

Changes in Postural Stability after Coordination Exercise

Ivan Struhár, Martin Sebera, Lenka Dovrtělová

Abstract—The aim of this study was to find out if the special type of exercise with elastic cord can improve the level of postural stability. The exercise programme was conducted twice a week for 3 months. The participants were randomly divided into an experimental group and a control group. The electronic balance board was used for testing of postural stability. All participants trained for 18 hours at the time of experiment without any special form of coordination programme. The experimental group performed 90 minutes plus of coordination exercise. The result showed that differences between pre-test and post-test occurred in the experimental group. It was used the nonparametric Wilcoxon t-test for paired samples ($p=0.012$; the significance level 95%). We calculated effect size by Cohen's d . In the experimental group d is 1.96 which indicates a large effect. In the control group d is 0.04 which confirms no significant improvement.

Keywords—Balance board, balance training, coordination, stability.

I. INTRODUCTION

MAINTEINING body balance is an essential part which depends on sensory integration and motor reactions. The most important factors which have a great effect of stability are base of support and the height of center of gravity. Postural stability is ability to maintain body components to external and internal perturbations [1].

In literature, we can find the term postural control which is the ability to control position of the body in a space. Many coordination exercise programmes are studied in order to reduce risk of falls especially in a retirement [2]-[4]. It is highly important to minimize risk of injury to musculoskeletal system. Gymnasts should always know where their body components are in a space. Forces which influence stability of the body can be divided into two groups (external and internal). Diminished postural stability is connected with ankle and knee injuries [5]. Coordination programme or stability programme should not be understood only as a way of improving postural stability and postural control. It was proved that balance training has a positive effect on regeneration of neuromuscular structures [6]. Coordination exercise training can be performed on stable or unstable surfaces. Not only stable or unstable surfaces are important for developing postural stability. When the person closes eyes, it

is harder to keep balance because the motor reactions rely only on vestibular and somatosensory cues [7]. A body weight is another factor which can also have effect on postural stability. However, this fact is often seen in anterior-posterior position especially for obese people [8].

Stability balls, balance boards, balance discs and other equipments are used in training of stability. In the study, it was chosen the set of exercises based on dynamic stabilization. Participants trained with special elastic cord against slow resistance.

II. METHODOLOGY

A. Subjects Characteristics

A total of 15 girls participated in the study. The participants were randomly divided into an experimental group (8 girls; mean age= 14.6 ± 1.3 years; mean height= 1.57 ± 0.08 m; mean mass= 46.56 ± 9.13 kg) and control group (7 girls; mean age= 13.85 ± 0.69 years; mean height= 1.55 ± 0.06 m; mean mass= 48.45 ± 7.27 kg). The participants did not report any musculoskeletal injuries or other diseases which may affect their stability for 6 months. Participation was voluntary and all parents had to sign the informed consent before the testing of gymnasts. All participants had been training for 18 hours per week. Only the experimental group performed 90 minutes plus of coordination exercise.

Exclusion criteria for participants in a study:

- Neurological disorders, orthopaedic disorders, vestibular disorders and impaired vision
- Experience with special balance programme or any other form of stability exercise during physical education class of gymnastics training
- Attendance on coordination exercise programme less than 90% (only in the experimental group)
- Any sort of medication during the intervention programme which could affect balance
- Any sort of medication 24 hours prior of the measurements

B. Measurements and Exercise Protocol

Technical data of electronic balance board:

- Surface: 42 x 42 cm
- Three balance radiuses: 5-12-20 cm
- Electric power supplied by PC
- Weight: 2.7 Kg

Postural stability was measured by electronic balancing board. The main task of all participants was to keep a balance in medio-lateral position for 20 seconds. Each performance of participants was expressed by number from 0 to 100. If the

I. Struhár, M. Sebera and L. Dovrtělová are now with the Faculty of Sport Studies, Masaryk University, Brno, 62500, Czech Republic (phone: +420774056870; e-mail: struhar@mail.muni.cz).

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participant did score 100, it was considered as the worst case and the score 0 was the best one. The overall score includes parameters of weighted average of area which is covered within the profile, area outside the profile and recovery time. Before the testing, each participant had the possibility to try standing on electronic balance board. The testing of participants was conducted before the intervention programme and after 3 months. The position on the balance board was precisely controlled (standing barefoot with bent knees, the feet opened at 30° angle and the heels 5 cm apart and the participants could have hands on the hips). The tilting part of the balance board had a radius of 5 cm. It was chosen the possibility of testing when the participant stood on the electronic balance board with eyes closed. It was not allowed to speak during the testing and there were only experimenter and the participant in the room in order to ensuring a calm environment as much as possible. The experimenter was also responsible for the protection of participant in the case of fall. The coordination exercise programme was demonstrated by programme designer and it is important to mention that every lesson was under the supervision. The intervention programme featured 5 exercises with a special elastic cord for only the experimental group and it followed by the training (45 minutes, two times a week for 3 months). Each exercise was performed on the balance mat.

