Original Article

The effect of a digital interactive game in distractibility, hyperactivity and impulsivity in individuals with attention deficit hyperactivity disorder and intellectual disability

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Abstract:

The purpose of this study was examine the effect of a digital interactive game in distractibility, hyperactivity, impulsiveness and other relative symptoms in individuals with attention deficit hyperactivity -disorder (ADHD) and Intellectual Disability (ID). Methods: The study involved 20 adults (10 men and 10 women) with ADHD and ID aged 20-25 years who were enrolled in a special school and were divided randomly into two groups. Ten adults with ADHD and moderate ID (5 men and 5 women, with mean age 23.6 ± 1.65 years, IQ 35-50) constituted the intervention group (IG) participating in the digital interactive tennis game, for twelve weeks, three times a week for twenty minutes per session. On the other hand, ten adults with ADHD and moderate ID (5 men and 5 women with mean age 23.6 ± 1.78 , IQ 35-50), constituted the control group (CG) who attended physical education lessons in their special school, twice a week, for forty five minutes per session. Results: Assessment for both groups included the use of the Instrumente zur Diagnose der Adulten ADHS (IDAA) questionnaire (Rösler et al. 2004), with no statistically significant differences noted between the two groups in all parameters evaluated prior intervention. Comparison between initial and final measurement revealed statistically significant differences in distractibility ($p<.01$), hyperactivity ($p<.01$), impulsivity ($p<.01$) and other evaluated sections ($p = .127$) of IG individuals. As to CG, statistically significant differences were noted between the initial and final measurement in distractibility ($p<.01$), impulsivity ($p<.05$) and other entries ($p<.05$), while there were no statistically significant differences in hyperactivity ($p=.508$). Conclusions: In conclusion, implementation of a digital interactive tennis game contributes effectively on reducing ADHD hyperactivity and impulsivity symptoms that characterize the behavior of adults with ADHD and ID.

Keywords: attention deficit hyperactivity disorder, intellectual disability, digital interactive game.

Introduction

Attention Deficit Disorder with Hyperactivity (ADHD) is one of the most known neurobiological disorders (Ballard & Bolan, 1997) of childhood and adolescence (Waternberg et al. 2007). According to the American Psychiatric Association (1994) ADHD is a psychiatric dysfunction, which may be described as a chronic disorder of behavior (Lakoff, 2000) with neurobiological basis characterized by not developmentally appropriate level of attention, impulsivity and / or hyperactivity, that affects social, academic and professional activity (American Psychiatric Association, 2000). The onset of ADHD is placed in early childhood and often occurs in adolescence and adulthood (Faigel, 1995; Fargason & Ford, 1994). As for intellectual disability (ID) and in accordance with the definition given in 1959 by the American Association for mental disorder (American Association on Mental Retardation, 2006), ID is referred as a significantly below average general intellectual functioning accompanied by shortages in adaptive behavior and manifested during the developmental period. However, researchers (Luckasson et al. 1992) revised this definition, giving special emphasis on the potential of the individual, the environment in which he lives and works, and finally, the operating level achieved within these environments. This reformulation led to the effective integration and adaptation of people with ID in environments like schools (Freeman, 2000).

In the last decade there have been several successful efforts to reduce the symptoms of ADHD through exercise, since physical education improves fine motor skills, increases playing time, reduces stress and

depression and improves self-esteem of people with ADHD. Numerous studies reinforce the important role of exercise on physical, mental and social condition of people with ID (Pate & Hohn, 1994), producing many benefits related to parameters such as self-knowledge, flexibility, endurance, joint mobility, muscle strength, synergy and eye - hand coordination.

Studies have shown that participation in exercise contributes to except endorphins, and catecholamine secretion which in turn help to increase attention span and blood flow to the brain leading to the release of its growth factor (Brain Derived Neurotrophic Factor) and the creation of new nerve cells (Aggelopoulou-Sakadami, 2004). The acute effects of exercise have been associated with improved behavioral and cognitive functions in children with ADHD (Tomprowski, 2003). According to researchers (Gapin et al. 2011), several studies indicated the positive effect of exercise on the behavior of individuals with ADHD in promoting self-awareness, self-esteem, behavioral and perceptual capacity, while at the same time decreasing behavioral problems such as attention deficit, hyperactivity, aggression and negativism (Aggelopoulou-Sakadami, 2004). Clearly, games play an important role in the socialization of people with ID (Winnick, 1995). However, reviewing the literature it seems that a lack of studies is noted concerning the effect of exercise in the form of a digital interactive game on individuals with ADHD and concurrent ID. Therefore, the purpose of this study was to investigate the effect of an interactive digital game on distractibility, hyperactivity, impulsiveness and other symptoms of individuals with ADHD and ID, in order to broaden the knowledge about the behavior of these individuals in exercise conditions, but also to examine the potential impact of a different way of exercise in reducing symptoms that affect the behavior of this population.

