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THE IMPACT OF PHYSICAL EXERCISE BASED ON ESHKOL-WACHMAN MOVEMENT NOTATION ON ATTENTION AND ON COORDINATION AMONG STUDENTS WITH ATTENTION DEFICIT HYPERACTIVITY DISORDER

A SUMMARY

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

INTRODUCTION

People who engage in physical activity (PA) might recognize the connection between movement and attention. This connection is even stronger when the motor tasks are complex and not being performed automatically. Whether in dancing, gymnastics or martial arts, at professional or popular sport, the attention ability plays an important role in PA, in addition to the required physical abilities. The executor needs to "pay attention" before starting the movement sequence, and to maintain a high level of attention throughout the performance.

The reasons for choosing this topic: As someone who is involved in *Eshkol-Wachman Movement Notation* (EWMN) for many years, as a dancer and as a teacher, it was interesting to examine this kind of physical activity. Following my practical experience, it was observed that the connection between PA and cognitive performance (CP) also exists in the performance of exercises based on EWMN. The question arises whether this kind of practice has an impact on different populations, including people with Attention-Deficit Hyperactivity Disorder (ADHD). Most studies in the field of ADHD were done among children. In our opinion, it is also important to study the adults population, in order to have further understanding regarding the disorder and its implications among this age group. Based on the literature review that will describe the positive connection between PA and CP, and the unique mental requirements of the exercise based on EWMN, two main hypotheses were suggested, regarding the possible impact of exercise based on EWMN on attention and on coordination.

Research Rational: Researches have shown that PA has positive effects on CP among different populations. Varied types of physical activities were examined, at different intensities, in a long or short term programs. To explore the connection between PA and CP, researchers examined different aspects of cognitive abilities, such as memory, spatial perception, executive functions and attention. The positive impact was shown among different age groups: children, adolescents and adults (Etnier et al., 1997; Sibley & Etnier, 2003; Chang et al., 2012a).

The etiology of ADHD and the putative mechanisms, by which PA impacts CP, suggest that physical exercise might be particularly beneficial for this population. Current researches generally support the potential for acute and chronic physical practice to mitigate ADHD symptoms (Gapin & Etnier, 2010; Gapin et al., 2011; Chang et al., 2012b).

According to Gruber (1975), exercises will only be beneficial for cognitive function if the exercise involves coordinated movements that require thought before execution. Coordination exercises are characterized by complex motor movements with different body parts for goal-

directed behavior (Newell, 1985). To our knowledge, very few researchers investigated the impact of coordinative practice on cognitive performance.

EWMN is the conceptual, as well as, the practical foundation of this research. EWMN was created in Israel by Prof. Noa Eshkol in collaboration with Prof. Abraham Wachman. Over the years, it was used for analyzing and documenting in varied movement disciplines. EWMN is a numerical notation method, proposing a system of symbols which represent basic values that describe the human movement in time and space (Eshkol & Wachman, 1958). EWMN is capable of representing complex movement events, including movements that are performed in simultaneous form. The structure of the notation exposes different coordination layers and enables many types of coordinative combinations.

This research focuses on the possible impact of practicing exercises based on EWMN. Since coordination is a motor phenomenon that characterizes both by cognitive and physical features (Summers & Pressing, 1994), two aspects will be examined: attention (cognitive ability) and coordination (physical ability) (Figure 1). The study will examine the impact of a structured intervention program, consists of exercises that are based on EWMN, on attention and on coordination among the unique population of ADHD college students.

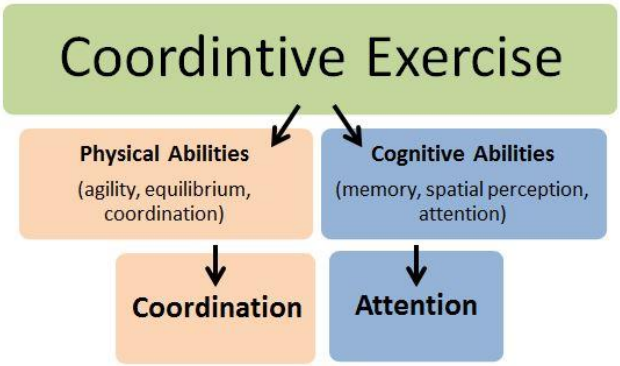

Fig 1. Research rational

The proposed research has two main goals. The first goal was to introduce a special intervention program targeted at physical exercise. The intervention program is based on EWMN and focuses on the coordination ability. The rational and the structure of the program was described, accompanied by practical examples of the exercises. The second goal was to examine the proposed intervention program regarding two different and complementary fields of knowledge: coordination ability as part of physical skills, and attention ability as one of the cognitive skills. Coordination and attention were measured and the findings were statistically analyzed.

In order to achieve the research goals and to examine its hypotheses, the thesis was divided into three main parts. The first part – Literature Review – contained the theoretical background of the research. A basic survey of the research topics was presented, in order to combine the different fields of knowledge that this research addresses. The second part of the thesis – Pilot Study – described the pilot study that was conducted before the experimental research. Its main purpose was to verify the research tools and the intervention program. The third part - Experimental Research – contained the practical aspects of the research and its analysis. The background information for the execution of the research was described in the methodology chapter. The special intervention program based on EWMN was fully detailed, presenting its overall structure and its unique exercises. The research results regarding coordination and attention were presented following the methodology. The results were accompanied by a discussion, which explained them in light of the theoretical background, and in relation to recent studies in the field of the impact of coordination practice.

