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The impact of exercise based on the Eshkol-Wachman movement notation on general coordination
Impactul exerciţiilor bazate pe sistemul de notare a mişcărilor Eshkol-Wachman asupra coordonării generale

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Abstract

Background. Coordination is a fundamental physical ability in everyday activities or in performing complex motor skills. It refers to the synchronization between different limbs of the body. The *Eshkol-Wachman Movement Notation* (EWMN) is a numerical notation method that can be used for the analysis and documentation of the movement phenomenon. This method is capable of representing complex movement events, especially those that are performed in simultaneous form, which can be seen in the execution of coordinative movements.

Aims. The aim of this research was to examine whether physical practice, based on EWMN, can improve general coordination ability.

Methods. 40 college students, which were diagnosed with Attention Deficit Hyperactivity Disorder (ADHD), divided into three groups, participated in the research. The student practiced the exercises during 13 weeks, 3 times per week. The *Matorin* test was conducted at the beginning and at the end of that period for measuring general coordination.

Results. The results indicate that the performances were significantly improved ($Z=1.89$ and $Z=1.73$; $p<.05$) after practicing exercises based on EWMN.

Conclusion. Coordinative practice based on EWMN improved general coordination. The significant improvement can be attributed to the conceptual framework of the intervention program that emphasizes the simultaneous and automatic performance of physical exercises.

Key words: coordination, EWMN, ADHD, motor skill.

Rezumat

Premize. Coordonarea este o calitate fizică de bază, întâlnită în activităţile de zi cu zi sau în efectuarea de mişcări complexe. Presupune sincronizarea dintre diferitele segmente ale corpului. Sistemul de notare Eshkol-Wachman (EWMN) este o metodă de înregistrare a mişcărilor, utilizată pentru analiza şi documentarea fenomenului mişcare. Această metodă este capabilă de a reprezenta evenimente de mişcare complexe, în special cele care sunt efectuate în formă simultană, întâlnite în executarea mişcărilor coordinative.

Obiective. Scopul acestei cercetări a fost de a examina dacă practicarea exerciţiilor fizice, bazată pe metoda EWMN, poate îmbunătăţi capacitatea de coordonare generală.

Metode. La cercetare au participat 40 de studenţi, diagnosticaţi cu Tulburare hiperkinetică cu Deficit de Atenţie (ADHD), împărţiţi în trei grupe. Aceştia au practicat exerciţiile pe parcursul a 13 săptămâni, de 3 ori pe săptămână. Testul Matorin a fost efectuat la începutul şi la sfârşitul studiului, pentru a măsura coordonarea generală.

Rezultate. Rezultatele indică faptul că după practicarea de exerciţii bazate pe EWMN performanţele au fost îmbunătăţite în mod semnificativ ($Z=1,89$ şi $Z=1,73$; $p<.05$).

Concluzii. Practicarea exerciţiilor de coordonare bazate pe metoda EWMN a contribuit la îmbunătăţirea coordonării generale. Îmbunătăţirea semnificativă poate fi atribuită cadrului conceptual al programului de intervenţie, care pune accentul pe performanţa simultană şi automatizată a exerciţiilor fizice.

Cuvinte cheie: coordonare, EWMN, ADHD, calităţi motrice.

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Introduction

Coordination ability is one of the motor characteristics that can be seen as having both a quantitative and qualitative nature, and is described by terms of efficiency and graceful movements. Coordination is considered to be a complicated ability, having an elusive quality and a variety of classifications. Therefore, it is evident in everyday life (tying shoelaces, driving), in sports (soccer, gymnastics etc.), and in general activities (playing piano, dancing etc.). Moreover, it is regarded as a combination of cognitive and physical properties of the neuromotor system (Summers & Pressing, 1994), representing the qualitative component of psychomotor activities (Pehoiu, 2010). Most of the researches that studied the subject of coordination examined one specific motor activity [for example, Serrien (2008), who studied finger tapping during bimanual and unimanual conditions] or used an existing sport program [for example, Budde et al. (2008), who studied soccer coordination training]. Here we offer a unique set of physical exercises that are based on *Eshkol-Wachman Movement Notation* (EWMN), and are aimed at improving coordination ability.

