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Effect of a Plyometric Training Program on the Physical Parameters of ADHD Children: Behavioral and Cognitive Consequences

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Abstract

Background: Attention Deficit Hyperactivity Disorder (ADHD) is a common neurodevelopment disorder with inappropriate levels of inattention and hyperactivity/impulsivity that emerge during preschool-age causing several impairement that should be supported.
Objectives: The purpose of this research was to explore the repercussion of plyometric training protocol (PT) on disruptive behavior and executive control among children with ADHD.
Methods: Executive functions and ADHD related behaviors are assessed by graded tests before and after a 12-week PT (plyometric training) or NPT (did not perform PT training).
Results: Findings show that participation in PT enhances behavior reports by parents and teachers ($P < 0.001$) and level of executive function ($P < 0.001$).
Conclusions: These findings suggest that PT may improve positively ADHD symptomatology.

Keywords: Plyometric Training, Physical Parameters, ADHD, Behavior, Executive Control

1. Background

Attention deficit hyperactivity disorder (ADHD) is a common neurodevelopmental disorder which is caused by the interplay of genetic and environmental risk factors (1). The disorder is characterized by developmentally inappropriate hyperactivity, inattention and impulsiveness, with a predicted worldwide preponderance of 5% in school-age children (2-4) and is associated with many dysfunctions across multiple functioning domains (5). Tistarelli et al. (6), pointed that ADHD co-occurs with many psychiatric troubles that could persist into adulthood and may interfer with normal functioning (7). Once ADHD is established during infancy, attention should be paid to the prevention incorporating different strategies Wich may to be effective to revert this disorder.

Recently, among these strategies; interest has grown in physical activity as alternative method for the treatment of children with ADHD. Regular physical activity could occur positive repercussion on health and development of children (8), and have shown promising result in improving core symptoms of children and adolescents with ADHD (9), and there is some evidence to recommend that aerobic monitoring has pertinent effects on ADHD symptomatology , and that regular aerobic training may also provide benefits for executive functions, attention and behavior (10), and motor skills (11).To improve ADHD motor skills difficulties and low levels of physical activity, Wrotniak proposed that running and jumping are basic skills for participation in active games and sports. Therefore, improving these skills in children with low motor ability may be a relevant method for ameliorating physical fitness. However, there is a lack on studies that aim to improve motor and coordination ability in children with low motor competence (12). Plyometric training refers to the performance of stretch shortening cycle movements that involve a high-intensity eccentric contraction immediately after a rapid and powerful concentric contraction. The nervous system reacts more quickly to the stretch-shortening cycle.

This type of exercise can enhance a child's speed of movement, increase power production (13, 14), and strengthen bone (15). Historically, plyometric exercise was considered unsafe for youth, especially for those who their level of strength was inappropriate (12). However, this instruction was not promoted by present research (16). Currently, little numbers of researches have investigated the influence of plyometric training (PT) on young children and especially on ADHD.

2. Objectives

The objective of this research was to explore the effects of 12 weeks protocol of plyometric training on attention deficit hyperactivity disorder children.

3. Methods

3.1. Participants

Participants were recruited from primary schools in the North West region of Tunisia. They were young people aged 12 years (n = 40) with DSM IV diagnosis of ADHD in three clinical forms (inattentive type, hyperactive-impulsive type, combination type) (17). The subjects selected for the study had a normal developpemental quotient (18) they passed a clinical interview conducted by a psychiatrist supplemented by a standardized semi-structured questionnaire the Kiddie-Schedule of Affective Disorders and Schizophrenia Present and Lifetime Version (K-SADS-PL, version 1.0, 1996). They received no chemotherapy, and were free from mental and physical retardation and they have dominance of right-hand writings. Parents gave written informed consent to participation.Two groups were randomly created. The first group was composed of ADHD children participating in the plyometric training program (PT), the control group were composed of children with ADHD not participating in the plyometric program (NPT). All the children were assessed prior to the start of the program and at the end.

3.2. Anthropometric and Physical Measurements

During a preliminary session, the weight, the height of each participant was measured and BMI Z-scores were calculated. A maximal effort test was administered; all participants were performed a progressive running test until exhaustion using the 20m shuttle run test (20 m SRT) to identify the rate at VO2 peak (19).

3.3. Cognitive Tasks

3.3.1 The Stroop Test

We used a Stroop version consisting of four cards each containing 100 items: a naming card, a reading card, an interference card and flexibility card (20); it was adapted in Arabic language by Bouzaoueche et al. (21). We have analyzed in the Stroop test the time reached in the inhibition and flexibility card and total number of errors for each card.

3.4. Behavioral Measures

We have used the conners (22) teacher and parents to assess ADHD behaviors validated in Arabic language (2006) with a coefficient $\alpha = 0.75$. The Conners scales are an external observer assessment of the behavioral manifestations of hyperactivity in children. There are three forms depending on the source of the information: the 48-item questionnaire is intended to be completed by parents (Behavioral difficulties, Attention difficulties, Somatization, Impulsiveness, Anxiety), the 28-item scale by teachers (Behavioral difficulties, Impulsivity /Hyperactivity, Inattention/ passivity). These scales have been validated in numerous studies and have norms adapted to age (from 3 to 17 years) and gender (22). They consist of different factors that allow for sub-score calculations. The parent and teacher scales allow an accurate assessment of behavioral symptomatology in different situations. The hyperactivity index allows following the evolution of symptoms under therapy.

