FACTA UNIVERSITATIS
Series: **Physical Education and Sport**, Vol. 19, No 3, 2021, pp. 285 - 294
https://doi.org/10.22190/FUPES211208028P

Research article

THE EFFECT OF DIFFERENT EXERCISE PROGRAMS ON MOTOR ABILITIES IN PRIMARY SCHOOL CHILDREN

UDC 796.012.1-053.5

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Abstract. *The aim of this study was to determine and to compare the effects of different exercise programs on motor abilities in primary school children. A total of 60 (30 boys and 30 girls) primary school children, aged 12 years ± 6 months voluntarily participated in this study. Motor abilities were assessed by the following variables: the squat jump, long jump, bent-arm hang, sit-ups, push-ups, sprint 30m, T-test, handgrip, and medicine ball throw tests. All groups had regular physical education classes twice a week and one hour of additional physical activity, with the experimental groups exercising with a medicine ball (E1) following a developmental gymnastics program (E2) during the 12 weeks. The ANCOVA showed statistically significant differences between the groups (p<0.05) in most motor abilities tests in favor of both experimental groups, with slightly better results in favor of the E1 group compared to E2. The results of this research show that exercise with a medicine ball and developmental gymnastics can lead to significant improvements in motor abilities among primary school children.*

Key words: *exercise, physical activity, medicine ball, developmental gymnastics*

INTRODUCTION

Physical education is the only subject in the school curriculum that concentrates on the physical, mental and social development of adolescents together. Moreover, it stimulates them for a healthy lifestyle, in which physical fitness, in addition to nutrition, also has a primary role (Džakula, Miljković, Pavičić, & Banjac, 2020). The variety of elements of preparation and its realization in practice characterizes the teaching of PE the world over. Despite so much

Received December 08, 2021 / Accepted December 29, 2021
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diversity, the teaching of physical education in different educational systems is characterized by a common goal, and that goal is to advocate for the process of physical education that contributes to the development of the individual (Hardman, 2009). The main goal of teaching physical education is that the desired transformations of the anthropological status of school children are in the function of satisfying the need for movement, of contributing to the increase in adaptive and creative skills in modern living and working conditions, and of preserving health and creating a lasting habit of physical activity, which should be accepted as a need that contributes to health culture and improves overall lifestyle (Najšteter, 1997). Physical education has a very important share in the education of the individual, and aims to contribute to the optimal development of the individual through physical activities as well as the growth and development of his physical abilities and psychosocial characteristics (Hardman, 2007).

During adolescence, muscle fitness is a significant indicator of future health (Ortega, Ruiz, Castillo, & Sjöström, 2008; Ruiz et al., 2009). Although they have beneficial effects on health, physical fitness trends have an annual decline of 2% (Cadenas-Sánchez, Artero, Concha, Leyton, & Cain, 2015). Modern fitness programs, especially exercise programs with loads on equipment and props such as medicine balls and developmental gymnastics programs, have positive effects on school children's health and motor abilities that are necessary for performing a large number of daily activities (Smith et al., 2014).

Although there are various safe and effective forms of equipment, medicine balls have become very popular in schools, gyms, fitness centers and sports training facilities (Faigenbaum & Mediate, 2008). The most important benefit of exercising with a medicine ball is that it affects the whole body instead of its individual segments. In addition, a medicine ball provides a unique type and number of exercises with unlimited intensity that can be used. Faigenbaum & Mediate (2006) have also shown that training with a medicine ball can be an effective method of improving the motor abilities of school-age children during PE classes.

Exercising with equipment and on the floor, as a type of developmental gymnastics, is very rich in a variety of movements and positions. The richness of movement and position during training on apparatus and floor enables the trainee to create a high level of motor knowledge. This knowledge, along with good physical condition and health enables a person to have a better quality of life. In addition, a high level of motor knowledge is a very good basis for engaging in any sport (Madić & Popović, 2012).