Material & methods

Participants

This study involved 20 adults aged 20-25 years diagnosed with ADHD according Instrumente zur Diagnose der Adulten ADHS (IDAA) (Rösler et al. 2004) and Adult ADHD Self-ReportScale-V1.1 (ASRS-V1.1) (World Health Organization, 2003), and with moderate ID (IQ: 35-50) according to Wisk-III test (Georgas et al. 1997). All participants lived with their families and attended a special school. Adults with ADHD and ID were divided randomly distributed into two groups of 10 adults with ADHD and moderate ID, that is, the intervention group (IG), (5 men and 5 women, mean age 23.6 ± 1.65 years, IQ 35-50) and the control group (CG) (5 men and 5 women, mean age 23.6 ± 1.78 years, IQ 35-50).

Measurement Procedures

ADHD was detected using ASRS - V1.1 questionnaire (World Health Organization, 2003) that includes six questions answered on a 5-point Likert scale (0 = never, 1 = rarely, 2 = sometimes, 3 = often, 4 = very often) and the IDAA questionnaire (Rösler et al. 2004) comprised of four subscales (inattention, hyperactivity, impulsivity, other entries) including 22 questions answered on a 4-point Likert scale (0 = never, 1 = rarely, 2 = often, 3 = always), with a higher score indicating a higher ADHD percentage. Both questionnaires were completed by the special school psychologist.

A total of 50 adults with moderate ID were evaluated, of whom 22 had ADHD symptoms. Prior the implementation of the intervention program, a pilot study was designed and implemented so as to determine the time duration of each session. The pilot study involved two adults with ADHD and ID (1 man, 1 woman) with similar age and IQ who were then excluded from the study, participating in three sessions of digital interactive tennis game within the same week. In each session, total participation time in tennis game was recorded up to the point where the individual refused to continue or was not focused on the game. Mean average of time spent participating in the game within these three sessions was the criterion for determining the duration of each session during the intervention program.

To evaluate the impact of the digital interactive game on behavior relevant parameters, the design of the study consisted of pre and post measurements.

Intervention program

The intervention program involved the participation of IG in exercise via a digital interactive play tennis (tennis) game, that is, the Playfull. The intervention program lasted 12 weeks, 3 times a week, for 20 minutes per session. Each session was individualized.

The digital interactive game was projected on a large white screen in the gym of the special school. The researchers adapted to the wrist of a trainee a shaped device with a built racket motion detector, which captures the reactions and records the performance of the trainee during the game according to wrist movement. For better control and maintenance of the device at hand, a drawstring was attached to the wrist of the practitioner so as to avoid the fall of the device and, therefore, stoppage of test. On the other hand, during these 12 weeks CG individuals participated in the PE lessons of their special school at a frequency of 2 times per week for 45 minutes per session.

Statistical analysis

Descriptive statistics were used to calculate mean and SD. The effect of the intervention program was analyzed using separate one-way repeated measures ANOVA with time as the repeated factor. Paired t-tests were used to determine the significance of changes in outcome measures from baseline to 12 weeks. Significance was set at $p \leq .05$. Effect sizes (ES) were used to evaluate the magnitude of change in outcome measure with intervention program. ESs were expressed as Cohen's d; ESs of 0.2-0.49 were considered small, 0.5-0.79 were considered moderate, and > 0.8 were considered large.

Results

Descriptive statistics

Table 1 shows the averages and standard deviations, and the significance of differences between measurements for each test variable and for each group separately.

