to reach his/her potential, understanding ways to improve the cognitive abilities (and perhaps most importantly the attention, decision-making and motor functions abilities) in student with impulsivity is critically important.

In the other hand, executive functions, such as attention, motor and decision-making are different in impulsive people<sup>20-22</sup>, and results have shown that impulsivity as an antipode of certain components of executive functions<sup>23</sup>. Also, according to the results in this field, individuals with various levels of impulsivity are different in cognitive and behavioral performance<sup>24-29</sup>, so, these differences should be taken consider in treatment methods. Therefore, the objective of this study was to investigate the effects of physical activity on attention, motor and decision-making functions in school students with high and low impulsivity.

## METHOD

### Participants

The subjects were 40 students aged between 9 and 12 years with a mean of 11 years (SD=2.19).

These subjects represented the top and bottom 33% of the distribution of impulsivity scores in the impulsivity rating scale (IRS) that was adjusted by their teachers. They were peer in IQ rate and selected among 6875 students that enrolled in state schools (I and II courses) in the central area of Mashhad city (Iran). They were randomly assigned in training and wait-list control groups in both levels of impulsivity. they were 10 subjects in each group, for a total of 40 subjects. Following institutional ethics approval, all subjects and parents were informed of the nature of the study and they all gave their informed consent. Table 1 presents the demographic characteristics of participants.

### Measures

#### The impulsivity rating scale (IRS)

The impulsivity rating scale (IRS) includes seven impulsivity criteria in daily life that was presented by Lecurbosier, Braconnier, Said & Payne (1995) for the diagnosis of impulsivity and, is the following: 1. patience and impatience. 2. Time taken for Decision making. 3. Ability to endure of postponements and delay. 4. Violence and aggression. 5. Responses Control. 6. Ability to carry on an activity, and 7. Irritability. Total range IRS= 0 to 21 and a threshold of 8 for the total score gives good specificity and sensitivity<sup>30</sup>. In the present study, this scale was edjusted by student techers.

**The Go/NoGo task**

The Go/NoGo task is impulse control task where a response must either be executed or inhibited. During this task, participants were required to watch a sequential presentation of letters and respond to a target letter by pressing a button. Behavioral performance of the task was assessed by calculating three values condition: executive accuracy, executive speed, inhibitive accuracy and inhibitive speed were assessed and calculated for each participant<sup>31</sup>.

**Continues Performance Test (CPT)**

The CPT involves the presentation of target and non-target stimuli. The test runs for 14 minutes and primarily assesses various aspects of attention<sup>32</sup>. Briefly, participants are required to respond to the stimuli on a computer screen by pressing a space bar for every letter except for the letter "X". Multiple dependent measures exist, including Omissions, Commissions, and Reaction Time.

**Linklon - Oseresky Motor Development Scale**

The Lincoln-Oseretsky motor development scale (LOMDS), which generally evaluates motor skills of the children, was employed as data collection tool. Validity and reliability of this test were approved after standardization and reported as 0.99 and 0.88 in order; the test assesses fine and gross motor skills and their combination quantitatively [33]. The modified form contains 36 subtests which evaluates the abilities of children between 6 and 14 years old; Balance skills, Eye-hand coordination, Hand skills, Jumping skill, Hand-foot coordination, Throw and catch movements.

**Balloon Analogue Risk Task (BART)**

The BART is a laboratory-based behavioural measure of risk taking and decision making behavior in which the participant makes button presses (pumps) to inflate individual balloons for incremented points or money with increasing risk that the balloon will explode. This would lead to the loss of the balloon's present point or monetary value. In this context, each button depression or pump is a "risky decision" with a finite probability that the balloon will explode, and thus the chance that no money will be earned increases with each pump. Empirical research has shown that the number of pumps on the BART is related to self-reports of real-world risk-taking

behavior in both adults and adolescents [34, 35]. In this study, the number of adjusted pumps on the blue balloon (Adj BART) was used for groups Assessment.

**Physical activities program**

The main objective was to maintain moderate to vigorous intensity in each session. Intensity was monitored by a polar heart rate monitor once a week for each child. Various physical activities including track and field (basic running technique), handball (passing, receiving), volleyball (passing, receiving, service), basketball (dribble, pass, shoot) and soccer (pass, dribbling, control, shoot) were used in order to maintain the motivation of the participants in the program. Also students were engaged in games during training programs, but they did not participate in sport competitions<sup>15, 17</sup>.

