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Effects of Selected Cognitive-Motor Intervention on the Level of Physical Literacy and Executive Functions in Attention deficit/hyperactivity disorder Girls: A One-month Follow-up Study

Efectos de la Intervención Cognitiva-Motora Seleccionada Sobre el Nivel de Literacia Física y Las Funciones Ejecutivas en Niñas con Trastorno por Déficit de Atención e Hiperactividad: Un Estudio de Seguimiento de un Mes

Efeitos da Intervenção Cognitivo-Motora Selecionada sobre o Nível de Literacia Física e Funções Executivas de Meninas sobre o Transtorno de Déficit de Atenção/Hiperatividade: Um Estudo de Acompanhamento de Um Mês

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ABSTRACT

The aim of the present study was to investigate the effectiveness of selected cognitive-motor intervention on the level of physical literacy (PL) and executive functions of Attention-deficit/hyperactivity disorder (ADHD) girls in a one-month follow-up plan. The statistical population included 30 girls with ADHD, all from Yazd (15 participants per group, experimental and control) were selected based on DSM-V criteria. While the control group was not exposed to any treatment and just continued working as usual, the experimental group participated in 18 sessions (3 sessions a week) of the cognitive-motor program. In order to evaluate PL, the Canadian Assessment of Physical Literacy Second Edition (CAPL-2), and for executive function the Continuous Performance Test (sustained attention) and Computer Mapping of the Tower of London task (motion planning) were used. Data analysis was

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also conducted using the mixed variance analysis test with repeated measures and an independent T-test at a significance level of $p \leq .05$. According to the results, the experimental group had better performance in PL and executive functions (sustained attention and movement planning) in the posttest and follow-up than the pretest. But, in the control group, no significant difference was observed between the test stages. Moreover, comparing the groups, the experimental group had better performance than the control group in PL, sustained attention, and movement planning. Therefore, cognitive-motor intervention can be used to develop PL and executive functions of ADHD girls.

Keywords: environmental enrichment, cognitive-motor, sustained attention, movement planning.

RESUMEN

El objetivo del estudio fue investigar la efectividad de una intervención cognitiva-motora seleccionada en el nivel de la Literacia Física (PL) y funciones ejecutivas de niñas con trastorno por déficit de atención e hiperactividad (TDAH) en un plan de seguimiento de un mes. La población eran niñas con TDAH, de Yazd, 15 participantes por grupo, experimental y control, fueron seleccionadas según los criterios del DSM-V. Mientras que el grupo de control no estuvo expuesto a ningún tratamiento y siguió trabajando como de costumbre, el grupo experimental participó en 18 sesiones del programa cognitivo-motor. (3 sesiones/sem). Para evaluar la PL se utilizó Canadian Assessment of Physical Literacy Second Edition (CAPL-2), y para la función ejecutiva el Continuous Performance Test (atención sostenida) y la tarea Computer Mapping of the Tower of London (planificación motora). Un análisis de varianza mixta con medida repetida y una prueba T independiente fue realizada a un nivel de significancia de $p \leq .05$. De acuerdo con los resultados, el grupo experimental tuvo mejor desempeño en PL y funciones ejecutivas (atención sostenida y planificación motora) en el posprueba y seguimiento que en la prueba previa. Pero, en el grupo de control, no se observó diferencia significativa entre las etapas de la prueba. Al comparar los grupos, se demostró que el grupo experimental tuvo un mejor desempeño que el grupo de control en PL, atención sostenida y planificación motora. Por lo tanto, la intervención cognitivo-motora se puede utilizar para desarrollar la PL y las funciones ejecutivas de las niñas con TDAH.

Palabras clave: enriquecimiento ambiental, cognitivo-motor, atención sostenida, planificación del movimiento.