Table 1. Descriptive statistics and significant differences

Variable	Measure	Intervention group		Control group		ANOVA
		M	SD	M	SD	Sig.
Distractibility	Baseline	5.23	.24	5.08	.35	$p > .05$
	Final	4.17	.39	4.68	.32	$p < .05$
Hyperactivity	Baseline	4.95	.31	4.93	.40	$p > .05$
	Final	4.22	.27	4.96	.33	$p < .05$
Impulsivity	Baseline	5.41	.40	5.22	.16	$p > .05$
	Final	3.81	.28	4.75	.40	$p < .001$
Other entries	Baseline	4.63	.32	4.88	.10	$p < .01$
	Final	4.91	.46	5.24	.14	$p < .05$

Effect of intervention program on Distractibility

Repeated measures ANOVA showed a significant main effect for the ADHD (Greenhouse-Geisser $F_{(1,10)} = 93.15$, $p < .001$, $ES = .912$, power = 1.000) (Table 2). According to the index ES 91.2% price reduction in distractibility observed for the IG is probably due to the training program. Results of the one-way ANOVA showed that the two groups (IG and CG) did not differ significantly from baseline ($p > .05$, power = .110) (Table 1). Absence of differences between the two groups was found for the final measurement ($p > .05$, power = .107). The value of the observed power in both measurements revealed the existence of a likelihood of a Type II error, i.e., non-rejection of the null hypothesis. A materially smaller value than .80 would incur great a risk of a Type II error (Cohen, 1992).

Given the very low value of the observed power in both analyzes, t-tests were used because this control is recommended when the sample size is less than 30 individuals (10 individuals in this study). The results of tests indicated that the mean scores between the two groups at baseline did not differ, while in final measurement they were statistically significantly different ($t_9 = -1.50$, $p > .05$, and $t_9 = 11.56$, $p < .001$, respectively). Thus, the IG showed a statistically significant decrease from the beginning of the implementation of the intervention program by the end of the intervention. The analysis of paired t-test showed that the IG the average baseline differed significantly from the average of final measurement ($t_9 = 11.50$, $p < .001$) by the end of the intervention with the value of distractibility which was greater than the corresponding reduction in the CG.

As for the CG, in particular variable significantly decreased value between the initial and final measurement ($t_9 = 8.55$, $p < .001$). According to the index ES, 89% price reduction in distractibility observed for the CG is probably due to the physical education program in a special school.

Table 2. Effect of intervention program on distractibility, hyperactivity, impulsivity, and other entries

Variable	Greenhouse-Geisser	p	ES
Distractibility	$F_{(1,10)} = 93.15$	.001	.912
Hyperactivity	$F_{(1,10)} = 66.62$	.001	.881
Impulsivity	$F_{(1,10)} = 132.51$	.001	.936
Other entries	$F_{(1,10)} = 21.66$	.001	.706

Effect of intervention program on Hyperactivity

Repeated measures ANOVA showed a significant main effect for the Hyperactivity (Greenhouse-Geisser $F_{(1,10)} = 66.62$, $p < .001$, $ES = .881$, power = 1.000), justifying further analysis of the dependent variable (Table 2). According to the index ES 88.1% reduction of hyperactivity variable value for the IG is probably due to the training program.

Results of the one-way ANOVA showed that the two groups (IG and CG) did not differ significantly from baseline ($p > .05$, power = .155) (Table 1). Following, t-tests were used for the same reasons mentioned previously. The results of tests indicated that the mean scores between the two groups at baseline did not differ significantly, while in final measurement statistically significant differences emerged ($t_9 = .35$, $p > .05$, and $t_9 = 8.46$, $p < .001$, respectively). Thus, the IG showed a statistically significant decrease from the beginning of the implementation of the intervention program by the end of the intervention with the value of hyperactivity which was greater than the corresponding reduction in the CG.

The analysis of paired t-test showed that the IG the average initial measurement differed significantly from that of the final measurement ($t_9 = 9.72$, $p < .001$). In CG, the average value of this variable did not differ significantly between the initial and final measurement ($t_9 = -.69$, $p > .05$). According to the index ES, non-significant reduction in hyperactivity price observed for the CG, 50% probably due to the physical education program in a special school.

Effect of intervention program on Impulsivity

Repeated measures ANOVA showed a significant main effect for the impulsivity (Greenhouse-Geisser $F_{(1,10)} = 132.51$, $p < .001$, ES = .936, power = 1.000), justifying further analysis of the dependent variable (Table 2). According to the index ES 93.6% reduction observed in impulsivity for IG is probably due to the effect of the training program.