**Procedures**

After formation the groups, according to their impulsivity score in the Barratt Impulsiveness Scale, the high and low training groups participated in the physical activity program that was performed 3 times/week for 60 min (54 training sessions). Each session was divided into a warm-up (8-10 min), main training program (45 min.) and cool-down (5-7 min.). To determine the training program, various research protocols were analyzed [e.g. 36-40]. During the training period, wait-list control groups were involved in ordinary school programs. Impuls control, attention, decision-making and motor functions were assessed before and after a training or control period by Go/no-go test, Continue Performance Test (CPT), The Balloon Analogue Risk Task (BART) and Linklon - Oseresky Motor Development Scale (LOMDS), respectively. Analysis of covariance and multivariate covariance (ANCOVA and MANCOVA) with LSD Post hoc test were used to examine differences between the groups for post training means of each variable; pre training means were used as covariates. All data are presented as means and standard deviations, with a *p* value of <0.05 considered as statistically significant.

**RESULTS**

Demographic characteristics of the study groups are presented in Table 2

**Impulsivity**

Result of ANCOVA in post-test showed a significant difference between groups in impulsivity scores with low impulsivity ( $F=5.687, P=0.11, \eta^2=0.223$ ). Similar results were obtained for groups in high impulsivity ( $F=3.583, P=0.014, \eta^2=0.314$ ).

**Impulse control**

In low impulsivity, analysis of MANCOVA in go/no-go test showed a highly significant difference between groups for execution accuracy ( $F=4.39, P=0.0001, \eta^2=0.427$ ), inhibition accuracy ( $F=5.11, P=0.0001, \eta^2=0.520$ ) and for inhibition speed ( $F=3.11, P=0.0001, \eta^2=0.380$ ) in post-test. But, there was no group difference in execution speed ( $F=2.89, P=0.101, \eta^2=0.187$ ). Comparison groups with LSD post hoc test indicated significant

difference between training and control groups in execution accuracy ( $P=0.0001$ ), inhibition accuracy ( $P=0.001$ ) and in inhibitive speed ( $P=0.003$ ). Similar results were indicated for high impulsivity in post-test: MANCOVA result in go/no-go test showed a significant difference between groups for inhibition accuracy ( $F=7.18, P=0.0001, \eta^2=0.511$ ) and inhibition speed ( $F=5.41, P=0.002, \eta^2=0.372$ ) and There were no group difference in execution accuracy ( $F=2.55, P=0.13, \eta^2=0.218$ ) and execution speed ( $F=3.35, P=0.09, \eta^2=0.283$ ). LSD test indicated significant difference between training and control groups in inhibition accuracy ( $P=0.0001$ ) and inhibition speed ( $P=0.01$ ).

**Attention functions**

In low impulsivity, MANCOVA result in

**Table 1.** Mean and standard deviation of demographic characteristics

Variables		LIC	LIT	HIC	HIT	Total
Age	Mean	10.8	11.3	11.7	11.1	11.3
	S.D.	2.6	2.3	2.1	2.2	2.2
Weight (kg)	Mean	36.7	37.2	33.2	34.9	35.6
	S.D.	4.3	5.1	4.6	5	4.8
Height (cm)	Mean	142.47	144.29	145.73	141.1	143.5
	S.D.	6.3	7.8	5.7	8.1	7.1
BMI	Mean	16.3	17.4	18.2	17.4	17.3
	S.D.	3.2	2.2	3.8	3.8	3.1
IQ	Mean	105.8	100.7	99.1	103.9	102.6
	S.D.	7.8	8.5	6.6	7.7	6.2