RESUMO

O objetivo do presente estudo foi investigar a eficácia da intervenção cognitivo-motora selecionada no nível de Literacia Física (PL) e funções executivas de meninas com transtorno de déficit de atenção/hiperatividade (TDAH) com um plano de acompanhamento de um mês. A população foi composta por 30 meninas meninas com TDAH, todas de Yazd, as quais (15 participantes por grupo, experimental e controlo) foram selecionadas com base nos critérios do DSM-V. Enquanto o grupo controlo não foi exposto a nenhum tratamento e apenas continuou trabalhando normalmente, o grupo experimental participou de 18 sessões do programa cognitivo-motor (3 sessões/semena). Para avaliar a PL, foi utilizado o Canadian Assessment of Physical Literacy Second Edition (CAPL-2), e para a função executiva o Continuous Performance Test (atenção sustentada) e a tarefa de Computer Mapping of the Tower of London (planeamento motor). A análise dos dados também foi realizada por meio do teste de análise de variância mista com medida repetida e um t test de amsotras independentes com nível de significância $p \leq .05$. De acordo com os resultados, o grupo experimental demonstrou melhor desempenho em PL e funções executivas (atenção sustentada e planeamento motor) no pós-teste do que no pré-teste. Já no grupo controlo não frami observadas diferenças significativas entre as etapas do teste. A comparação dos grupos evidenciou que o grupo experimental teve melhor desempenho do que o grupo controlo na alfabetização física, atenção sustentada e planeamento motor. Portanto, a intervenção cognitivo-motora pode ser usada para desenvolver a PL e as funções executivas de meninas com TDAH.

Palavras chave: enriquecimento ambiental, cognitivo-motor, atenção sustentada, planejamento de movimento.

Physical Literacy and ADHD children

INTRODUCTION

Attention deficit/hyperactivity disorder (ADHD) is recognized as the most common psychiatric disorder in childhood (Medina et al., 2010). The disorder is very common in the united stated of America so that about twenty-four million US children have been diagnosed with ADHD. In Iran, its prevalence is estimated to be about 10 to 20 percent (Sadat Karimi, et al., 2011). Motor hyperactivity which is considered as one of the main aspects of ADHD, is characterized by excessive motor activity, restlessness, high level and volume of speech (Kaiser et al., 2015). ADHD Children are significantly impaired in fine and gross motor skills and also sensory-motor skills (Juliana et al., 2013). According to clinical and epidemiological studies, 30-50% of ADHD children have problems in basic motor skills (Juliana et al., 2017; Kovalčíková et al., 2018). The findings also show low levels of balance and motor abilities as well as deficits in the motor learning ability of ADHD children (Dahan et al., 2018; Juliana Barbosa Goulardins et al., 2011). According to Adolf (2015), the ontogenesis of motor skills in children with ADHD disorder has certain characteristics which can affect their psycho-motor development and movement planning. On the other hand, having different and weak motor skills can also affect the level of physical literacy (PL) of these children.

According to Whitehead (2018), PL refers to the ultimate goal of a qualified educational program that includes motivation, self-confidence, physical competence, and knowledge to maintain physical activity throughout whole life. PL enjoys several anticipated benefits, such as increasing the amount of people's health care, improving physical and mental health, increasing productivity in activities, developing skill levels and more participation in sports activities (Giblin et al., 2014). The nourishment of the mentioned aspects not only enriches the experience and helps to realize all human potentials (Whitehead et al., 2018), but it also makes a person to be more intelligent and focused in understanding different aspects of the physical environment, anticipating movement needs and responding appropriately to them (Taş, 2019).

According to Edward (Edwards et al., 2017), high-quality physical education can help people to move forward and progress in their PL. All people regardless of their age and gender poses the ability to acquire PL. Experts from different countries highlight the necessity of expanding the strategy of PL as an integral part of life. Despite international recognition, not many researches have been done in the field of PL, and this deficiency is especially noticeable in the field of ADHD children (Boržíková & Lenková, 2021).

Since the understanding of PL can help the perceptual-motor development of ADHD children and based on research results, motor development is related to cognitive development; Therefore, it can be said that movement and cognitive skills create such a cycle in which increasing each one causes the other to increase (Emarati et al., 2012). However, many researches had declared that children with ADHD disorder face problems in their cognitive and executive functions (Gapin et al., 2011). Executive functions are important structures that play a fundamental role in controlling and directing behavior and are also very important for adaptation and successful performance in real life (Blair & Razza, 2007). Attention and movement planning are among executive functions influencing motor learning. Indeed, attention is a basic but complex cognitive process (Riddle, 2007).

Generally, there are different types of attention, the special type of which is selective attention, that includes divided and sustained attention. Selective attention is a type of attention in which a person pays attention to a certain stimulus but ignores the other (Riddle, 2007). On the other hand, sustained attention is the ability to maintain focus on a task, activity or stimulus for a long period of time (Jarraya et al., 2019). In addition, most daily routines and activities depend on a person's ability to plan before starting movements and consider situational constraints. Since ADHD children are at a low level in terms of attention and usually face problems in planning movements, which require the design of appropriate programs, movement plan plays an important role in learning (Zeinali et al., 2016).