EWMN is one of the three movement notations that are accepted today in the western world. It was created in Israel by Prof. Noa Eshkol in collaboration with Prof. Abraham Wachman. Over the years, it has been used for analyzing, documentation and creation in varied movement disciplines. EWMN is a numerical notation method proposing a system of symbols which represent basic values that describe human movement in time and space (Eshkol & Wachman, 1958). EWMN is capable of representing complex movement events, including movements that are performed in a simultaneous form. The structure of the notation exposes different coordination layers and enables many types of coordination combinations. Starting from the basic principles of EWMN (body, space and time), within its unique structure, almost endless coordination combinations can be created.

The method relies on the premise that physical movement phenomena can be analyzed and symbolized within a framework of a concise system of defined symbols (Eshkol & Wachman, 1958). The elementary units that are essential to describe human movement are defined by EWMN and can be represented in 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 by human eyes (Eshkol & Harries, 1998). Ofer (2009) further emphasizes that EWMN enables to encode the movement information, conceptualize and represent it ('writing'), decode it ('reading') and perform the represented movement ('moving').

Because of its unique structure, EWMN exposes and enables many coordination layers. In the manuscript page (Figure 1), the body segments are organized in vertical columns, like in a music score. Each body part has its own horizontal line which describes the movement course in time. This unique representation allows to compose coordination exercises that utilize multiple body parts simultaneously and varied time possibilities. The combination of motor exercises with their reading and writing adds a deeper significance to the process of learning.

In view of its structure, EWMN summons deconstruction of a movement phenomenon to its basic components and afterwards reconstructs those components, or just several of them. Thus, it creates new combinations – both chords (vertical column) and lines (horizontal line). This concept per se creates new coordination ensembles (Al-Dor, 2004). According to Al-Dor, the ability to deconstruct and reconstruct basic components makes motor coordination work unique. The possibility of deconstruction and reconstruction of movement components creates a new way of thinking about coordination that integrates different combinations of limbs over different durations.

This study examined the impact of a structured intervention program on general coordination among college students with ADHD (Attention Deficit Hyperactivity Disorder). This subject may raise new possibilities of improving coordination ability through varied freestyle physical exercises. The exercises are built on the representation of the body's limbs on the manuscript page. This way of representation organizes the exercises in a clear way, expresses the coordination complexity and demands a cognitive and motor response.

Hypothesis

Our main hypothesis is that practicing coordination exercises based on EWMN will have an impact on general coordination among students with ADHD.

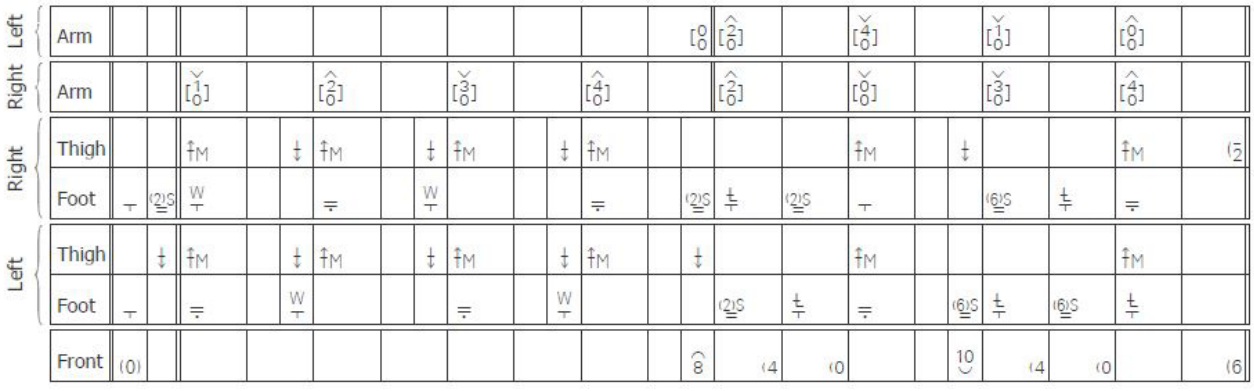

Fig. 1 – Example of an EWMN manuscript page

Materials and methods

The study was approved by the Ethics Committees of *Kibbutzim College of Education, Technology and Arts* and *Orot Israel College of Education*. The ethical principles of confidentiality, anonymity and informed consent were applied to the study subjects.