The purpose and importance of this research: This research addressed the subject of EWMN, aiming at revealing some of its possibilities, and to give them empirical validation. In this manner, a new form of motor activity can be developed, in order to reach new populations and perhaps even to improve some of their abilities. The research will try to provide further establishment to the understanding of the positive impact of physical exercise on cognitive abilities. In addition, a potential contribution can be made for the ADHD population, especially adults with ADHD.

PART I
LITERATURE REVIEW

CHAPTER 1. THEORETICAL BACKGROUND

The theoretical frame of this research integrated two separate but complementary disciplines: the field of movement and motor abilities and the field of cognitive abilities. The first part of this chapter introduced the subject of EWMN, being the conceptual and the motor foundation of this research. Basic principles of movement and movement analysis were discussed, reviewing the unique way of thinking through this method. The second part presented the concept of attention as one of the basic CA of humankind, and a measured variable in this research. The third part demonstrated the concept of coordination, being both a fundamental property of the intervention program and also a measured variable. The fourth part integrated the two disciplines by reviewing the connection between physical abilities and cognitive performance, emphasis on coordination and cognition. Since the subjects of the research were college students with ADHD, the fifth part described this disorder, its main definitions and characteristics. This part focused on the effect of physical activity on cognition among this population, and also described ADHD in adulthood, the difficulties and the challenges they face.

1.1. Eshkol-Wachman Movement Notation (EWMN). EWMN was chosen due to its ability to create complex and simultaneous movement sequences, which characterizes the physical exercises.

EWMN was created in Israel by Prof. Noa Eshkol in collaboration with Prof. Abraham Wachmann, and was published in 1958. EWMN is a notation method, proposing a system of symbols which represent basic values that describe the human movement in time and space. The method relies on the premise that physical-movement phenomena can be analyzed and symbolized within a framework of concise system of defined symbols (Eshkol & Wachmann, 1958).

The elementary units that are essential to describe the human movement are defined in EWMN and can be represented at the desired level of details. The writing is done by numbers and common graphic symbols that are written on a designated manuscript page. In this way, the system enables one to write every movement event that can be seen in human eyes (Eshkol & Harries, 1998). Ofer (2009) further emphasizes that EWMN enables encoding the movement information, conceptualize and represent it ("writing'), decode it ('read') and perform the represented movement ('moving').

Because of its unique structure, EWMN exposures and enables many coordination layers. In the manuscript page, the body's limbs are organized in a vertical column, like in a music score. Each body part has its own horizontal line which describes the movement course in time. This unique representation enables to compose coordination exercises that are characterized by a simultaneous performance of different body parts at varied time durations. The integration of physical exercises with reading and writing, adds deeper significance to the process of learning.

1.2. Attention. The expression "to pay attention" indicates that this is a valuable and limited resource. The subject of attention as a cognitive process contains different and broad elements. Attention is one of the most central cognitive abilities, which is connected to varied aspects of life. Attention is required in everyday activities, in learning, in performing movement and it is also connected to human behavior and socialization. In his book about motor learning, Magill (1998) refers to attention as "… engagement in the perceptual, cognitive, and motor activities associated with performing skills" (p. 102). He further emphasis that these activities may be performed consciously or non-consciously. Regarding motor performance, Abernethy (2001) views the importance of the optimal, selective and sustained allocation of attention to the learning and performance of sports skills. According to Best (2010), physical activities require complex cognition in order to employ strategies and adapt to ever-changing task demands. Similar demands are shown in executive function, including attention, where the tasks require to create, monitor and modify a cognitive planning. According to Schmidt & Lee (1999) engaging in two activities at the same time, is common in daily life. The term 'dual task interference' refers to the decrement in performance of one or both tasks when two activities are carried out concurrently. Performing dual tasks usually results in performance decrements as compared to single-task performance due to attention limitation.

Over the years, researchers tried to explain the mechanism of attention in the process of reception and processing of information. Several theories exist referring to attention capacity and resources. For example: Filter theory of attention (bottleneck theory), Limited availability of resources, Central resources theories, and Multiple-resource theories. It is currently believed that attention is not a unitary phenomenon, but comprises a group of elements with a limited resource. Allocations of that resource have to be made on the basis of the supply available for processing (Mirsky et al., 1991).

1.3. Coordination. Coordination is an important physical skill in performing everyday activities or in performing complex motor skills. It involves the nerve-muscle synchronization (or separation) between different organs of the body. A traditional definition was made by

Turvey (1990), defining coordination as "the patterning of the body and limb motions relative to the patterning of environmental objects and events" (p.938). Magil (1998) further emphasis that goal directed movements must be performed within a time that is accurately set and often minimal, and they need to be spatially coordinated with maximum precision. The coordinative ability is one of the key factors in motor performance. Together with equilibrium and kinesthesia, they provide the performer the possibility of controlling his movements and to execute them in an efficient manner. Lidor & Nabel (1994) indicated that improving the coordination ability will eventually lead to an improvement of the overall motor ability.

The literature classifies coordination according to the specific requirement. It is important to notice that every movement can contain several of coordinative classifications. For example: Gross motor coordination, eye-hand coordination, upper and lower limbs coordination, bimanual coordination, etc.

1.4. Physical Activity and Cognitive Performance. Current literature indicates that physical activity has positive effects on cognitive performance. The premise underlying those researches is that physiological changes in response to exercise have implications for cognitive function.

The connection between action and cognition is revealed when executing new complex motor skills such as those involving sequencing or coordination (Serrien et al., 2007). The authors argued that neural regions typically associated with cognitive operations may also be recruited during the performance of motor tasks. According to Serrien et al. (2006) the cerebellum and the frontal lobe are responsible for coordination as well as cognition.

Coordination was found associated with cognitive abilities in preschool children (Planinsec, 2002); intelligence level among adolescents (Planinsec & Pisot, 2006); academic achievements in elementary school children (Lopes et al. 2013) and with age-related deterioration in older women (Capranica et al. 2005).