Treatment programs designed for these people often include stimulant drugs such as methylphenidate (Ritalin), which does not work for about 30% of people (Gualtieri & Johnson, 2008). In addition, long-term use of such drugs can have negative side effects, including high blood pressure, sleep

problems, and mood disorders (Tantillo et al., 2002); Therefore, in order to reduce, the number of problems that they are struggling with, a new wave of scientific research has been launched to find effective non-pharmacological methods. Among Interventional methods that focused on psycho-motor problems it can be mentioned to the practice of cognitive-motor skills. These days, the relationship between motor activity and cognitive benefit has received increasing attention. Motor activities can improve the structural flexibility of gray and white matter of children and adolescents' brain, as well as increase the change of brain activation pattern under specific motor tasks (Xue et al., 2019). Moreover, cognitive-motor activities lead to the improvement of brain structure and functional networks involved in attention, memory and executive performance in children and adolescents (Xue et al., 2019).

Considering the positive role of such programs, it seems necessary to investigate their impact on children with attention deficit/hyperactivity disorder, In addition, due to the importance of PL and executive functions in the field of children's and public health, and since no study was found related to the effect of cognitive-motor intervention on the level of PL and executive functions of ADHD children, the present study examines the effects of cognitive-motor intervention on the level of PL and executive functions of ADHD girls.

METHODS

Research Design

In the current study, a semi-experimental research method was used in terms of practical purpose with a pretest-posttest design and a one-month follow-up.

Participants

Using the statistical package G*Power (version 3.1) for sample size analysis (repeated measures, within-between interaction), an α error of 5% was considered, a statistical power of 85% and an effect size of 0.30, resulting in 28 participants (2 participants were added considering a sample loss of < 10% over the course of the study). The statistical population included girls with ADHD in Yazd city in the academic year of 2023, from which 30 volunteers (aged 10 to 12) were selected as a sample and were diagnosed as children with ADHD disorder based on DSM-V criteria by a child and adolescent psychiatrist. According to the self-report of the participants and also medical records in their schools, the children did not take any medications that would disturb their movements. The other inclusion criteria of subjects include having a normal IQ, not having physical disability, muscle and sensory damage (hearing and vision damage), not having cardiovascular disease, and obvious postural abnormalities and not suffering from other disorders. Exclusion criteria included non-cooperation of the child/parents during the sessions and non-participation of the child in all test sessions. The participants who are not able to understand and perform all the levels of the physical literacy tests or who do not cooperate well in the exercises and games will be excluded from the study. Finally, the children were randomly divided into experimental and control groups and in order to maintain the ethical principles of the research, this study was received and approved by the ethics code number IR.YAZD.REC.1400.183 was received from the ethics committee of Yazd University, and was conducted according to the ethical declaration of Helsinki (Harriss et al., 2019). All participants voluntarily agreed to take part to the present study and informed consent was signed by their parents.

Materials & Instruments

In a current study, sub constructions of CAPL-2 model including Daily physical activity, Physical competence, motivation and self-confidence, knowledge and understanding were used in order to evaluate the PL. For measuring the level of PL, the four levels of CAPL-2 were evaluated according to CAPL-2 manual (available at www.capl-eclp.ca/international). Daily physical activity were investigated through two tests: a) direct measurement of physical activity using a pedometer; b) Indirect measurement of physical activity using PL questionnaire, and the sum of points for them includes 30 points (Longmuir et al., 2015). physical competence includes tree elements; a) 15-20 m Progressive Aerobic Cardiovascular Endurance Run (PACER) to evaluate aerobic fitness (Meredith & Welk, 2010) b) Plank trunk strength test to evaluate musculoskeletal endurance (Boyer et al., 2013); and c) the Canadian Agility and Movement Skill Assessment (CAMSA) (Longmuir et al., 2017) which

is a composite of fundamental Movement skills. The sum of the points for physical fitness includes 30 points, of which 10 points were allocated to PACER, 10 points to Plank and the last 10 points to CAMSA. The sum of the points for the area of motivation and self-confidence that evaluates children's' motivation and self-confidence in order to participate in PA also includes 30 points. And lastly, was the sum of the points for the area of knowledge and understanding that assesses children's knowledge about PA through five questions (Longmuir et al., 2018) which was 10 points. Generally, the sum of the points for PL is 100 points (Francis et al., 2016). Since the CAPL-2 has been culturally adapted and validated in Iran by Valady et al., (2020), its use is valid for measuring the PA level of Iranian children.