Research protocol

Period and place of the research

The study took place between 25.2.2013-20.6.2013 at Kibbutzim College of Education, Technology And Arts, Tel-Aviv, Israel.

Subjects and groups

The research subjects consisted of 40 female college students (mean age 25.9), which were diagnosed with attention deficit hyperactivity disorder (ADHD). The students were medically diagnosed with ADHD before beginning their graduate studies, and were learning a full time program. The average prevalence of adult ADHD is estimated to be between 2.5 and 4.9% (Franke et al. 2012). The students were volunteers recruited from two colleges of education in Israel: Kibbutzim College of Education, Technology and Arts, Tel-Aviv (8000 students), and Orot Israel College of Education, Elkana (2000 students).

The subjects were randomly divided into three groups, two experimental groups and one control group: students in the first experimental group (N = 13, mean age 26.8) practiced coordination exercises based on EWMN; students in the second experimental group (N = 14, mean age 25.2) practiced general coordination exercises [for example: skipping, jumping rope, bouncing steps (Ben-Sira, Tenenbaum & Lidor, 1998)]; and the control group (N = 13, mean age 25.8) did not practice coordination in any form.

Tests applied

To assess the level of manifestation of coordination we used the *Matorin* Test. The aim of this test is to measure gross motor coordination. Description: from standing position performing a jump with rotation along the longitudinal axis of the body. During the jump, the examinee must not lose balance and land with feet together, as in the original position. A circle with a diameter of 40 cm and a jump start line are drawn on the ground. The examinee is standing with feet placed either side of a line drawn on the floor, arms relaxed. Then, he will execute a jump back to the right. After the jump, the examinee will remain in place in landing position and the examiner will measure the return angle. This test was measured twice: one jump in clockwise direction and the second jump in counterclockwise direction. Each score was taken separately.

Statistical processing

A series of non-parametric tests (Wilcoxon) were conducted in order to examine whether there was an improvement among the subjects following the intervention. The Wilcoxon test is a non-parametric method for comparing two related samples, in this case, the repeated measurement of a single sample. We chose to conduct a non-parametric test due to the small size of the groups, which prevents the assumption of normal distribution of residuals. The software used was SPSS.

Experimental procedure

At the beginning and end of the study period, the students were tested for general coordination. The students of the two experimental groups met with the instructor once a week, at the beginning of every week. During this group meeting, they learned and practiced coordination exercises. Throughout the week after, the students were asked to practice the exercises individually, during their own time, another two practices. The students of the control group met with the instructor only two times – at the beginning and end of the research.

Intervention program

The exercises of the first experimental group are part of the *Sapir Method* (Sapir & Blum, 2002) that is intended to improve basic abilities of the learning process. The method was created by Tirza Sapir and was developed by the author. The physical and motor performance of physical exercises gives an indication of the performer's abilities. Moreover, physical performance requires high levels of attention and concentration and by practicing the exercises, one can improve them.

The program is based on learning and practicing 2-3 new coordination exercises every week (a total of 31 exercises). A three stage process (Figure 2) occurs every time when performing a new exercise. The first stage deals with learning the exercise, which requires physical and cognitive decoding. This is done by performing each coordination layer separately. The next stage is practicing the exercise by performing the motor layers together, simultaneously. The aim is to succeed in performing simultaneous movements and by that, to correctly execute the coordination challenge. The third stage is directed at reaching the automatic performance of the exercise. When the exercise is performed automatically, one must move on to a new exercise that contains other coordination combination (different limbs, different duration, different coordination classification), and start the cycle again.