When examining coordination and cognitive abilities after intervention programs, several elements should be taken into consideration: the population, the duration of the programs and the type of cognitive ability.

Budde et al. (2008) studied attention and concentration among 150 adolescents. The results revealed higher improvement of the coordination exercise group. They assumed that the coordinative character of the exercises might be responsible for the significant impact. Kwok et al. (2011) investigated the effectiveness of coordination exercise in improving cognitive function

in older adults. The results showed that participants in the coordination exercise group had significant improvements in global cognition after the intervention program.In older adults Voelcker-Rehage et al. (2011) reported better performance in cognitive function (visual search task) after coordination training as compared to the relaxation or stretching. Hötting et al. (2012) demonstrated improvement in selective attention and memory after non-endurance coordination training among middle-aged humans. Chang et al. (2013) examined the behavioral and neuroelectrical impacts of a coordinative exercise intervention among kindergarten children. Their findings revealed that exercise intervention, regardless of intensity, resulted in shorter reaction times and higher response accuracy. These results suggest that coordinative exercise may specifically be beneficial by increasing the allocation of attentional resources and enhancing the efficiency of neurocognitive processing.

1.5. Attention Deficit Hyperactivity Disorder (ADHD). ADHD is one of the most prevalent disorders in children. It is characterized by inattention, hyperactivity, and/or impulsivity and has a negative impact in many areas of children's life (American Psychiatric Association, 2000).

It is conservatively estimated to occur in 3% to 6% of children from diverse cultures and geographical regions, with an over representation of boys by approximately 3:1. ADHD encompasses the lifespan, affecting children from preschool to school age and continuing through adolescence into adulthood, albeit with age and gender-related changes in its manifestation (Tannock, 1998). Currently, there are more than one identified etiologies of ADHD. Research findings hypothesize that ADHD is caused by a combination of environmental and genetic factors (Furman, 2005).

Motor performance appears to be impaired, as with the various areas of competency affected by the disorder, for an important sub-set of this population (Barkley, 1997; Brossard-Racine et al. 2011). In general, children with ADHD demonstrate poorer physical performance measures of motor proficiency (balance, bilateral coordination, strength, upper limb coordination, response speed, visual- motor coordination, and upper limb speed and dexterity) (Beyer, 1999). It has been proposed that physical activity can benefit executive functions by modifying brain structure and function, particularly in the frontal regions of the brain. This is of particular relevance to ADHD populations considering that ADHD models posit that a core deficit in frontal lobe function underlies its various cognitive and behavioral manifestations. It is plausible that physical activity may benefit children with ADHD by positively impacting executive functions (Gapin & Etnier, 2010; Etnier, 2014).

The main characteristics of ADHD in childhood and adulthood are not identical. In adults, less obvious symptoms of hyperactivity or impulsivity occurs, and more inattentive symptoms revealed (Franke et al. 2012; Wilens et al. 2009). Wilens et al. (2009) suggest that prominent ADHD symptoms persist in approximately one-half of childhood cases reaching adulthood. A similar data were presented by Gjervan et al. (2012) who reported that ADHD persist from childhood into adulthood in 30%-60% of the population. In adulthood, people with ADHD are coping with different developmental challenges, such as: education, occupational status, driving and interpersonal relationships (Weiss et al. 2002).

PART II

PILOT STUDY

CHAPTER 2. VERIFICATION OF THE RESEARCH TOOLS

The second part of the thesis described the pilot study that was conducted before the experimental research. The pilot study was held in order to verify the research tools and the intervention program. It took place during the semester break (4 weeks), between 27.1.2013-22.2.2013. A number of 5 students, diagnosed with ADHD, participated in the intervention program: practice of physical exercises based on EWMN. The students were examined with two tests: *d2 test of attention* and *Matorin test* for coordination. Four group meetings were held at the beginning of every week, and the students were asked to practice twice more over the week. At the end of that period, the students were examined again, with the same tests.

Conclusions and practical applications:

- The research tools were proven compatible with the research objectives. Nevertheless, it became clear that one coordination test was not enough and it could not capture the uniqueness of this phenomenon. Coordination is a very complex physical ability and it contains varied and different types and classifications.

Following this, two decisions were made:

1. Two more coordination tests were chosen and added to the research (*Alternate Hand Wall Toss Test* and *Plate Tapping Test*). Adding the two coordination tests, enabled to expand the frame of reference regarding the types of coordination *(Alternate Hand Wall Toss Test*: eye-hand coordination; *Plate Tapping Test*: upper-limb coordination).

2. The first two tests were performed and measured twice, in two different variations (*Matorin test* – clockwise and counterclockwise; *Plate Tapping Test* – preferred hand and non-preferred hand).

The five measurements together will try to give a wider understanding regarding the coordination ability, and will enable different coordination classifications to be examined.

- The exercises based on EWMN were at different difficulty levels. It was evident that several exercises were at a very high difficulty level.

Following this understanding, the exercises were given to a group of EWMN experts. The members of this group work for the past 20 years in the field of EWMN, by performing, reading and writing varied of movement cultures. Most of them are also teachers for EWMN at various institutions. The exercises were performed and rated by the group members. Several of the exercises were cut out of the program due to their high difficulty level.

- During the period of the pilot study, it became clear that it was hard to keep track of the individual practices.

In order to try to overcome this obstacle, a weekly timetable was formed. The timetable contains a chart with the dates of the following week. The students will be asked to fill it during the week, and to hand it to the instructor at the group meetings.