On the other hand, the components of sustained attention and movement planning were used to evaluate the executive functions, while Connors' continuous performance test (Conners et al., 2000) was used to examine the sustained attention of the participants. The main purpose of this test is to measure sustained attention and impulse control. Therefore, the subject must focus on a set of 150 relatively simple visual stimuli and respond upon seeing the target stimulus. The interval between two stimuli is 1000 msec and the duration of presenting each stimulus is 200 msec. Different parts of the test also include omission error, response error, number of correct answers and reaction time (Bijsterbosch et al., 2011), while, the last two items were examined as the most important components of the test. Moreover, to check motion planning, a computer mapping of the Tower of London task (motion planning) was used, which was first designed by Challis (Shallice, 1982). In this test, examinees are asked to move a set of colored beads mounted on three vertical bars to match a specific target. Later et al. (1995) designed a computerized version of the test in which beads are displayed as rings with a three-dimensional structure. During the test, two different row layouts are shown to the subjects on a computer screen. In each trial, the top arrangement remained constant and represented the target arrangement. However, the bottom row contains rings that the subject rearranges them to match the layout of the top row. Here, the number of movements are considered as a general measure of performance and planning time while the time of responding is considered as performance measure (Morris et al., 1995).

Procedures

After making the necessary arrangements, 30 children aged 10 to 12, who were diagnosed with ADHD by a child and adolescent psychiatrist, were subjected to a pretest (PL and executive function test) after receiving the parental consent form and placed in two control and experimental groups (15 people in each group) using a simple random method. Afterwards, the experimental group participated in Cognitive-motor training protocol. The duration of the intervention was 6 weeks, which was carried out in the form of tree 60 minutes training sessions a week, 5-10 minutes of which were devoted to warm-up, 40-45 minutes to the training program, and the last 5 minutes to cooling down. For the training program, games that included basic skills were selected. In addition, the participants also performed a cognitive exercise while doing the motor exercises. The games included rolling (for preparation), various jumps, keeping the basket full of balls (moving), children's basketball, kicking, soccer and saving the ball (manual skills), self-balancing, playing figurines and crowbars (to strengthen). Moreover, in order to engage children's cognitive performance, they were asked to, for example, count numbers in order or viceversa during the game, receive balls of a certain color, jump on certain colors, or say a series of sentences in order, movement and cognitive exercises can be used simultaneously in each session (Gallotta et al., 2015). On the other hand, the control group were doing their daily routines and activities. Finally, like the pretest, the posttest was also conducted after one-month follow-up and the results were recorded.

Statistical análisis

Descriptive statistics were performed using mean and standard deviation (*SD*). Sample sizes were estimated using the G*Power software (version 3.1) from the effect size equation proposed by Cohen. The Shapiro-Wilk's test was used to verify the normality of data. After analysis the assumptions of normality and sphericity, a two-way repeated-measures analysis of variance (ANOVA) and independent t test was used to evaluate the effect of group and time. Post-hoc comparisons were performed using the Bonferroni test, adopting a significance level with $p < 0.05$ (Statistical Package for the Social Sciences 24.0 - SPSS).