Recent studies show that medicine ball training has benefits for physical fitness (Trajković, Madić, Andrašić, Milanović, & Radanović, 2017; Boyaci & Afyon, 2017), self-perceived and actual motor competence (Duncan, Jones, O'Brien, Barnett, & Eyre, 2018), working memory (Jansen, Scheer, & Zayed, 2019), as well as acute cardio metabolic responses (Faigenbaum et al., 2018) in children. Contrary to the abovementioned studies, one study showed non-significant improvements in 1RM chest press strength as compared to the control group (Faigenbaum et al., 2007). With that being said, more school-based interventions concerning medicine ball training are needed. Moreover, some studies also showed that developmental gymnastics causes positive effects on the development of motor abilities in primary school children in relation to the current regular PE curriculum (Aleksic, Mekic, & Tosic, 2011; Paunović, 2017).

Since there are no studies that directly compared the abovementioned types of strength programs, the aim of this study was to compare the effects of medicine ball training, developmental gymnastics, and regular physical education programs on motor abilities in primary school children.

METHOD

Sample of participants

The sample for this research was taken from the population of 7th grade children of the primary school "Pale" from Pale, aged 12 years ±6 months. A total of 60 participants (30 boys and 30 girls) were randomly divided into 3 groups: the first experimental group (E1) (n = 20), second experimental group (E2) (n = 20), and the control group (K) (n = 20). All participants were completely healthy on the days of testing and were not exempt from physical education classes. In addition, they all had the consent of their parents. For the final data processing, only those participants were included who participated in both the initial and final measurements. The basic descriptive data are presented in Table 1.

Table 1 Descriptive characteristics of the participants

Variable	E1	E2	K
Body height	165.4 ± 6.1	161.1 ± 4.1	160.9 ± 5.9
Body mass	54.7 ± 5.5	52.2 ± 5.1	52.8 ± 7.3
BMI	19.9 ± 1.5	20.1 ± 1.5	20.3 ± 2.2

BMI – body mass index

Procedure

Measurement of motor abilities was performed immediately before the beginning of the experimental treatment, and after 12 weeks. All measurements were conducted on the sports fields of the primary school "Pale" from Pale. The participants came in groups of 10 to 20 and during the measurement they were trained in using sports equipment for physical education classes.

All measurements were performed with the same measuring instruments. Also, the same measurement techniques were applied at the initial and final measurements. The measurement was performed by assistants at the Faculty of Physical Education and Sports. To avoid a daily impact on performance, all tests were performed at the same time of day, according to standardized protocols and in accordance with the recommendations of the equipment manufacturers and equipment used. The sample of measuring instruments consisted of: the squat jump, long jump, bent-arm hang, sit-ups, push-ups, sprint 30m, T-test, handgrip, overhead medicine ball throw forwards (MBT1), overhead medicine ball throw backwards (MBT2), and medicine ball supine overhead throw (MBT3).

Description of Motor Abilities Assessment

The squat jump

The participant stands in the position of legs bent at the knees at an angle of 90°, feet hip-width apart, arms to the sides. From the initial position, the participant jumps as much as possible and lands on the ground with both feet at the same time. The parameter of explosive power of the legs, which was obtained with the help of the Optojump device, and which was statistically processed, is: jump height (in cm) (Harman, Rosenstein, Frykman, & Rosenstain, 1990).

The long jump

The participant is in a shoulder-width apart position, face facing the expert, fingertips placed just behind the line. With a strong swing of the arms and a takeoff forward, the maximum long jump is performed. From the initial position, the respondent jumps as much as possible, and the better result from two attempts is graded, and expressed in centimeters (Erkmen, Taşkin, Sanioğlu, Kaplan, & Baştürk, 2010).

The bent-arm hang

The participant tries to endure as much as possible with arms outstretched hanging from a bar. The time spent by the participant hanging with arms bent is measured, and the result is entered in seconds (Sudarov & Fratrić, 2010).

Push-ups

The participant occupies a plank position, straight legs and feet slightly apart. The participant pushes against the floor until the arms are straight at the elbows, the legs, and back are extended. The back should be kept in a straight line from head to toes throughout the body. The participant then lowers the body using the arms until they are bent at an angle of 90 degrees and the upper arms are parallel to the ground. This movement is repeated as many times as possible (Castro-Piñero et al., 2009).

Sit-ups

The participant lies on his back, knees bent, arms bent and fingers crossed at the nape of the neck. He then lifts his torso until his chest reaches his knees and his assistant holds his feet firmly. The number of correct runs in 60 seconds is entered (Castro-Piñero et al., 2009).