PART III

EXPERIMENTAL RESEARCH ON THE EFFECT OF PHYSICAL EXERCISE BASED ON EWMN AMONG STUDENTS WITH ADHD

The third part of the thesis described the organization and the execution of the research regarding the impact of exercise based on EWMN on coordination and on attention among college students with ADHD.

CHAPTER 3. METHODOLOGY

This chapter presented the research structure and the methodological procedures that were used in collecting and analyzing the data. In order to present a valid and reliable answer for the impact of exercises based on EWMN on coordination and attention, this chapter reviewed the research hypotheses, stages, tools, and subjects. A detailed description of the intervention program was given in order to understand its rational and structure.

The presented research was aimed at examining whether practicing exercises based on EWMN will have an impact on coordination and on attention abilities. The research was held among 40 female college students that were diagnosed as having ADHD. The students were randomly divided into three groups: 1st experimental group (practicing exercises based on EWMN); 2nd experimental group (practicing general coordinative exercises); and a control group (no practice). The intervention programs were held for a period of 13 weeks between 25.2.2013-20.6.2013 (3 practices per week). Four tests were chosen and performed before and after the intervention programs (*Matorin* Test, *Alternate Hand Wall Toss* Test, *Plate Tapping* Test, *d2 Test of Attention*). The statistical analyzes were performed using SPSS (version 20 SPSS) software.

3.1. Objectives and Hypotheses. The present study sought to address two main objectives. The first objective was to introduce a special intervention program targeted at physical exercise based on EWMN. The intervention program consists of multiple physical exercises that were created according to the basic principles proposed by EWMN method. In addition, an original model was presented offering a framework of learning, performing and practicing the exercises. The second objective was to examine the proposed intervention program regarding two different and complementary fields of knowledge: coordination ability as part of physical skills, and attention ability as one of the cognitive skills.

Research Hypotheses:

I. Practicing exercises based on EWMN will have an impact on coordination among students with ADHD.

I.1. Practice exercises based on EWMN will have an impact on general coordination.

I.2. Practice exercises based on EWMN will have an impact on eye-hand coordination.

I.3. Practice exercises based on EWMN will have an impact on upper-limb coordination.

II. Practicing exercises based on EWMN will have an impact on attention variables among students with ADHD.

3.2. Research Stages. The pretest – post-test control group design was chosen in order to examine the impact of the specific intervention program. The next figure presents the research stages according to its progression.

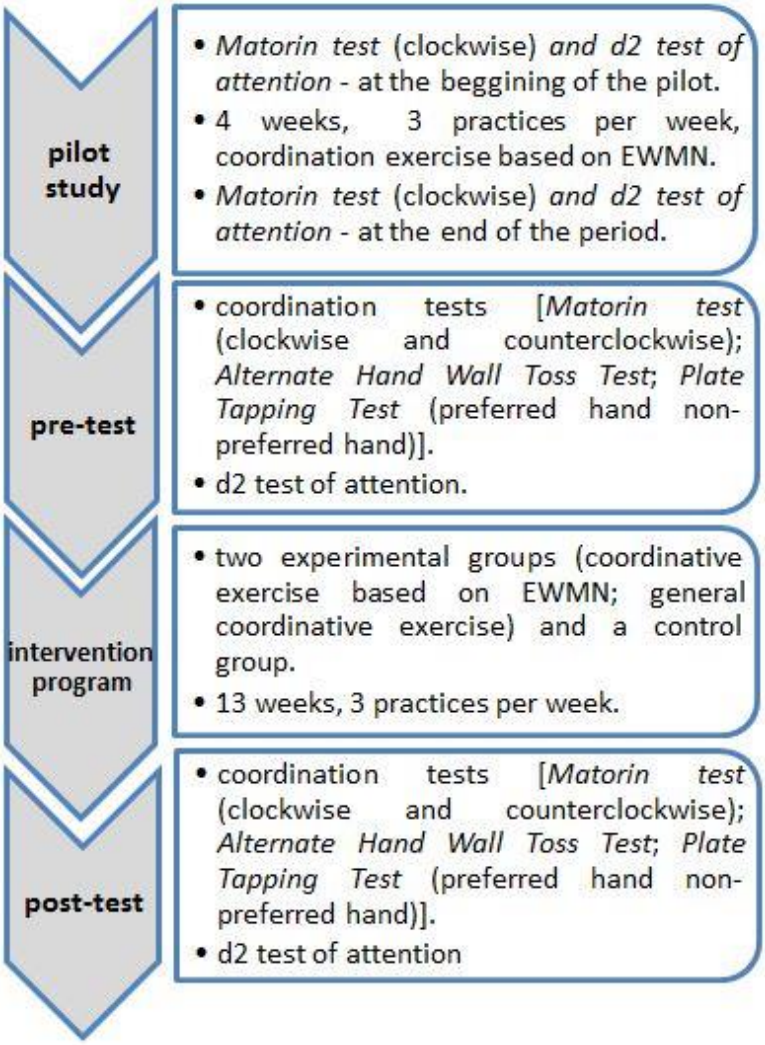

Fig 2. Research stages

3.3. Research Tools. Due to the research hypotheses, the research tools derived from two different theoretical disciplines: coordination – physical ability, and attention – cognitive ability. Four different tests were chosen to be used in this research.

Coordination tests. Three coordination tests were chosen and performed in order to give an overview of the coordination ability: *Matorin* Test (general coordination), *Alternate Hand Wall Toss* Test (eye-hand coordination) and *Plate Tapping* Test (upper limb coordination).

Attention test: The *d2 Test of Attention* is a cancellation test involving simultaneous presentation of visually similar stimuli. Several abilities are involved in this test: Mental concentration, visual perception, visual scanning ability, and perceptual speed. It has been proposed as a particularly useful measure of attention and concentration processes. The validity and reliability of the d2 test were examined by Brickenkamp & Zillmer (1998).