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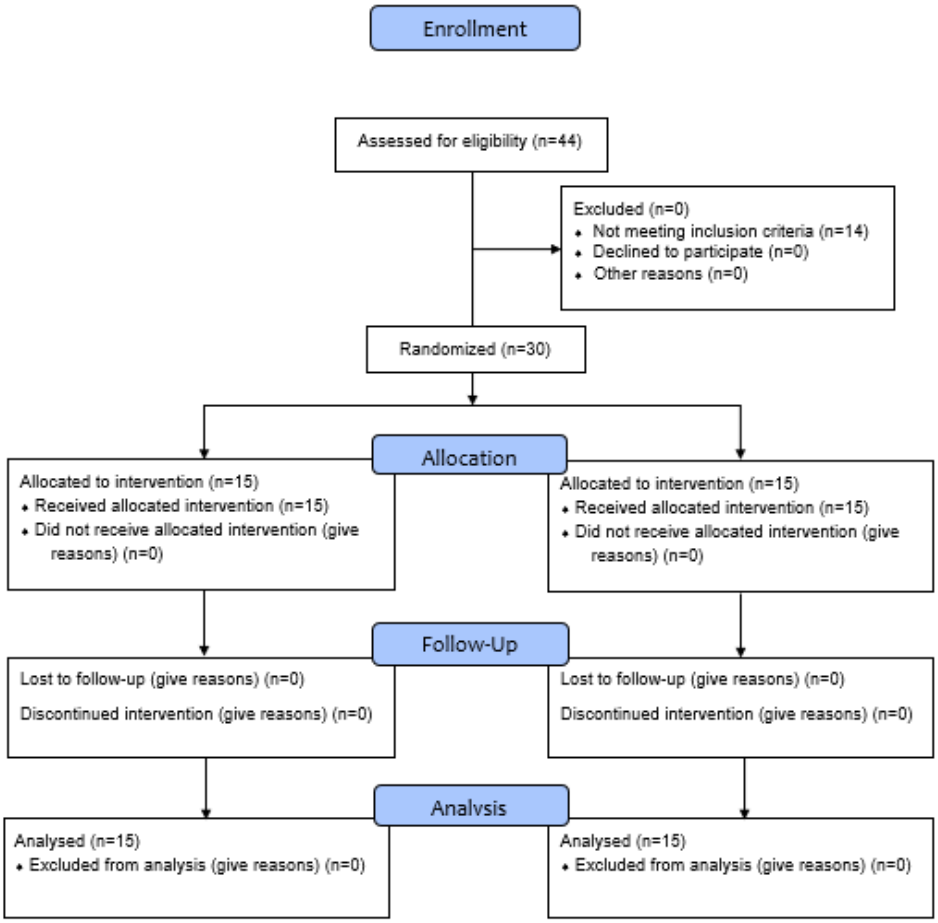
Figure 1
Selection of ADHD children to participate of the study.



RESULTS

The minimum and maximum age of the research participants were 10 and 12 respectively. The normality of data distribution was confirmed using the Shapiro-Wilk test at the 95% confidence level. Considering the normal distribution of scores, mixed variance analysis test with repeated measure was used. In addition, since the results of Mauchly's and Levene test were respectively equal to (χ^2 = 0.112) and (p = .701), the assumption of equality of variances and intragroup covariance matrix was also observed. Table 1 shows the average and standard deviation of the demographic characteristics of the participants in the experimental and control groups. According to the table 1, the mean and standard deviation of age, weight and height of participants for the experimental group and control group are equal to: 11.06 ± 0.248, 38.13 ± 2.38, 146.66 ± 2.21 and 11.26 ± 0.284, 35.92 ± 2.02, 145.86 ± 1.93 respectively.

Table 1

Mean and standard deviation of participants' demographic characteristics.

Group	Age (year)	Weight (kilograms)	Height (centimeter)
Experimental	11.06 ± 0.248	38.13 ± 2.38	146.66 ± 2.21
Control	11.26 ± 0.284	35.92 ± 2.02	145.86 ± 1.93

According to the table 2, the results from the mixed variance analysis test with repeated measure which was conducted to examine the components of PL, including daily routines and activities, physical fitness, motivation, self-confidence, and knowledge

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and understanding, showed the main effect of time, group, and also Time*group interaction is significant. In order to compare the test levels (including pretest, posttest and fallow-up) and comparing the two groups with each other, the hoc Bonferroni test and independent T test were used respectively.

Table 2.
The results from the mixed variance analysis test with repeated measure to evaluate the PL of the groups in different stages of the test.