Sprint 30m

The participant starts from a high start at the moment when he estimates that he is ready and sprints over the entire 30m course. The time from start to finish is measured. The time is read in a 1/100s by an electronic timekeeping system with photocells (MICROGATE) set at 30m (Sudarov & Fratrić, 2010).

The T-test

Three cones are placed in the same plane at a distance of 4.57 meters. The starting line is perpendicular to the middle cone and 9.14 meters away. The task is to cross the path between the four bases (A, B, C and D) placed in the shape of the letter T in the shortest possible time. The participant at the start has both feet behind the starting line. From the start line, the participant runs towards the middle cone (B) and touches it with his right hand, then moves sideways to the left cone (C) which he touches with his left hand. He then moves sideways to the right cone (D) which he touches with his right hand and then returns laterally to the middle cone (B) which he touches with his left hand and finally returns inwards to the starting line (A). Timing begins and ends at base A. When moving sideways, he does not cross his legs. The test is performed three times (with a sufficient break between repetitions), one of which is a trial attempt and then run two more times, taking into account the better result for statistical processing (Sudarov & Fratrić, 2010).

Handgrip

The participant is in a smaller stride position, the hand with which he performs the grip is bent at the elbow at an angle of 90 °. The participant squeezes the dynamometer as hard as possible at the examiner's signal, and the task is completed after the examiner reads the result. The result is the value read on the dynamometer scale. The task is performed 2 times (Sudarov & Fratrić, 2010).

Overhead medicine ball throw forwards (MBT1)

The test is performed indoors or outdoors on an area with minimum dimensions of 25x10 m. A line is drawn in the middle of one end of the shorter part of the spatial rectangle, which is also the initial line for measuring the throw. The participant is in a parallel, slightly outstretched position in front, facing in the direction of the throw. With the technique used to throw in football, he throws out the medicine ball in order to achieve the best possible result. The participant is allowed to cross the line after the throw. The evaluation is performed in all units of length by marking the place of landing of the medicine ball, and measuring the distance from the starting line to that place. Three attempts are recorded, and the best of all is entered (Sudarov & Fratrić, 2010).

Overhead medicine ball throw backwards (MBT2)

To perform this test, a sports hall or an outdoor space with minimum dimensions of 25x10 m is required. In the middle of the shorter part of the space, a line is drawn behind which the participant stands and from which the ejection is measured. The participant is in a stride stance position behind the line marked on the test area by facing the opposite direction of the medicine ball throw. He holds the medicine ball with his hand on one side at knee height. From that position, he makes a strong swing backwards and over his head, after which he throws the medicine ball in the opposite direction. He is entitled to one trial and two attempts, between which he uses a 30-second break. Evaluation is done by recording the best of all attempts. The measurement is performed from the ejection line to the place where the medicine ball made contact with the surface (Sudarov & Fratrić, 2010).

Medicine ball supine overhead throw (MBT3)

The task is performed in a sports hall or outdoors. The mat is placed so that its narrower edge touches the narrower edge of the spatial rectangle. In the middle of the line where the sides of the spatial rectangle and the mat meet, a zero point and a medicine ball are placed. From this place, a straight line is drawn with chalk on which the measuring tape is placed. The participant is in a supine position with his hips wide, lying on a mat with legs slightly apart, facing the measuring tape. When throwing, he uses the technique of the throw in football, by holding the medicine ball and making a strong swing, after which he throws the ball as far as possible, without raising his head and torso. The participant performs this throwing procedure four times. The distance from the zero point to the place where the medicine ball fell is measured, and the best of four throwing results is entered (Sudarov & Fratrić, 2010).

Experimental procedure

This research is a pre-post treatment (12 weeks), realized on the sports fields of the elementary school "Pale" from Pale (East Sarajevo).

Experimental group (E1) had three classes a week in which two regular physical education classes were conducted according to the curriculum for primary education and upbringing prescribed by the Ministry of Education and Culture of the Republic of Srpska "Official Gazette of the Republic of Srpska - No. 74" (2014) and one class of additional physical activity where the exercise with the medicine ball was described in detail in Table 1. Each class consisted of a four-part structure, a warm-up period with medicine ball games (5 minutes), a preparatory part where shaping exercises and exercises for raising the level of motor abilities were performed (10 minutes), a the main part of the class (25 minutes) where exercise with medicine balls was realized, Table 1, And the cool down period of lowering intensity and stretching (5 minutes).