3.4 Subjects. The research subjects consist of 40 female college students, which were diagnosed with ADHD before beginning their graduate studies. The students were voluntary recruited from two colleges of education in Israel: *Kibbutzim College of Education, Technology and Arts*, Tel-Aviv; *Orot Israel College of Education*, Elkana. The students are learning at a regular full time program.

The students were randomly divided into three groups. The next figure presents the three groups according to their division.

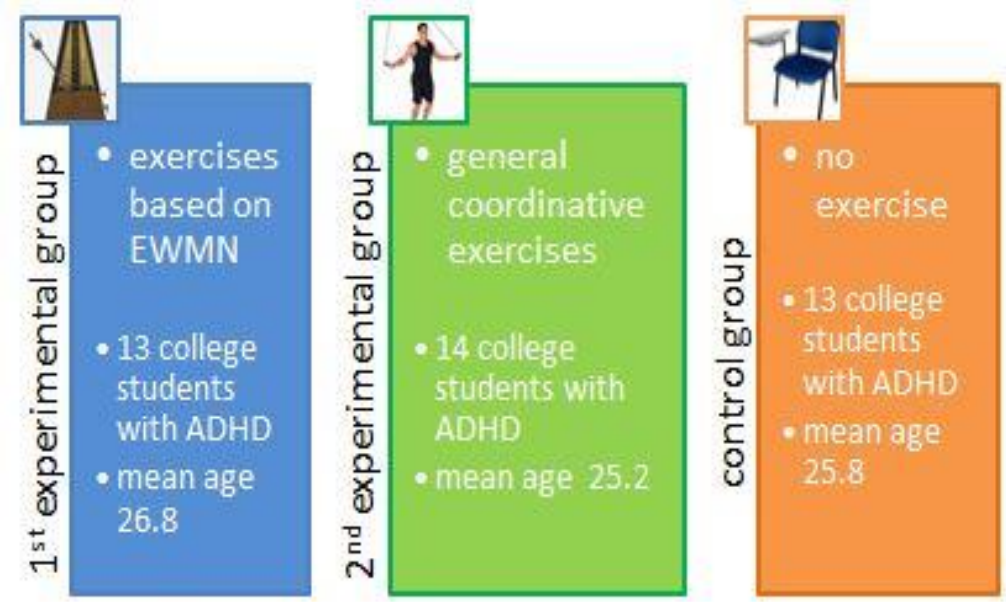

Fig 3. The Research groups

3.5. Intervention Programs. The research was conducted over one semester (13 weeks) between 25.2.2013-20.6.2013. The students of both experimental groups participated in intervention programs that were based on practicing physical exercises.

3.5.1. Exercise based on EWMN – First experimental group. *Research procedure.* The students used to meet with the instructor once a week, at the beginning of every week. Each practice lasted for about 45 minutes, including warm-up, 15 minutes of physical exercises based on EWMN and some release exercises at the end. In each group meeting the students learned and practiced 2-3 new physical exercises. Throughout the week, the students were asked to practice the exercises to more times.

Program Description. The intervention program consists of physical exercises that were built on the basic principles of EWMN. The program was based on learning and practicing new exercises every week, a total of 31 exercises.

Based on the relevant literature and on a practical experience in teaching these exercises, a circular model was developed by the author. A three stage process occurs every time when performing new exercise. The next figure presents the circular model.

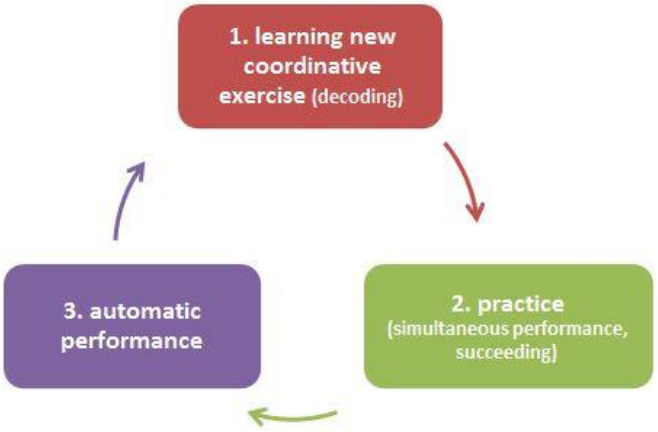

Fig 4. The Circular Model of Coordinative Exercises (Shalit & Hantiu, 2014)

The first stage deals with learning the exercise, which requires physical and cognitive decoding. This is done by separately performing each motor layer, each movement sequence. The second stage is practicing the exercise by performing the motor layers together, simultaneously. The aim is to succeed in performing the simultaneous movements and by that to correctly execute the coordinative challenge. The third stage, directed at reaching the automatic performance of the exercise. When the exercise is being performed automatically, one must move on to a new exercise that contains other coordinative combination (different limbs, different duration, different coordination classification). As a result, the cycle starts again (Shalit

& Hantiu, 2014). The motor goal of the exercises is to correctly succeed in their performance, and therefore there is less focus on the quality of the motor performance.

The creation of the exercises was done based on one of the basic principles of EWMN – the manuscript page. Using the manuscript page enables to apply different body limbs and different durations, and by that to create layers of movement sequences. The basic components (limbs and time) enable the composing of simple and complex coordination exercises that involve sequences of simultaneous movements of various body parts in different duration.

The exercises consisted of movements that occur one after the other, and thus created a motor sequence. The sequence repeats itself several times, requires motor and cognitive abilities such as coordination and sequence memory. In the simple exercises the sequence consists of 2-3 movements, and on the more complex exercises the sequence can reach up to 8-10 movements.