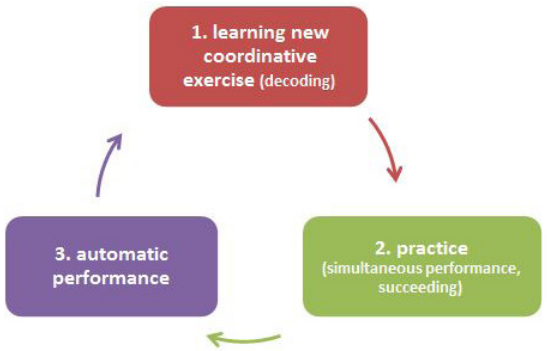

Fig. 2 – A circular model for coordination exercises (intervention program based on EWMN)

Results

Table I presents the mean scores and standard deviation of the *Matorin Test* for general coordination (clockwise) at the pre-test and the post-test phases in the three research groups. Also, the *Wilcoxon* test results comparing the performance of each group before and after the intervention are presented.

Table I

Means and standard deviation of the Matorin test for general coordination (clockwise) at the pre-test and post-test phases among the groups, and Wilcoxon test results assessing the degree of progress of each group

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

*p<.05

As expected, the results presented in Table I show a significant improvement following the intervention in the performance of the first experimental group. No significant improvement was found in the performance of the second experimental group and the control group.

Figure 3 presents the degree of improvement of the *Matorin Test* for general coordination (clockwise) among the three research groups.

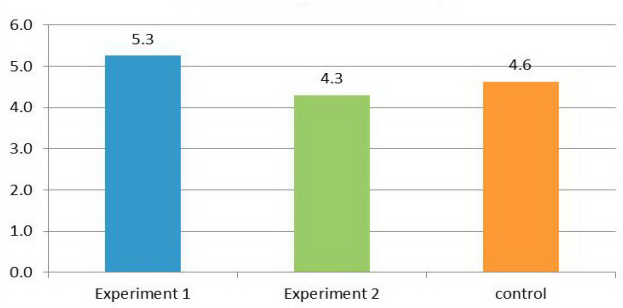

Fig. 3 – Degree of improvement in percentage - *Matorin* test (clockwise)

As shown in Figure 3, the first experimental group had the highest improvement (5.3%) in the *Matorin test* (clockwise) as compared to the second experimental group (4.3%) and the control group (4.6%).

The next table presents the mean scores and standard deviation of the *Matorin Test* for general coordination (counterclockwise) at the pre-test and post-test phases among the three research groups. Also, the Wilcoxon test results comparing the performance of each group before and after the intervention are presented.

Table II

Means and standard deviation of the Matorin test (counterclockwise) at the pre-test and post-test phases among the groups, and Wilcoxon test results assessing the degree of progress of each group

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

*p<0.5

Table II shows that a significant improvement was found in the performance of the first experimental group following the intervention. No significant improvement was found in the performance of the second experimental group and the control group.

Figure 4 presents the degree of improvement of the *Matorin Test* for general coordination (counterclockwise) among the three research groups.

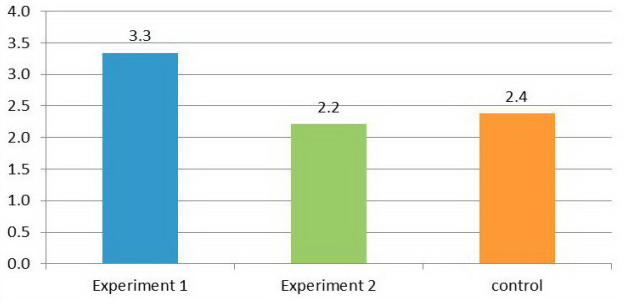

Fig. 4 – Degree of improvement in percentage - Matorin test (counterclockwise)

As shown in Figure 4, (counterclockwise), the first experimental group had the highest improvement (3.3%) in the *Matorin test* as compared to the second experimental group (2.2%) and the control group (2.4%).

Discussion

Regarding general coordination, the findings showed a significant improvement in both tests in the first experimental group who practiced coordination exercises based on EWMN. The improvement of the first experimental group can be explained by the structure of the intervention program.