Variable	Source of changes	sum of squares	*df*	Mean of squares	F	*p*	Eta coefficient	Test power
Daily physical activity	Time	57/867	2	28/933	9/367	**.001	0.251	0.973
	Group	24/067	1	24/067	5/631	**.025	0.167	0.630
	Time*group	34/489	2	17/244	5/583	**.006	0.166	0.838
Physical competence	Time	90/022	2	45/011	31/334	**.001	0.528	0.999
	Group	115/600	1	115/600	24/284	**.025	0.464	0.997
	Time*group	54/867	2	27/433	19/097	**.006	0.405	0.999
Motivation and self-confidence	Time	72/271	2	36/135	17/158	**.001	0.380	0.999
	Group	68/994	1	68/994	6/342	**.018	0.185	0.681
	Time*group	27/551	2	13/775	6/541	**.003	0.189	0.894
Knowledge and understanding	Time	25/089	2	12/544	20/55	**.001	0.423	0.999
	Group	32/40	1	32/40	7/302	**.012	0.207	0.742
	Time*group	22/067	2	11/033	18/07	**.001	0.392	0.999
Physical literacy	Time	838/467	2	419/233	57/64	**.001	0.673	0.999
	Group	328/050	1	328/050	50/200	**.001	0.642	0.999
	Time*group	576/289	2	288/144	39/62	**.001	0.586	0.999

Note: ** $p \leq .01$

The results from Bonferroni test showed that, the experimental group had better performance in posttest and fallow-up than pretest in doing daily routines and activities (posttest (p = .014), follow-up (p = .041)), physical fitness (posttest (p = .001), follow-up (p = .001)), motivation and self-confidence (posttest (p = .001)), follow-up (p = .013)), knowledge and understanding (posttest (p = .001), follow-up (p = .001)) and total PL score (posttest (p = .001), follow-up (p = .001)). But, the difference between posttest and follow-up was not significant for any of the studied components. In addition, no significant difference was observed in any of the variables in the control group. On the other hand, the results from the independent T-test also showed that, the experimental group had better performance than control group in daily routines and activities (post-test (p = 0.038, t = 2.17), follow-up (p = .015, t = 2.66)) physical fitness (post-test (p = .001, t = 6.41)), follow-up (p = .001, t = 5.28)) motivation and self-confidence (post-test (p = .002, t = 3.49), follow-up (p = .003, t = 3.31)) knowledge and understanding (post-test (p = .001, t = 3.94), follow-up (p = .001, t = 4.41)) and total PL score (post-test (p = .001, 30 t = 5.00), follow-up (p = .001, t = 5.94).

According to the table 3, the results from the mixed variance analysis test with repeated measure which was conducted to examine the executive functions including Sustained attention and motion planning showed that the main effect of time, group, and also Time*group interaction is significant. which means that, the selected cognitive-motor intervention has a significant effect on the executive functions of ADHD female students aged 10-12. Also, as the effect of time and group are significant, the hoc Bonferroni test was used to compare the test levels (including pretest, posttest and fallow-up) while the independent T test was used to compare the two groups with each other.

The results from the Bonferroni test showed that in the stable attention component, the number of responses (post-test (p = .001), follow-up (p = .005)) and time of responding (post-test (p = .030), follow-up (p = .001) and also in movement planning in response number component (post-test (p = 0.001), follow-up (p = .046)) and time of responding (post-test (p = .002), follow-up (p = .004) The participants of the experimental group performed better in the post-test and follow-up stages than the pre-test, but the difference between the post-test and the follow-up was not significant in any of the investigated components. moreover, in the control group, no significant difference was observed in any of the variables in different stages of the test. On the other hand, the results from the independent T-test showed that in the sustained attention area (the component of the number of responses (post-test (p = .001, t = 4.85), follow-up (p = .001, t = 5.29) and response time (post-test p = .003, t = 3.20), follow-up (p = .001, t = 5.60)) and also movement planning area (The component of number of responses (posttest (p = .001, t = 5.11), follow-up (p = .001, t = 5.20)) and response time (posttest (p = .001, t = 6.30), follow-up (p = .001, t = 5.79)) the experimental group performed better than the control group.

Table 3

The results from the mixed variance analysis test with repeated measure to evaluate the executive functions of the groups in different stages of the test.

Variable		Source of changes	sum of squares	*df*	Mean of squares	*F*	*p*	Eta	Test power
Sustained attention	The Number of answers	Time	240.467	2	120.233	16.383	**.001	0.369	0.999
		Group	716.844	1	716.844	13.132	**.001	0.319	0.938
		Time*group	267.222	2	133.611	18.206	**.001	0.394	0.999
	Time for answering	Time	13262.067	2	6631.033	8.900	**.001	0.241	0.965
		Group	32238.178	1	32238.178	7.143	**.012	0.203	0.732
		Time*group	12785.756	2	6392.878	8.581	**.001	0.235	0.959
Motion planning	The Number of answers	Time	60.556	2	30.278	8.561	**.001	0.234	0.959
		Group	40.017	1	40.017	7.671	**.010	0.215	0.762
		Time*group	62.067	2	31.033	8.775	**.001	0.239	0.963
	Time for answering	Time	12635.467	2	6317.733	18.026	**.001	0.392	0.999
		Group	8881.667	1	8881.667	16.290	**.001	0.368	0.973
		Time*group	11868.889	2	5934.444	16.932	**.001	0.377	0.999