LI: Low Impulsivity, HI: High Impulsivity, C: control, T: training

**Table 2.** Mean and standard deviation of dependent variables

Impulsivity	Groups	Stages		go / no-go				CPT variables			BART	LOM DS	IRS
				Execution Accuracy (N)	Speed (MS)	Inhibition Accuracy (N)	Speed (MS)	Omission errors	Commission error	reaction time			
Low impulsivity	Control	Pre-test	Mean	25.79	713	4.59	987	23.81	5.18	422	23.6	65.7	15.1
		Post-test	S.D.	3.11	213	1.34	193	8.34	1.29	33	12.3	13.7	2.1
	training	Pre-test	Mean	26.10	691	4.18	931	23.43	5.13	425	24.1	67.7	14.9
		Post-test	S.D.	3.17	281	1.12	180	9.89	1.17	41	10.9	10.3	1.8
		Pre-test	Mean	25.23	710	4.68	970	23.69	5.22	412	25.1	65.8	15.7
		Post-test	S.D.	3.35	227	1.40	214	8.11	1.31	46	11.9	14.1	2.5
High impulsivity	Control	Pre-test	Mean	28.04	581	6.73	718	21.51	4.13	368	21.8	89.8	9.8
		Post-test	S.D.	3.11	208	2.01	205	6.16	1.03	50	11.3	11.4	1.9
	training	Pre-test	Mean	21.21	798	3.83	918	27.10	6.88	532	32.6	63.7	18.1
		Post-test	S.D.	3.80	280	1.21	249	6.03	2.11	47	12.8	16.3	2.9
		Pre-test	Mean	22.42	780	4.08	901	24.81	6.68	529	31.7	65.6	18.3
		Post-test	S.D.	3.15	317	1.30	187	6.81	2.05	51	12.5	17.8	2.1
training	Pre-test	Mean	20.90	811	3.73	921	25.31	6.76	534	31.3	59.6	18.2	
	Post-test	S.D.	3.52	228	1.22	224	8.19	2.19	60	10.1	10.6	3.3	
training	Pre-test	Mean	24.12	639	5.88	719	23.42	4.79	452	28.6	81.6	13.9	
	Post-test	S.D.	3.61	279	1.26	198	6.04	1.22	49	12.4	16.5	2.7	

CPT: continue performance test, BART: Balloon Analogue Risk Task, Adj BART: number of adjusted pumps on the blue balloon, LOMDS: Lincoln-Oseretsky motor development scale, IRS: impulsivity rating scale.

post-test for CPT showed a significant difference between groups for omission errors ( $F=8.60$ ,  $P=0.0001$ ,  $\eta^2=0.501$ ) and commission error ( $F=4.22$ ,  $P=0.01$ ,  $\eta^2=0.463$ ) and there was no group difference in reaction time ( $F=7.21$ ,  $P=0.08$ ,  $\eta^2=0.287$ ). LSD test indicated a significant difference between training and control groups in omission errors ( $P=0.0001$ ), commission error ( $P=0.001$ ). But about high impulsivity in post-test: MANCOVA result in CPT showed a significant difference between groups for omission errors ( $F=7.52$ ,  $P=0.0001$ ,  $\eta^2=0.601$ ) and there was no group difference in commission error ( $F=3.81$ ,  $P=0.12$ ,  $\eta^2=0.159$ ) and reaction time ( $F=6.49$ ,  $P=0.11$ ,  $\eta^2=0.329$ ). LSD test showed significant difference between training and control groups in omission errors ( $P=0.001$ ).

#### **Decision-making**

ANCOVA results in AdjBART scores showed a significant difference between groups in the low impulsivity ( $F=4.88$ ,  $P=0.01$ ,  $\eta^2=0.483$ ). But in high impulsivity, ANCOVA results were not significant for difference between groups in AdjBART scores ( $F=3.13$ ,  $P=0.1$ ,  $\eta^2=0.561$ ).

#### **Motor function**

The results of ANCOVA in post-test showed a significant difference between groups in Lincoln-Oseretsky test in the low impulsivity ( $F=6.68$ ,  $P=0.0001$ ,  $\eta^2=0.623$ ). Also in high impulsivity, similar results were indicated for training group compare to the control group ( $F=5.53$ ,  $P=0.001$ ,  $\zeta^2=0.514$ ).

#### **Comparative analysis between high and low impulsivity group**

The comparison impulsivity score between high and low impulsivity groups by MANCOVA test showed significant difference between groups ( $F=4.11$ ,  $P=0.023$ ,  $Wks\ Lambda=0.051$ ,  $\eta^2=0.358$ ). LSD test showed significant difference between training groups in high and low impulsivity ( $P=0.011$ ), in addition to the difference between training and control groups ( $P=0.0001$ ).