Results of the one-way ANOVA showed that the two groups did not differ significantly from baseline ($p > .05$, power = .113). Absence of differences between the two groups was found for the final measurement ($p > .05$, power = .503) (Table 1). Following, the results of t-tests indicated that the mean scores between the two groups at baseline did not differ significantly, while post test results were statistically significantly different ($t_9 = -1.39$, $p > .05$, and $t_9 = 10.56$, $p < .001$, respectively). Thus, the IG showed a statistically significant reduction in the value of the variable from the beginning of the implementation of the intervention program by the end of the intervention which was greater than the corresponding reduction in the value of the variable in the CG.

Paired t-test analysis showed that the IG the average baseline differed significantly from the average the final measurement ($t_9 = 12.88$, $p < .001$). In CG, there was a significant difference between initial and final measurement ($t_9 = 3.98$, $p < .01$). According to the index ES, the 63.8% reduction in impulsivity observed for the CG is probably due to the physical education program in a special school.

Effect of intervention program on Other entries

Repeated measures ANOVA showed a significant main effect for the other entries (Greenhouse-Geisser $F_{(1,10)} = 21.66$, $p < .001$, ES = .706, power = .992), justifying further analysis of the dependent variable (Table 2). According to the index ES 70.6% price reduction observed in this variable is probably due to the training program.

Results of the one-way ANOVA showed that the two groups did not differ significantly from baseline ($p > .05$, power = .121) (Table 1). T-test results indicated that the mean scores between the two groups in the initial and final measurement differed significantly ($t_9 = 5.23$, $p < .01$, and $t_9 = 2.52$, $p < .05$, respectively). Thus, the IG showed a statistically significant reduction in the value of the other entries from the beginning of the implementation of the intervention program by the end of the intervention, however, the decrease was less than the corresponding reduction in the CG. Paired t-test analysis showed that the IG the average baseline differed significantly from the average of the final measurement ($t_9 = -2.78$, $p < .05$). Significant difference was observed between the initial and final measurement in the value of this variable and CG ($t_9 = -3.95$, $p < .01$). According to the index ES, the 63.5% reduction in the values of other entries observed for the CG is probably due to PE program in the special school.

Discussion

This study investigated the effect of a digital interactive game in tennis distractibility, hyperactivity, impulsivity, and other entries, symptoms affecting the behavior of individuals with ADHD and ID. Review of the literature showed that the interest of researchers focused solely on ADHD individuals. This study attempted to further include individuals diagnosed as having both ADHD and ID and to examine the effect of an interactive tennis game on the behavioral symptoms of this population so as to produce genuine results.

At baseline, despite randomization of participants with ADHD and ID in both groups, the results of multivariate analysis between the two groups showed no statistically significant differences, confirming the common starting point of both groups in this study. The findings showed that a 12 weeks exercise program in the form of digital interactive tennis was effective in reducing negative behavioral symptoms observed in people with ADHD and ID. More specifically, the incidence of symptoms of attention deficit, hyperactivity and impulsivity in IG reduced significantly throughout the duration of the intervention, resulting at the end of the program to an impressive reduction of 20.27%, 14.92% and 29.39%, respectively.

The pilot program designed and implemented prior study contributed greatly to the accurate determination of the duration of each session so that no trace of fatigue, boredom or any other problem could be observed that could affect participation of individuals with ADHD and ID during program application. Regarding the exercise protocol, the reactions of participants showed that it was properly designed in relation to the total duration and frequency of application as well as the diversity and the unpredictable behavior of people with ADHD and ID, who were required to change their daily routine in return of being systematically present throughout the twelve-week exercise program.

The significant reduction of negative behavioral symptoms can also be attributed in choosing digital interactive play tennis as a mean of intervention for the treatment of symptoms. Apparently, there was no previous experience of participants within a similar exercise which was highlighted by the great interest exhibited for this game and the pleasure with which each individual participated throughout the whole program with no drop outs occurred. Individual instruction followed in this study seemed also to help participants concentrate leading to further reduction of symptoms. Most experts believe that individual sports and exercise are the most appropriate means of exercise intervention for individuals with ADHD.

Researchers reported that people with ADHD perform better when driven individually by the physical education teacher, and suitable modifications and adaptations of exercise contribute to maximizing the performance of a person with ADHD, leading to the reduction of disorders that affect behavior (Chang et al. 2012). Moreover, the acute effects of exercise have been associated with improved behavior in individuals with ADHD (Tomprowski, 2003). According to Gapin, et al. (2011), findings of previous studies suggest the effect of exercise on the behavior of individuals with ADHD.