For example: the left arm draws a triangle – performing 3 movements for each sequence; at the same time, the right arm draws a square – performing 4 movements for each sequence.

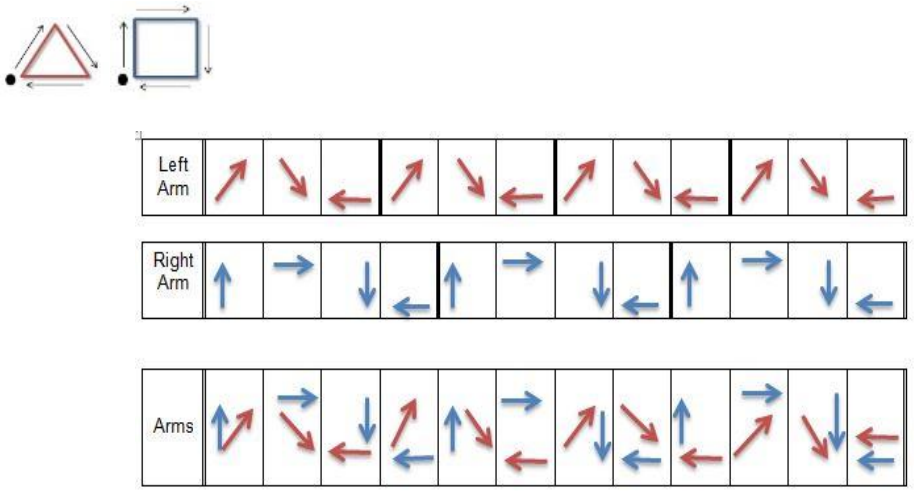

Fig 5. An example of an exercise – using EWMN manuscript page *(exercise No.14)*

The complete intervention program was fully described. The period was divided into units, according to the weeks. The course of the program was detailed in accordance with the exercises that were learned and practiced in each week. A verbal description was given, followed by the main types of coordination that were evident in the exercise. Afterwards, some possible variations were presented for each exercise.

Full intervention program – demonstration of exercises based on EWMN, verbal description

Week 2*: Exercise 4 - Different Types of Jumps*	
Description	Three types of jumps that are performed in a fixed order: jumping on both legs, jumping on the right leg, jumping on the left leg. These three types of jumps are performed in a fixed cycle: 4 jumps, 3 jumps, 2 jumps, 1 jump (4 on both legs, 3 on the right, 2 on the left, 1 on both, and so on).
Types of coordination	Gross motor; Rhythm and tempo.
Possible variations	I. Performing the jumps while changing the spatial directions. II. Performing the jumps while advances. III. Performing the pattern of the exercise using the hands, tapping on the thigh/floor.

Week 4*: Exercise 8 - Arms at a Canon*	
Description	The arms perform six movements: side up (shoulder level), straight forward, up, side down (shoulder level), straight forward and down. The right arm starts the sequence and the left arm joins after one movement.
Types of coordination	Gross motor; Upper limb, Asymmetry; Spatial (body).
Possible variations	I. The left arm will start the sequence. II. Starting in a different position (lying down).

The intervention program was accompanied by a researcher diary. Several impressions and observations were written after each group practice of the first experimental group. This information tried to give a wider perspective regarding the physical performance of the exercises, the difficulties, the success and the participants' responses.

3.5.2. General Coordinative exercises – Second experimental group. *Research procedure.* The students used to meet with the instructor once a week, at the beginning of every week. At the first meeting they learned general coordination exercises (Ben-Sira et al. 1998). The practice consisted of skipping, skipping a rope, bouncing steps, clapping hands while jumping Throughout the week, the students were asked to practice the exercises two more times. Overall, the students performed 45 minutes of physical activity in each practice (stretching, light warm-

up, etc.). Every practice included a section of general coordination exercises that lasted 15 minutes.

The students that were assigned to the second experimental group, practiced general coordination exercises. After learning the exercises, they continued to practice the same exercises throughout the research period. These exercises were chosen since they were characterized as having coordinative features.

3.6. Statistical Analysis. Descriptive analysis was calculated for each measurement. Also, in order to check our hypotheses, a series of non-parametric tests were done. The *Kruskal-Wallis* test is a non-parametric method for testing whether samples originate from the same distribution. The *Wilcoxon* test is a non-parametric method for comparing two related samples, in this case, repeated measurement of a single sample. We chose to conduct non-parametric test due to the small size of the groups, which prevent the assumption of normal distribution. All analyzes were performed using SPSS (version 20 SPSS) software.

CHAPTER 4. RESULTS

This chapter presented the research results, according to its hypotheses regarding the impact of exercise based on EWMN on coordination and on attention.

4.1. Results - Coordination. This part presented the findings regarding the connection between practicing exercises based on EWMN and coordination. The findings presented the results of the coordination tests, according to the three research groups: 1st experimental group (practiced exercises based on EWMN), 2nd experimental group (practiced general coordinative exercises) and control group (did not practice coordination).

The main assumption of this part of the research was that coordination practice based on EWMN will improve coordination among students with ADHD. Three secondary hypotheses were derived out from the main hypothesis regarding the different types of coordination that are expressed in the coordination tests. The following findings present the results regarding the secondary hypotheses.

The following tables (1-5) present mean scores and standard deviation of the coordination tests at the pre-test phase and post-test phase among the three research groups. Also are presented the *Wilcoxon* test results comparing the performance of each group before and after the intervention.

Table 1 presents the results of the Matorin test in clockwise direction. This in accordance with the research hypothesis regarding the impact of exercise based on EWMN on general coordination.