Note: ETA: Eta Coefficient; ** $p \leq .01$

DISCUSSION

The aim of the current study was to investigate the effectiveness of selected cognitive-motor intervention on the level of PL and executive functions of ADHD girls in a one-month follow-up plan. According to the results, participating in cognitive-motor program has led to the improvement and persistence of PL, and the participants of the experimental group performed better than the control group in the post-test and follow-up stages. Since no study was found on the effectiveness of cognitive-motor interventions on the development of PL, studies that examined the development of PL after a physical activity program were used to examine the results of this research. In this regard, the results from this part of research are in line with the results from Masini et al. (2020) and Boržíková & Lenková (2021).

Cognitive-motor intervention affects the PL of ADHD girls through a wide variety of fundamental movements and physical skills. Generally, people with higher PL are more willingness to participate in sports. According to the evidence, people can become

physically literate regardless of their age (Lundvall, 2015). In order to explain the results, it can be said that the cognitive-motor intervention has led to the development of PL of the participants of the experimental group by creating a fun and attractive environment. In this regard, based on the results, it was found that cognitive-motor intervention has a significant effect on the components of daily behavior, physical competence, motivation and self-confidence and also the knowledge and understanding of the PL model. Besides, according to the Canadian PL model, daily behavior and physical competence have a strong relationship with the amount of physical activity, which is in line with the results from this part of the study. Mirali et al., (Mirali, 2019) announced that there is a weak relationship between physical activity and physical competence, which is not in line with the results from this part of the present study. The age of the participants can be considered as one of the possible reasons for the inconsistency because, the participants in their Mirali's study were 10-year-old children, but participants of present study were between 10 and 12 years old.

As humans grow and progress as a result of interaction with the environment, proficiency in physical competence and appropriate daily activity level plays a very important role in the development of PL. Considering the fact that physical fitness includes things such as having proper movement skills, physical fitness related to health and even physical fitness related to performance and finally body composition. Therefor when the level of children's physical activity will be high, they take higher scores in daily behavior and physical competence.

Among the other findings of the current study, the significant effect of cognitive-motor intervention on motivation and self-confidence of ADHD girls can be mentioned. The effectiveness of cognitive-motor intervention on improving children's self-confidence was one of the first strategies used in the mentioned program. Similarly, providing opportunities for children to make decisions and encouraging them to solve problems may help them to self-regulate their emotions. This can ultimately strengthen their sense of ownership and empowerment, which are important components in the development of self-confidence and motivation (Lundvall, 2015). In this regard, Franco et al. (2017) suggested that interventions which enhance Students' competence understanding in the field of physical education, may contribute to their intention to participate in physical activity. According to the results, the cognitive-motor intervention led to an increase in the physical competence of the participants in an experimental group, and since there is a relationship between physical competence and motivation and self-confidence, therefore, increasing mobility through cognitive-motor intervention led to an increase in motivation and self-confidence. On the other hand, in relation to the knowledge and understanding substructure of the PL model, the results indicated the positive effect of the cognitive-motor intervention on the knowledge and understanding of the participants. The results from this part of the study are consistent with the results of the research by Mirali et al. (2019), although they are not consistent with the results of the study by Mohammadi et al. (2022). The inconsistency can be caused due to the type of program as, in their study the relationship was measured, while in the present study, the intervention was applied. Cognitive attitude, emotional attitude, self-efficacy and perceived competence are the essential factors determining the psychological health of children, which are themselves improved through physical activity (Franco et al., 2017). Considering the nature of the cognitive-motor intervention that simultaneously stimulates physical and cognitive activity of children and increases their mental involvement, it seems that it can also improve the knowledge and understanding of the participants by increasing the cognitive capabilities.