The general structure of the program was compatible with the three main phases of motor skill acquisition that were described by Puttemans et al. (2005). At the proposed intervention, each exercise stands on its own and matches the phases of motor skill acquisition. Moreover, the whole program as a complete unit matches those phases. In that sense, the subjects improved their physical abilities (Hötting & Röder, 2013).

The learning process of each and every one of the exercises can be examined according to the phases of motor skill acquisition. The participants started by learning the exercise, which required highly attentional demands (early phase); continued on by practicing the exercise and establishing the level of performance (intermediate phase); and then reached automatic performance (final phase). This course happened again and again with each new exercise during the entire period of the intervention program. An additional perspective can be gained by examining the process of the whole program in light of the phases mentioned above. The program lasted for 3 months. At the beginning (first month), the students experienced difficulties, both motor and cognitive. The students "learned" the program, its requirements and demands. Each student needed to make certain adjustments to complete the program. This stage matches the first phase of high attention demands. The second month can be characterized by balancing. The students already knew the course of the program and could begin focusing on the motor performance of the exercises. This stage matches the established performance level. The third month can be described as fluent practicing and mostly involved physical

practice. This stage matches the automatic performance phase (it is important to notice that it does not mean that the exercises were immediately performed automatically). The intervention program can be seen as a process of sequential elaboration and stabilization of different states of coordination. The process of changes in coordination among the subjects took place during the development of the coordination skill (Temprado et al., 1997).

In the proposed intervention program, there was a large emphasis on the practice of every exercise. Through practice, the ability to perform several tasks simultaneously can improve (Swinnen & Wenderoth, 2004; Kahneman, 2011). Furthermore, one of the main findings in the study about the impact of learning EWMN on the development of coordination (Al-Dor, 2004) was that a significant gap in physical performance was evident between the first and second time of each coordination performance. The physical goal of practice within the intervention program was succeeding in performing the coordination combination (right performance of the simultaneous movement sequences, "cracking" the coordination combination) until a "reasonable degree of success" was obtained (Walter & Swinnen, 1994). Till then, the participant did not move on to the next exercise. This kind of oriented practice may probably lead to the improvement of coordination. The progressive improvement of performance following practice of a new complex motor skill was also explained by Rémy et al. (2008), who indicated the transition from attention-demanding to more automatic performance throughout the learning.

The intervention program dealt with the subject of "part-whole training" (Walter & Swinnen, 1994) but from a different perspective. The authors offered a training technique based on decomposing a skill into logical separate components and then reassembled them into the "whole" skill. The intervention program offers exercises that are initially built from separate layers of movement ("parts") that are performed simultaneously and by that create a united performance ("whole"). Walter & Swinnen assumed that their technique may promote the acquisition of some multicomponent skills by simplifying its performance. The results of this research take this assumption one step further by suggesting that not only the acquisition can be promoted, but the coordination ability itself is improved.

In addition to the importance of practicing mentioned earlier, it is not enough to practice coordination per se. Following Doidge (2007), it can be said that practice must include new learning so that the general effect will be meaningful. In this study, the program of the first experimental group consisted of learning several new exercises each week. This enabled the existence of several processes such as new learning and improving coordination skills. The program was based on 31 basic exercises (and several more variations of each exercise) that were composed of new combinations of movements. Not only new exercises were learned and practiced, but also, each exercise contained a different coordination combination and by that increased the level of new learning. The intervention program of the second experimental group consisted of practicing the same previously learned coordination exercises. As a result, the subjects repeated the same movements and it can be assumed that no new learning occurred.

Conclusions

1. Students with ADHD can improve their general coordination ability by physical exercising. Among female students, the coordination ability can be significantly improved.

2. Significant improvement in general coordination can be achieved by practicing exercises based on EWMN. The significant improvement can be attributed to the conceptual framework of the intervention program. The exercises emphasize the different movement sequences that can be performed separately and simultaneously, and by that can enhance the coordination ability. Moreover, the exercises were aimed at an automatic performance that reflects both the success of the coordination execution and the improvement of the ability. These exercises might serve as a useful intervention to improve general coordination.

Conflicts of interest

There are no conflicts of interest.

Acknowledgement

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