3.5. Training Program

The plyometric exercises were performed on non-consecutive days twice a week and based on exercises of double-leg jump, medicine ball overhead throw, and medicine ball single-leg dip in the first 4 weeks, the exercise of hurdle hops, zig-zag jump drill, and medicine ball backward throw in the weeks 5 - 9 and single-leg cone hops, single-leg zig-zag drill, and medicine ball partner push pass in the weeks 9 - 12. Training session began with a period of warm up (10 min of jogging +stretching), plyometric training maintained 20 min (15s vs 15s passive recovery) and finished with a period of cool dawn (10min) (23).

3.6. Statistical Analysis

Statistical analyses were performed using SPSS (Version 21.0) for Windows (SPSS Inc., Chicago, IL, USA). A significance level of 0.5 was used prior to the adjustment. Examination Kolmogorov-Smirnov test used to reveal that all indices are distributed normally. A two-way analysis of variance (ANOVA) with repeated measures has been performed to compare the data from the two groups before and after

the intervention. A η^2 (eta square) value was used as an index of the effect size.

4. Results

Results show that there was no significant change between the groups in age, M/F sex ratio, weight, height and BMI indices at base line and after plyometric protocol but only maximum oxygen consumption ($F_{(1, 38)} = 102{,}001$, $P < 0.001$, $\eta^2 = 0.729$) increased in PT group. Concerning Cognitive tasks assessed by stroop test, PT group showed a higher level of information processing compared to the control group. They were faster in the visual research as assessed by the time-target pondered score of the tow cards of interference ($F_{(1, 38)} = 30{,}740$, $P < 0.001$, $\eta^2 = 0.447$) and flexibility ($F_{(1, 38)} = 63{,}842$, $P < 0.001$, $\eta^2 = 0.627$.

PT group committed fewer errors that indicate a better selective attention. Also Paired t tests showed a decrease of raw scores and significant differences were observed for total problems score in posttest concerning behavioral problem especially attention difficulties, Behavioral difficulties, Impulsiveness, Anxiety and Somatization in both parent and teacher reports.

5. Discussion

Thus, the aim of this research was to explore the effectiveness of 12 weeks PT on ADHD children's related behavior and executive function. Findings show that participation in a PT improves related behavior reports by parents and teachers and level of executive function. Given that, to our knowledge, this is the first study to explore the relevance of a plyometric program on physical, attentional and behavioral parameters in children with ADHD. Some studies have reported that physical training improves cognitive and behavioral function in children and adolescents with ADHD (24, 25). This study is in concordance with previous research that have found a positive relationship between cognitive function, aerobic fitness tests and motor skills (26, 27). The improvement may be due to improved long-term hippocampal potentiation (LTP) (28), neurogenesis, neocortical neurotrophin mRNA expression (29), cerebellar blood vessel density (30), catecholamine response (31), changes in blink responses, and reduced motor impersistance (32). Among several physical activities, plyometric exercise was considered as a pathway to mental and physical health. Ramirez-Campillo et al. (33) reported that 7 weeks of low-volume, high-intensity plyometric training induced a significant improvement in the countermovement jump (CMJ) height in young male soccer players aged 13 years. Our results are consistent with these findings and demonstrate that prepubescent ADHD patient can increase their symptoms significantly with monitoring plyometric training. Similarly, another study showed that exercise increased attention and calmness in a 4-year-old boy with ADHD (34). In the course of this work, we have demonstrated that improvements are found in several scales of the Conners Multi-Source Inventory, specifically the externalized problem scales such as the Attention Deficit Hyperactivity Disorder. We noticed a positive effect on behaviors such as aggressive behavior, conduct disorders, interpersonal problems and attention/hyperactivity problems. These results can be explained by the fact that the plyometric training sessions encourage cooperation in group situations and consider tolerance and acceptance. The social interactions in the experimental group during the training sessions may therefore lead to significant improvement in behavior. Most children tend to be more active and attentive at the end of the program.

5.1. Conclusions

In this work we contribute to the body of knowledge in the area of physical activity (PA) and ADHD. The plyometric program produced significant behavioral and attentional improvements in all ADHD children who participated in the training program. Behavioral improvements were demonstrated on several of the Conners parent-teacher scales. Specifically, the plyometric program had a greater impact on inattention/hyperactivity behaviors and somatic complaints/problems in children in the experimental group compared to children in the control group. These improvements were statistically and clinically significant.

The results of this study, despite limitations, suggest that a plyometric program could have a positive impact on the attentional functions of children with ADHD and could provide preliminary support for other therapeutic interventions.

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Footnotes

Authors' Contribution: Soukaina Hattabi, Meher Boullegue, Thouraya Mhenni and Jamel Halouani: Data collection and analysis; Soukaina Hattabi, Meher Boullegue: Writing the first version of the manuscript; Jamel

Halouani and Hamdi Chtourou: Drafting and revising the manuscript. All authors have participated in preparation of the final version of the manuscript, whose contents they approve.

Clinical Trial Registration Code: CPP-02/18

Conflict of Interests: No conflict of interest exists.

Data Reproducibility: The data presented in this study are openly available in one of the repositories or will be available on request from the corresponding author by this journal representative at any time during submission or after publication. Otherwise, all consequences of possible withdrawal or future retraction will be with the corresponding author.

Ethical Approval: The study conducted according to the Declaration of Helsinki (2013), was approved by the Sfax University ethics committee (parents gave their written informed consent to participate in the research.CPP-02/18).

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Informed Consent: Parents gave their written informed consent to the participation of their children in this research.

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