Coordination Exercise Protocol:

Exercise 1: Participant stands relaxed, the palm of the exercising hand facing down. The shoulder blade is extended forward. Then, participant tight the buttocks and pull the shoulder blade back and down. The hand is completely relaxed and remains extended by the elastic rope, the palm rotates upwards. When participant is in this position, she lifts the heel from the floor. After that, the participant repeats the same for the other side. Participants perform 3 sets of 12 repetitions [9].

Exercise 2: Participant stands relaxed backwards. Firstly, participant raises the arm back with pushing the elbows and palms as far back as possible. Then, participant raises the arm as far as it goes and looks down. The chin is tucked toward the breastbone and the limb is raised. After this, the chest is slowly bent towards the pelvis but the arm is in the same position. The arm completes very slowly the circle. After that, the participant repeats the same for the other side. Participants perform 4 sets of 10 repetitions [9].

Exercise 3: Participant stands relaxed and chest is bent downwards. The arms are crossed in front of the body. The shoulder blades have to be pressed backward and downward. Then, participant tries to pull the shoulder blades together, backward and downward as much as possible. The palms rotate upwards and the head is raised. When the spine is aligned, participant raises the limb from the floor and tries to remain in this position 10 seconds. After that, the participant repeats the same for the other side. Participants perform 4 sets of 10 repetitions [9].

Exercise 4: Participant stands relaxed, the right knee is raised upwards, and the left hand touches the knee. Then,

participant moves the right foot backwards and tip of the foot touches the floor at the end of movement. The head has to be extending upwards and shoulders are pressed down. It is highly important to emphasize that when the knees pass each other, participant has to tight the left buttock. At the end of the exercise, the right buttock is tightened and the left one must remain tightened. After that, the participant repeats the exercise with the other limb. Participants perform 3 sets of 12 repetitions [9].

Exercise 5: Participant kneels on back leg and the front leg is extended forward. The buttocks are tightened; the chest and head are levelled into the posterior axis. Then, participant starts to roll down vertebra by vertebra. The chest is pulled towards the stretched leg. Participant remains in this position for 10 seconds and then he/she aligns the chest vertebra by vertebra to the starting position. Participants perform 4 sets of 12 repetitions [9].

C. Analyses

Analyses were conducted using programme Statistica 12.0 and included descriptive statistics. The nonparametric Wilcoxon t-test for paired samples was used to analyze the data within each group. Significance was set at $p < 0.05$ and results are given as the mean \pm SD.

III. RESULTS

Results are presented in Tables I-II and on Figs. 1-4.

TABLE I
DESCRIPTIVE STATISTIC OF PARTICIPANTS

Participant group	Age (years)		Height (m)		Weight (kg)	
	Mean	SD	Mean	SD	Mean	SD
Experimental (n=8)	14.6	1.3	1.57	0.81	46.56	9.13
Control (n=7)	13.85	0.69	1.55	0.67	48.45	7.27

TABLE II
THE OVERALL SCORE OF PARTICIPANTS ON THE ELECTRONIC BALANCE BOARD

Participant group	Pre-test	Post-test
Experimental (n=8)	45.27 \pm 1.22	42.78 \pm 1.18
Control (n=7)	45.38 \pm 0.98	45.42 \pm 1.04

It was supposed that both groups (the experimental group and control group) are homogenous. The independent t-test was used for verification ($p = 0.851370$) and this indicates that both groups are homogenous.

A mean score of participants in the experimental group had decreased (pre-test 45.27 \pm 1.22; post-test 42.78 \pm 1.18) but mean score of participants in the control group had risen (pre-test 45.38 \pm 0.98; post-test 45.42 \pm 1.04). We rejected hypothesis about normality by Kolmogorov-Smirnov and Shapiro-Wilk's tests.

The effect of 3 months coordination programme was evaluated by using the electronic balance board. The result of the study showed that there is a significant improvement in a level of postural stability in the experimental group (the nonparametric Wilcoxon t-test for paired samples, $p = 0.012$; the significance level 95%) and no significant improvement in

the control group (the nonparametric Wilcoxon t-test for paired samples, $p=0.590$; the significance level 95%).

We calculated effect size by Cohen's d . In the experimental group d is 1.96 which indicates a large effect. In the control group d is 0.04 which confirms no significant improvement.