During exercise, catecholamine concentration contributes to attention as increased blood circulation in the brain and released growth factor in the brain (Brain Derived Neurotrophic Factor) leads to the generation of nerve cells and synapses (Aggelopoulou-Sakadami, 2004).

Our findings are reinforced by the findings of a recent study (Gapin, & Etnier, 2013) where a decrease in attention deficit, hyperactivity and impulsivity in individuals with ADHD through exercise was also noticed. Similarly another study (Verret et al. 2010) reported that a 10-week program comprising warm-up aerobic games, motor skills and recovery, contribute to the improvement of attention and reduce of hyperactivity and impulsivity. Similar findings were also observed in another study (Barzegary, 2011) following a 12 weeks exercise program, reporting improvement of attention and decrease of impulsivity and hyperactivity in individuals with ADHD.

Contrary to the findings of this study, other studies did not confirm the simultaneous reduction of the three behavioral symptoms as a result of participation in exercise. However, a previous study (Medina et al. 2009) reported a decrease in ADHD and impulsivity after an aerobic exercise of 30 minutes, while no changes were noticed in hyperactivity. Similarly, in an earlier study (Allen, 1980), the researcher reported that a jogging program of six weeks total duration helped to reduce disruptive behavior by 50% and increase control of impulses. On the contrary, hyperactivity remained unchanged probably because of the limited duration of the intervention, and the limited time of each session. The absence of changes in hyperactivity can be attributed to the fact that hyperactivity change form during development, resulting in the person to perform differently in relation to kinetic activity (Weiss & Hechtman, 1993). It is also important to note that symptoms of hyperactivity can also get a verbal form with the onset of binge chatter (Wright et al. 2009) in relation with the impulse of the individual or influenced by environmental factors that strongly the onset of ADHD symptoms (Romano et al. 2006).

As a result of the findings of this study, “other entries” was the only variable that did not show a decreasing trend during the study, as this variable increased by 6.26% between initial and final measurement. However, it should be noted that in this variable, the four questions included in the questionnaire related to the history of the individual and his behavior outside school and, therefore, it was difficult to answer with absolute knowledge of the teachers in the special school.

As for the CG, it seemed that the physical education program followed during these 12 weeks in the special school, helped to reduce the incidence of ADHD and impulsivity, while no change was observed in the incidence of hyperactivity. However, despite the fact that at baseline both groups started from the same reference point, the reductions observed in ADHD (7.86%) and impulsivity (9.18%) was clearly lower compared to the reductions observed in the same variables in the IG group that involved participation in the digital interactive game. This finding can be attributed to the lack of individual instruction in PE lessons compared to individual sessions involving application of the digital interactive game, the less frequency of lessons (two as opposed to three) between the two groups and the probable repetition of the same or similar activities during the PE lessons in school resulting to boredom and reduced willingness to participate in the program. As regards to the “other entries”, it was the only variable that did not show a decreasing trend during the study, as this variable increased by 7.16% between initial and final measurement, as in the IG.

In the last decade there have been several successful efforts to reduce the symptoms of ADHD through exercise. It has been observed that physical education improves fine motor skills, increases participation time in

an activity, reduces anxiety and depression, causes clarity, improves memory and movement coordination while at the same time improves mood and increases self-esteem and confidence of these individuals (Aggelopoulou-Sakadami, 2004). As a result, attention improves concentration and reduces hyperactivity and impulsivity (Gapin & Etnier, 2013).

According to teachers' observations of primary school teachers children after PE classes appear quieter in class and with increased attention span ability. Therefore, activities in physical education should be carried out with precision and simplicity, without many changes, so that the child can participate on a regular basis in PE lessons (Aggelopoulou-Sakadami, 2004).

Conclusions

In conclusion, this study has shown that an interactive digital game help in addressing behavioral problems that people with ADHD and ID often exhibit, thus their inclusion in PE programs within schools should be reconsidered in future National Education Curriculums. Future researches implementing activity programs to larger samples of ADHD and ID individuals of different ages and different IQ range are needed so as to compare the influence between digital interactive games and other programs of exercise. Examining similar variables through longitudinal studies across the spectrum of developmental age and up to adulthood could help to further investigate possible differences in relation to gender and age in terms of behavior and quality of life improvement for individuals with ADHD and ID.

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