Table 1: Matorin test (clockwise) – Means and standard deviation [degrees]

	Pre-test		*Post test*		*Z(1)*
	M	*SD*	*M*	*SD*	
Experiment 1(N=13)	350.08	48.07	370.38	49.14	1.89*
Experiment 2 (N=14)	343.93	48.68	356.79	44.88	1.63
Control (N=13)	332.31	43.23	346.15	42.63	1.63

*p<.05; **p<.01; ***p<.001

Table 2 presents the results of Matorin test in counterclockwise direction.

Table 2: Matorin test (counterclockwise) - Means and standard deviation [degrees]

	Pre-test		*Post test*		*Z(1)*
	M	*SD*	*M*	*SD*	
Experiment 1 (N=13)	325.38	37.44	335.77	39.47	1.73*
Experiment 2 (N=14)	331.07	41.80	337.50	38.47	1.41
Control (N=13)	321.92	31.00	328.85	28.37	1.41

*p<.05; **p<.01; ***p<.001

Table 3 presents the results of Alternate Hand Wall Toss Test. This in accordance with the research hypothesis regarding the impact of exercise based on EWMN on eye-hand coordination.

Table 3: Alternate Hand Wall Toss Test – Means and standard deviation [Number of catches in 30 sec.]

	Pre-test		*Post test*		*Z(1)*
	M	*SD*	*M*	*SD*	
Experiment 1 (N=13)	19.31	5.01	21.46	4.58	2.59**
Experiment 2 (N=14)	19.93	5.27	21.43	5.53	1.79*
Control (N=13)	20.15	5.96	20.08	6.16	0.14

*p<.05; **p<.01; ***p<.001

Table 4 presents the results of Plate Tapping Test (preferred hand). This in accordance with the research hypothesis regarding the impact of exercise based on EWMN on upper limb coordination.

Table 4: Plate Tapping Test (preferred hand) - Means and standard deviation [number of hands crossing in 30 sec.]

	Pre-test		*Post test*		*(1)*
	M	*SD*	*M*	*SD*	
Experiment 1 (N=13)	56.61	7.38	59.62	7.97	2.59**
Experiment 2 (N=14)	57.29	7.25	58.64	6.17	2.34**
Control (N=13)	60.15	7.23	61.31	8.26	1.21

*p<.05; **p<.01; ***p<.001

Table 5 presents the results of Plate Tapping Test (non-preferred hand).

Table 5: Plate Tapping Test (non-preferred hand) - Means and standard deviation [number of hands crossing in 30 sec.]

	Pre-test		*Post test*		*Z(1)*
	M	*SD*	*M*	*SD*	
Experiment 1 (N=13)	52.31	7.39	55.61	6.60	2.82***
Experiment 2 (N=14)	53.43	6.51	55.07	6.17	1.30
Control (N=13)	57.31	7.19	57.69	6.93	0.49

*p<.05; **p<.01; ***p<.001

Following the findings presented above, it can be said that the performances of the first experimental group were significantly improved in all five coordination tests that were conducted [*Matorin test* (clockwise); *Matorin test* (counterclockwise); *Alternate Hand Wall Toss Test*; *Plate Tapping Test* (preferred hand); *Plate Tapping Test* (non-preferred hand)]. The highest improvement was measured at the *Alternate Hand Wall Toss Test* (13.1%) as compared to the lowest improvement at the *Matorin test* (counterclockwise) (3.3%). The performances of the second experimental group were only significantly improved in two tests *[Alternate Hand Wall Toss Test*; *Plate Tapping Test* (preferred hand)]. As with the results of the first experimental group, its highest improvement was evident at the *Alternate Hand Wall Toss Test* (9.1%) and its lowest improvement was at *Matorin test* (counterclockwise) (2.2%). The performances of the control group were not significantly improved in any test. As opposed to the other two groups, its highest improvement was shown at *Matorin test* (clockwise) (4.6%), and the lowest improvement was observed at the *Alternate Hand Wall Toss Test* (0.02%).

4.2. Results – Attention. This part presented the main findings regarding the connection between practicing exercises based on EWMN and attention.

The following tables (6-9) present means and standard deviation of the d2 test of attention at the pre-test and post-test phases among the three research groups. Also are presented the Wilcoxon tests results examining the degree of progress for each group.

TN is a measure of the overall amount of work that was done. Table 6 prsents the results of TN variable.

*Table 6: **TN** (Total Number of items marked) - means and standard deviation*

	Pre-test		*Post test*		*Z(1)*
	M	*SD*	*M*	*SD*	
Experiment 1 (N=13)	298.08	46.15	437.62	72.98	3.11**
Experiment 2 (N=14)	301.71	80.10	330.14	80.94	1.98*
Control (N=13)	294.31	73.93	301.15	65.63	0.84

*p<.05; **p<.01; ***p<.001

Table 7 prsents the results of E1 variable. E1 is a measure of errors of omission, number of d2 items omitted or not marked.

Table 7: E1 (Errors of omission) - means and standard deviation

	Pre-test		*Post test*		*Z(1)*
	M	*SD*	*M*	*SD*	
Experiment 1 (N=13)	19.77	14.13	10.08	8.42	-2.97**
Experiment 2 (N=14)	23.36	23.48	19.50	19.30	-1.61
Control (N=13)	17.85	11.05	14.77	8.33	-1.72*

*p<.05; **p<.01; ***p<.001

E2 is the number of d2 test items marked contrary to test instructions. Table 8 prsents the results of E2 variable.

Table 8: E2 (Errors of commission) - means and standard deviation

	Pre-test		*Post test*		*Z(1)*
	M	*SD*	*M*	*SD*	
Experiment 1 (N=13)	3.00	2.35	1.77	1.67	-2.03*
Experiment 2 (N=14)	3.07	2.37	1.07	2.13	-1.79*
Control (N=13)	3.38	3.95	3.08	2.25	0.00

*p<.05; **p<.01; ***p<.001

Table 9 prsents the results of CP variable.