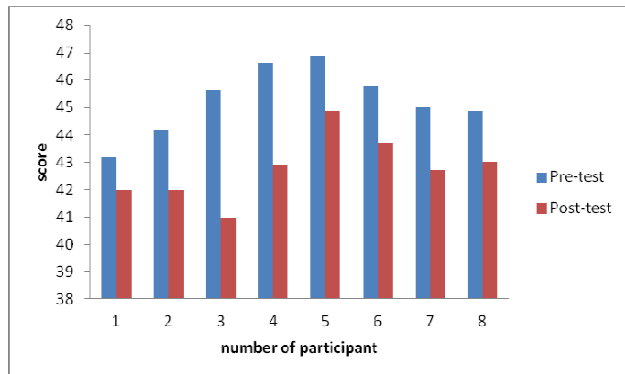


Fig. 1 The overall score of participants in experimental group

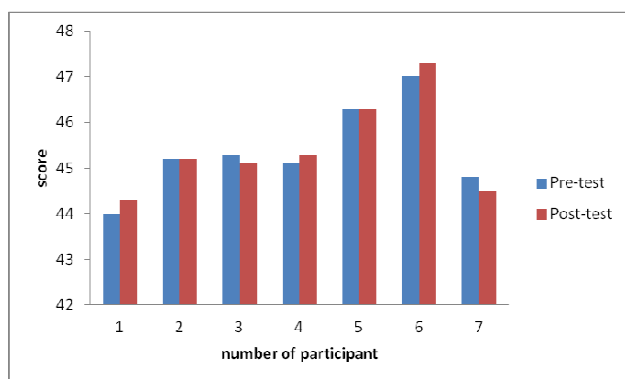


Fig. 2 The overall score of participants in control group

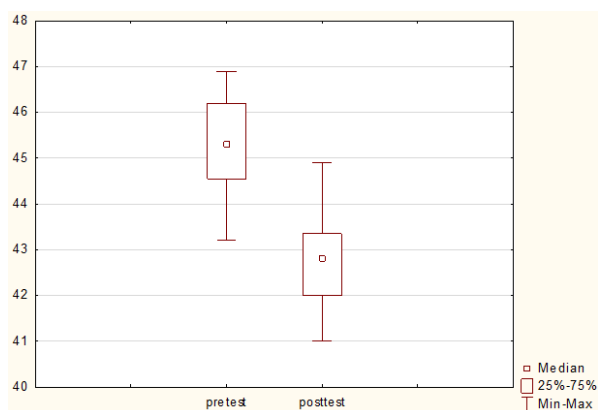


Fig. 3 The experimental group's average score between pre-test and post-test

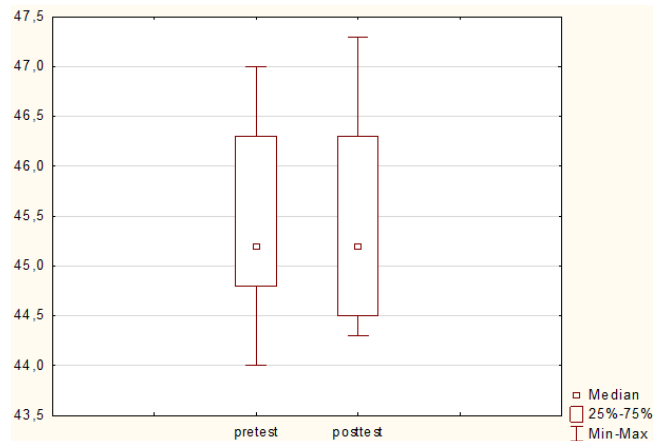


Fig. 4 The control group's average score between pre-test and post-test

IV. DISCUSSION

The balance system includes components which are responsible for motor reaction. The vestibular system responds to movement of the head and this fact plays a crucial role for maintaining upright position. Proprioception is another component of balance system which informs us about position of the body from movement of joints, muscles and ligaments. A visual acuity and depth perception of the space can affect the motor reaction of the person. At the beginning of balance training, it is better to begin with static and bilateral surface and after that we can add more specific exercises.

The main purpose of the study was to evaluate whether the coordination exercise with elastic cord can improve postural stability of participants in the experimental group. The results showed that a mean score of participants in the experimental group had decreased (pre-test 45.27 ± 1.22 ; post-test 42.78 ± 1.18) but mean score of participants in the control group had risen (pre-test 45.38 ± 0.98 ; post-test 45.42 ± 1.04). Several studies also confirmed positive effect of coordination exercise on postural stability and postural control [10] - [12].

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Ivan Struhár was born in Partizánske (Slovakia) in 1986. He is PhD student at the Department of Health Support - Faculty of Sports Studies, Masaryk University, Brno (Czech Republic).

Martin Sebera was born in Vyškov (Czech Republic) in 1974. He is an assistant professor at the Division of Sport Motorics and Methodology in Kinanthropology - Department of Kinesiology - Faculty of Sports Studies, Masaryk University, Brno (Czech Republic).

Lenka Dovrtělová was born in Brno (Czech Republic) in 1977. She is an assistant professor and head of the department of Health Support - Faculty of Sports Studies, Masaryk University, Brno (Czech Republic).