Experimental group (E2) had two classes a week conducted according to the curriculum for primary education and upbringing prescribed by the Ministry of Education and Culture of the Republic of Srpska "Official Gazette of the Republic of Srpska - No. 74" (2014) and one class of additional physical activity where the developmental gymnastics program was realized. Each class consisted of a four-part structure, a warm-up period (5 minutes), a preparatory part where shaping exercises and exercises for raising the level of motor abilities were performed (10 minutes), the main part of the class (25 minutes) where developmental gymnastics compositions were processed: floor exercises, vault, pommel horse, still rings, uneven bars, horizontal bar, balance beam, and a cool down period of lowering intensity and stretching (5 minutes). After the experimental program, the final measurement of the control and experimental groups was performed.

The control group (K) had two regular PE classes per week (gymnastics and explosive strength exercise were not included) according to the curriculum for primary education.

Table 2 Exercise program plan with a medicine ball

Exercise plan 1-3 weeks		
Name of exercise	Series number	Number of repetitions
Throwing a medicine ball over your head	3	10
Jumps with a medicine ball	3	12
Throwing a medicine ball with a turn *	3	10
Adding medicine ball from the chest	3	10
Lateral jumps over the medicine ball	3	20
Throwing the medicine ball backwards by rotation *	3	10
Exercise plan 4-6 weeks		
Lateral addition of breast medicine ball *	3	12
Burpee with a medicine ball	3	12
Diagonal throwing of the medicine ball back *	3	8
Throwing the medicine ball upwards from a squat	3	10
Diagonal throw of the medicine ball from the floor *	3	10
Star jumps	3	15
Exercise plan 7-9 weeks		
Push-ups through medicine ball	3	18
Squat jumps with a medicine ball throw	4	8
Diagonal throw of the medicine ball from the floor *	3	8
Depth jumps	3	8
Throwing a medicine ball over your head with a step	4	10
Throwing a medicine ball through your legs	3	10
Exercise plan 10-12 weeks		
Squat jumps with a medicine ball throw	4	8
Push-ups through medicine ball	4	14
A combination of chest jumps and deep jumps	4	8
Throwing the medicine ball backwards with a jump	4	8
Lateral jumps over the medicine ball	4	12
Throwing a medicine ball out of a squat	4	8

Exercises marked with an asterisk (*) are done on both sides (left and right hand)

Statistical analysis

The normality of the distribution was determined by the Kolmogorov-Smirnov test. To determine the significance of differences between the control and experimental groups in the initial testing, a univariate analysis of variance (ANOVA) was used. An analysis of covariance (ANCOVA) was used to evaluate intervention effects. Additionally, Cohen's d effect sizes (ES) were also calculated to determine the magnitude of the group differences in motor abilities. The significance level was set at $p<0.05$. The data obtained by the previously described procedure were processed in the statistical package SPSS 20. (Statictical Package for Social Science, v20.0, SPSS Inc., Chicago, IL, USA).

RESULTS

The results of the Kolmogorov-Smirnov test are below the limit value of max.d = 0.231, for a sample of 20 participants at the level of statistical significance (p>0.20) (Facchinetti, 2009), and thus confirm the normality of the distribution of the results in all variables.