### **DISCUSSION**

It is generally agreed that regular physical activity promotes physical and mental health, but what are the benefits with high and low impulsivity and their functions? So, this experiment was

designed to examine the effect of physical activity on impulse control, attention, motor and decision-making functions in school students with high and low impulsivity.

Overall, our findings indicate that a significantly decrease impulsivity rate with training groups compare to the wait-list control groups in both levels of impulsivity. In this regard, after the training period, decreased impulsivity scores are reported by teachers for training groups in high and low impulsivity. Another central features of the present study are impulse control and attention functions improvement that have been measured by go/no-go test and CPT. About impulse control and attention functions, results revealed a significantly improve for training groups in go/no-go test and CPT compare to the control groups in the low and high levels of impulsivity. Similar findings were obtained in motor functions: Motor function was better in the training groups as shown by the increase in Lincoln-Oseretsky test scores. But in decision-making, results revealed a significant and non-significant improve for training groups with low and high impulsivity, respectively. Finally, comparative analysis between high and low impulsivity group showed that effect of physical activity on low impulsivity group was significantly higher than the high impulsivity group.

These findings are consistent with extend previous research results by showing a specific association between physical activity and cognitive/behavioral disorders<sup>17</sup>. Although to our knowledge, this is the first study researching the effect of a physical activity program on individuals with various levels of impulsivity. But in humans study, research with adults has shown that participants who are more aerobically fit or who participate in a physical activity program show benefits in cerebral structure<sup>37, 39</sup> as evidenced by reductions in cortical tissue density and volume. Additionally, there is greater brain activity within regions associated with behavioral conflict and attentional control processes<sup>39, 36</sup>. Even so in this context, acute effects of PA have been associated with reductions in negative behaviors and improvements in acceptable behaviors and cognitive functions in children with clinical disorders categorized by poor impulse control and attention<sup>40</sup>. There is also evidence that PA benefits

cognitive function in general and executive function specifically [17], thus, Our results are consistent with this evidence, and providing indirect support for our findings that PA impact the attention, motor and decision-making functions of impulsivity individuals. Some of biological mechanisms that underlie such beneficial effects are elucidated. They include BDNF, IGF-1, hormone and other biological mechanisms (36, 39 and 40)

### CONCLUSION

The previous studies have found that children rated high on impulsivity have been demonstrated to achieve lower grades than their peers with low impulsivity ratings [9], also, it is known that impulsivity is consistently associated with lower grades and achievement scores, even when IQ is partialled out [10]. So, the importance of impulsivity during childhood has been established. In this context, the results of our study suggest that a physical activity program may be beneficial for student with different level of impulsivity, especially effective with low impulsivity. In addition to impulsivity reduction, it positively influences behaviors and cognitive function such as impulse control, attention, motor and decision-making functions with impulsivity student.

PA program is as effective as more common treatment is recommending, especially considering the time and cost involved with treatments such as Pharmacotherapy. PA provides additional health benefits that other interventions do not. For example, AP is associated with a decreased incidence of obesity, especially among school children, as well as reductions negative behaviors such as impulsivity and improvements cognitive and behavioral functions such as impulse control, attention, motor and decision-making functions Thus, since PA is cost-effective, has positivity health benefits, it is viable alternative to many of more current therapies. In this regard, future studies should examine the differences between medication and PA in impulsivity. Also, in order to add support to those results, future research should include follow-up.

Considering the beneficial effect of PA participation on some important impulsivity-related variables, parents of children with impulsivity

should look to maximize opportunities for structured group physical activity in their children's life. Also, given that the American College of Sport Medicine (1978) recommends a PA program of at least 15-20 weeks and 3 time/week to achieve a significant change in physical and mental benefits [15], so, schools should look to increase physical activity programs. Currently, these programs are done one or two sessions per week, therefore it is essential to note.

Since, this study is one of the first research in this field, it is necessary to repeat in different samples size and earns more empirical verification. In addition, the small sample used in the study because groups were similar for behavior and other variables in different level before the program. Due to these limitations, our results should be interpreted with caution. Further studies with a different sample size are needed to clarify the results.

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