Table 9: CP (Concentration Performance) - means and standard deviation

	Pre-test		*Post test*		*Z(1)*
	M	*SD*	*M*	*SD*	
Experiment 1 (N=13)	132.77	23.77	158.77	36.88	1.64*
Experiment 2 (N=14)	137.00	25.53	140.71	22.87	0.98
Control (N=13)	135.69	32.53	137.46	29.06	0.35

*$p<.05$; **$p<.01$; ***$p<.001$

Following the findings presented above, it can be said that the performances of the first experimental group were significantly improved in all attention variables that were measured in d2 test of attention (TN - total number of items marked; E1 - errors of omission; E2 - errors in commission; and CP - concentration performance). The performances of the second experimental group were significantly improved at the TN – total number of items marked and E2 - errors in commission. The performances of the control group were only significantly improved at E1- errors of omission.

CHAPTER 5. CONCLUSION AND RECOMMENDATIONS

This research examined the effect of exercise based on EWMN on attention and on coordination among college students with ADHD. The research results indicated that the coordination and attentional performances were significantly improved among ADHD college students who practiced exercises based on EWMN.

The first hypothesis assumed that practicing exercises based on EWMN will have an impact on coordination among students with ADHD. This hypothesis was confirmed according to the different types of coordination that were examined (general coordination, eye-hand coordination, and upper limb coordination). Significant improvement was evident due to the unique structure of the coordinative exercises that has influenced the process of learning and practicing. This process emphasizes the simultaneous performance of separate movement sequences, resulting in a high level of coordination complexity.

The second hypothesis assumed that practicing exercises based on EWMN will have an impact on attention among students with ADHD. The results presented a significant improvement of attention measures as tested by the d2 test of attention. It has already been proven that coordinative practice can improve the ability of attention since it requires both physical and cognitive abilities. In order to isolate the specific factors of coordination that might cause this improvement, we examined two different intervention programs, both characterized by coordinative practice: physical exercise based on EWMN (1st experimental group) and general coordinative exercises (2nd experimental group). According to the reviewed literature, it was found that a high level of motor complexity leads to an attentional effort. This information is compatible with the exercises of the first experimental group that are built from separate movement sequences at different limbs, which are being performed simultaneously. As a result of this structure, the exercises based on EWMN are characterized by a high level of difficulty. But this is not enough. Even a difficult coordinative exercise can be mastered after a period of practice, and it becomes quite easy to perform. Another factor, and maybe even the key factor, is the process of new learning. This process occurs every time a new skill or task is being learned. The process of new learning activates the system of attention and increases the level of attentional effort. Yet, after learning and practicing, the performance becomes automatic and the level of attention considerably decreases. The intervention program based on EWMN provides a solution to this issue. The program consisted of 31 different exercises. Each exercise is composed of new and different combination of movements or limbs, thus creating a new coordinative combination. Therefore, the process of new learning, followed by advanced

attention levels, occurs again and again. As a result, the system of attention was constantly activated.

The intervention program based on EWMN contained the two discussed factors (high difficulty level and new learning). It is suggested that these factors might be the reason for the significant improvement.

Future Researches: this particular field of study should be examined by further researches. Since it was shown that exercise based on EWMN improved coordination and attention among ADHD college students, additional directions of study can be examined.

- Characteristics of subjects: the presented study examined the ADHD population. Additional researches can investigate populations with other characteristics, for example: learning disability, Developmental Coordination Disorder (DCD), Etc.
- Age of subjects: the presented study examined college students. Other age groups should also be examined, for example: children or adolescents.
- Variables: this study measured the improvement of coordination and attention. Further studies can examine the impact of the same intervention program on other physical abilities (agility, equilibrium, flexibility, Etc.), or on other coordination types (fine motor coordination, coordination of rhythm and tempo). Other cognitive abilities can also be measured (for example: memory, spatial perception, executive functions, Etc.).

The presented research is added to the field of knowledge regarding the connection between physical activity and cognitive performance. This research provides further establishment to the understanding of the positive impact of motor practice on cognitive abilities. In addition, the research validates the positive impact of physical activity on cognitive performance among the ADHD population.

The coordination ability is at the center of attention in this study. The writer believes that this ability is of high importance both to professionals (athletes, dancers) and to those who are not. Coordination is viewed as a complicated ability, having an elusive quality and variety of classifications. The success in performing coordinated movements is also evident in the quality of the performance – harmonious way. This ability itself can serve as a bridge between physical and cognitive abilities, since it combines features of them both.

As far as we know, there are very few intervention programs aimed mainly at coordination. In light of this study, the development of such programs, for varied populations, is important. The presented intervention program offers a large number of physical exercises accompanied by several different variations for each exercise (and by that their number even increases). In addition, EWMN can serve as a useful tool for creating new exercises. One can decide to create coordinative exercises using the basic principles of EWMN, and thus to adjust them to his particular needs. This working method enables to customize the intervention program to the intended population, and not vice versa.

The presented research is added to existing studies that explored EWMN method itself, or as a research tool. It provides a new point of view regarding the practical possibilities of using this method among different populations.

In summary, the presented research aimed at two main goals - to introduce and to examine a designated intervention program consisted of physical exercises based on EWMN. The program was described and explained according to basic theoretical and motor principles, including EWMN that formed the basis for the exercises. Furthermore, an original model was developed, presenting a circular process of coordinative exercise and practice. The effect of the intervention program on coordination and on attention was examined among college students with ADHD, indicating a significant improvement of the subjects' performances.

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