Table 3 Differences between groups in motor abilities - ANCOVA

Variables	Initial E1	Final E1	ES	Initial E2	Finl E2	ES	Initial K	Final K	ES	p
Squat jump	22.1± 6.0	24.3± 6.0	0.4	20.1± 4.6	21.6± 4.4	0.3	20.6± 5.7	20.7± 5.7	0.0	0.09
Long jump	169.4±28.5	175.6±26.1	0.2	156.8±19.1	161.7±17.9	0.2	158.8±27.0	161.0±26.3	0.1	0.08
Bent-arm hang	36.7±16.5	42.7±16.5*	0.4	31.8±11.5	37.0±11.4	0.4	30.5±12.0	31.7±12.2	0.2	**0.01***
Sit-ups	21.7± 4.8	26.0± 5.2	0.8	21.7± 4.4	26.1± 4.9	0.9	21.2± 3.4	21.9±3.5†	0.2	**0.01***
Push-ups	14.3±10.0	18.8±10.4	0.4	14.0± 9.8	17.3±10.2	0.3	11.7± 7.5	12.0±7.6†	0.1	**0.01***
Sprint 30m	5.9± 0.5	5.8± 0.5	0.2	5.8± 0.3	5.7± 0.3	0.3	5.9± .5	5.9± 0.5	0.1	0.45
T-test	15.7± 1.8	14.6± 1.7	0.6	15.6± 1.3	14.4± 1.2	0.9	15.8± 1.7	15.7±1.6†	0.1	**0.01***
Handgrip	20.3± 4.0	22.7± 3.9	0.6	19.5± 4.4	21.5± 4.1	0.4	20.1± 3.1	20.4± 3.0	0.1	**0.02***
MBT1	6.4± 0.7	6.9±0.7*	0.7	6.3± 0.6	6.4± 0.6	0.1	6.2± 0.5	6.2± 0.5	0.1	**0.01***
MBT2	6.0± 0.6	6.5±0.6*	0.8	5.8± 0.5	5.9± 0.5	0.2	5.8± 0.4	5.8± 0.4	0.1	**0.01***
MBT3	4.6± 0.2	5.1±0.3*	1.9	4.5± 0.2	4.6± 0.2	0.5	4.5± 0.2	4.6± 0.2	0.5	**0.01***

*- E1 significantly different from E2 and K**;** † - K significantly different from E1 and E2; ES – effect size

The results of the ANOVA showed that there were no statistically significant differences between groups at the initial measurement (p>0.05). The ANCOVA showed that there were statistically significant differences in the effects of the intervention program between the groups for the bent – arm hang (p=0.01), sit ups (p=0.01), push – ups (p=0.01), T-test (p=0.01), handgrip (p=0.02), MBT1 (p=0.01), MBT2 (p=0.01), and MBT3 (p=0.01). The Post Hoc analysis showed that the E1 group had better results for the bent – arm hang, MBT1, MBT2, MBT3 compared to the E2 and K group. Moreover, the E1 and E2 groups had statistically better results compared to the K group in variables: sit ups, push ups, T-test and handgrip strength. Furthermore, higher effect size was found in E1 (from 0.2 to 1.96), compared to E2 (from 0.33 to 0.96) and the K group (from 0.04 to 0.20).

DISCUSSION

The main goal of this study was to determine and to compare the effects of different exercise programs (exercise program with a medicine ball and a developmental gymnastics program), which was applied as additional physical activity for 12 weeks, on primary school children's motor abilities. The primary findings of this research are that the experimental treatments have brought greater improvement in motor abilities than traditional PE classes. These results show that certain exercise programs with medicine ball and the program of developmental gymnastics, as an entire part of the process of teaching PE, can be considered very useful for improving the motor abilities of primary school children. Several studies involving this population noticed improvements in some motor abilities parameters (Trajković, Madić, Sporiš, Aleksic-Velkovic, & Zivcic-Markovic, 2016; Paunović, 2017; Trajkovic, Madic, Andrasic, Milanovic, & Radanovic, 2017; Durmo et al., 2020; Pržulj et al., 2020). According to Falk & Tenebaum (1996), primary school children can increase strength by up to 50% during the first 8 weeks of exercise. The results from this research can be compared with these results because exercise with medicine ball and developmental gymnastics proved to be very good for the development of motor abilities of primary school children.

An emerging body of evidence increasingly supports the need for school-age youth to improve their strength and enhance their motor abilities performance (Artero et al., 2014; Hardy et al., 2012; Ortega et al., 2012). As part of comprehensive school physical activity guidelines, the inclusion of these activities demonstrates the importance of this type of intervention for all youth (SHAPE, 2014). Furthermore, the difference between children with higher and lower motor abilities competence seem to remain stable over time (Fransen et al., 2014). Given that physical activity declines rapidly after puberty (Whitt-Glover et al., 2009), the mentioned program specifically targets exercise deficits in school-age children, so children should begin with activities early in life before they become resistant to targeted interventions (Faigenbaum et al., 2015).