In explaining the effectiveness of cognitive-motor intervention on the level of PL, it can be said that the motor ability of children with ADHD is significantly lower than what is expected from a child with this age and expected level of intelligence. Children who suffer from such disorders, not only have problems in gross motor skills, motor coordination, dexterity and fine motor skills, and bilateral coordination but the delay in acquiring motor development stages, disturbances in movement planning and execution, balance and postural control are also observed in them. However, the use of sports exercises increases the positive aspects conditional on the response and provides situations that divert one's attention from threatening and anxiety-provoking conditions (Goulardins et al., 2013). On the other hand, physical

activity strengthens the nervous and deep vestibular system and improves superior brain functions such as motor skills and integration in action, which by creating a suitable environment for increasing self-confidence and a sense of self-efficacy, can reduce ADHD and improve motor skills, which results in improving the level of PL (Allan et al., 2017).

Among the other findings of the current study is the significant effect of cognitive-motor intervention on executive functions. In fact, during the examination of the test stages, it was found that in the components of sustained attention and movement planning, the experimental group performed better in boat the post-test and follow-up stages. In addition, they had better performance than the control group in the post-test and follow-up phase. these findings are consistent with the results of many previous studies (Pan et al., 2019; Ziereis & Jansen, 2015). In explaining the effectiveness of cognitive-motor intervention on the executive functions of ADHD girls, it can be mentioned that ADHD is a kind of neuro-psychological disorder, the recent theories emphasized on the main role of attention and the lack of cognitive functions on it; So, according to the research of Dutier (Kiluk et al., 2009), people suffering from ADHD have problems in measures of response inhibition, working memory, planning, and attentiveness. Accordingly, participating in cognitive-motor exercises can reduce the action potential in the sinoatrial node of the heart, slowly help to calm the nerves, reduce attention deficits and ultimately improves executive functions (sustained attention and movement planning) by creating physiological changes such as regulating the cardiovascular system, especially by influencing the parasympathetic automatic nervous system and stimulating the vagus nerve (Pan et al., 2019). Another possible reason for improving executive functions through a cognitive-motor program is that it may improve attentional maintenance in children with ADHD, which somewhat proves the hypothesis that the interaction of catecholamine and their receptors in the prefrontal cortex and striatum regions improves the cognitive processes that were created through effort. Cognitive-motor intervention and its playfully activities are focused on empowering the individual in the effective use of executive functions, and as a result, it is expected that due to the effective use of neurological executive functions, self-control will increase and emotional and behavioral problems of the person will be improved.

During the examination of the test components, it was found that the participants made significant progress in the number of correct answers and the responding time both in the post-test and follow-up stages. Since the error of committing and the ratio of correct responses to all non-target stimuli are indicators of response inhibition, the findings of the present study are in line with the results of Pontifex et al. (2013) and Piepmeyer et al. (2015). Generally, the findings indicate the improvement of response inhibition of children suffering from ADHD in response to physical activity. In addition, in order to better understand the relationship between physical activity and cognitive functions of children with ADHD, it is said that the main symptoms of inattention disorder and impulsivity/hyperactivity are caused by defects in the prefrontal cortex that supports sustained attention. This part of the cortex has wide connections with parts of the frontal cortex that directly involve motor actions. The premotor cortex and the supplementary motor areas are also connected with the motor cortex. therefore, it can be said that they can justify the connection between attention and movement (Pontifex et al., 2013).

PRACTICAL APPLICATIONS

Finally, it can be concluded that sports and cognitive-motor activities can be utilized as a complementary method to reduce some cognitive disorders in children suffering from ADHD and also to improve their PL level. Since physical activities are enjoyable for children and they naturally have a desire to do physical activities, they benefit from them. If it is possible to purposefully combine physical activities with cognitive activities, it is possible that ADHD children can benefit from this type of exercises, and PL and executive functions, which are the problems of these children, can be improved at the same time. However, it is necessary to conduct more studies in this field. Inevitably, every study has limitations that make it necessary to interpret its findings in the context of that limitations. So, considering the limitations that the present study was faced, it can be concluded that the results from the present study can only be generalized to 10-12-year-old girls with ADHD in Yazd, and if it was intended to generalize them to other ADHD children, it is necessary to do

the work accurately and with sufficient knowledge. Considering the existing theoretical scope as well as the present findings and limitations, it is suggested that the current research be conducted in other geographical regions with different cultures and, if possible, with a larger sample. It is also suggested that teachers and coaches use cognitive-motor interventions in physical education programs to not only prevent the abandonment of sports activities and its health consequences but properly develop the children's PL level.

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