Compared to the initial results, there was a significant improvement ($p < 0.05$) in all tests of motor abilities. Faigenbaum & Mediate (2006) stated that exercising with a medicine ball can be a very effective method for improving motor abilities of school children during physical education classes. Related studies (Trajković et al., 2017; Pržulj et al., 2020) involving the same population lasting 12 weeks showed an improvement in motor abilities, so increases observed in this study were consistent with the expected results.

Trajković et al. (2016) have found improvement in motor abilities of school children who were included in the gymnastics program. The authors found improvements in all tests ($p < 0.05$), except in the 4x10m test. The results from our study show that there was a significant improvement in the bent-arm hang, sit-ups, push-ups, t-test and handgrip tests in both experimental groups compared to the control group. However, the group that practiced with a medicine ball achieved significantly better results in the throwing tests of the medicine ball compared to the developmental gymnastics program and control group ($p = 0.001$).

Faigenbaum et al. (2018) had a similar structure of the medicine ball training protocol, which was mixed, because different abilities or combinations could be characterized as moderate to vigorous (Hollis et al., 2016), depending on the needs, goals and the abilities of the participants. This adds variety to the program and reflects how children may actually perform these abilities at school.

The Faigenbaum et al. (2007) study is very similar to ours, since they also had an additional training program. Although both studies included motor abilities, our medicine ball exercises were likely incorporated into the developmental gymnastics program, same as their resistance training was likely incorporated with their plyometric training. With that being said, the results are in accordance with findings of Vossen et al. (2000) who noted that the addition of upper body training may increase the ability to improve whole body performance and motor abilities.

A new finding from this research is that the introduction of exercise with a medicine ball, or developmental gymnastics at least once a week results in better physical fitness results than is usually achieved with standard physical education classes for children. Since all three groups participated in the same traditional physical education classes at school, such differences in motor abilities are probably due to specific training adjustments that resulted from medicine ball exercises, as well as developmental gymnastics programs.

CONCLUSION

The results of this research indicate that exercise with a medicine ball and a developmental gymnastics program can result in significant improvements in selected components of children's motor abilities, and are an effective method for promoting physical activity in school children and youth in general. Exercising with a medicine ball resulted in significantly greater improvements in motor abilities than the program of developmental gymnastics, as well as traditional physical education classes. Future studies should focus on including such programs in PE classes and potential differences in exercise intensity, as well as the long-term effects of childhood exercise with a medicine ball and developmental gymnastics on physical activity habits and health-related conditions.

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EFEKTI RAZLIČITIH PROGRAMA VEŽBANJA NA MOTORIČKE SPOSOBNOSTI UČENIKA

Cilj ovog istraživanja bio je da se utvrdi i uporedi uticaj različitih programa vežbanja na motoričke sposobnosti djece osnovnoškolskog uzrasta. Ukupno 60 (30 dečaka i 30 devojčica) dece osnovnovno školskog uzrasta, uzrasta 12 godina ± 6 meseci je dobrovoljno učestvovalo u ovoj studiji. Motoričke sposobnosti su procenjivane sledećim varijablama: skok iz čučnja, skok udalj, izdržaj u zgibu, podizanje trupa, sklekovi, sprint 30m, T-test, stisak šakom i testovi bacanja medicinke. Sve grupe su imale redovnu nastavu fizičkog vaspitanja dva puta nedeljno i po jedan čas sekcije, a eksperimentalne grupe su imale vežbe sa medicinkom (E1) i program razvojne gimnastike (E2) tokom 12 nedelja na času sekcije. ANCOVA je pokazala statistički značajne razlike između grupa ($p<0.05$) u većini testova motoričkih sposobnosti u korist obe eksperimentalne grupe, sa nešto boljim rezultatima u korist E1 grupe u odnosu na E2. Rezultati ovog istraživanja pokazuju da vežbanje sa medicinkama i razvojna gimnastika mogu dovesti do značajnog poboljšanja motoričkih sposobnosti kod dece osnovnoškolskog uzrasta.

Ključne riječi: *vežbanje, fizička aktivnost, medicinka, razvojna gimnastika*