

THE EFFECT OF EXTRACURRICULAR PHYSICAL ACTIVITY ON BONE PROPERTIES, MUSCLE STRENGTH, AND MOTOR COORDINATION IN YOUNG CHILDREN

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ABSTRACT

The purpose of this study was to examine the effect of extracurricular physical activity (EPA) on bone properties, muscle strength, and motor coordination. Participants were 114 boys and 108 girls, aged 7-8 years, who were divided into several physical activity (PA) clusters based on activity type. Bone speed of sound (BS) was measured in the radius and tibia using a qualitative ultrasound method. Muscle strength (MS) was tested in the upper extremities through a static pull-up test (SPUT) and a modified pull-up test (MPUT), and in the lower extremities through a standing long-jump test (SLJT) and a vertical jump test (VJT). Motor coordination (MC) was evaluated using the Kiphard-Schilling body coordination test (KTK). The results of this study revealed no significant differences in the BS measurements between the PA clusters or between the genders. Boys playing ball games or tennis maintained higher MS values than non-participants and the martial arts cluster. Girls in the gymnastics group scored higher in both upper and lower extremity strength than non-participant girls and girls participating in the other activities. No differences in MC were found between the PA clusters in boys, but girl gymnasts performed better on some of the MC tests than girls who played ball games and dancers. The results of this study indicate that the effect of EPA is associated with muscle strength and motor coordination. More data on children's activities during after-school hours are required to substantiate these findings.

Keywords: Vertical jump, standing long jump, modified pull-up, static pull-up.

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1. INTRODUCTION

Extracurricular physical activity (EPA) performed after formal school hours comprises various sports and physical activities (PAs) performed in educational contexts. EPA aims to advance children's motor skills and physical health. Boys and girls typically engage in different physical activities, and thus work separately.

EPA was found to (a) decrease the amount of time children spend in sedentary activities, such as sitting at home watching TV or playing video games (Sirard, Peiffer, Dowda, & Pate, 2008); (b) increase the amount of time children spend in PA (Ara, Vicente-Rodriguez, Perez-Gomez, Jimenez-Ramirez, Serrano-Sanchez, Dorado, & Calbet, 2006); (c) contribute to children's health status by decreasing the risk for obesity (Wolch, Jerrett, Reynolds, McConnell, Chang, Dahmann,, & Berhane, 2011); and (d) increase fitness components such as endurance, speed, strength, and motor coordination (Curtner-Smith, Sofo, Chouinard, & Wallace, 2007; Zahner, Muehlbauer, Schmid, Meyer, Puder, & Kriemler, 2009). The current study examines three health components that develop at a young age and are assumed to be affected by EPA: bone properties measured by speed of sound (BS), muscle strength (MS), and motor coordination (MC).

Bone properties relate to the quantity, quality, and mineral density of bone mass. It increases with age up until the mid-twenties (Karlsson, Nordqvist, & Karlsson, 2008), and protects against osteoporosis at later stages in life (Gunter, Almstedt, & Janz, 2012). Bone-loading exercises performed during the growth stage of life develop BS (Karlsson *et al.*, 2008), particularly at a young age (Baptista, Fragoso, Branco, de Matos, & Sardinha, 2011). Moreover, specific exercise strengthen the bones and muscles they are aimed at (Nasri, Zrour, Rebai, Najjar, Neffeti, Bergaoui, .., & Tabka, 2013). Most of the forces acting on the skeleton during PA are those delivered through skeletal muscle contractions, or are gravitational forces delivered by impact with the ground (Kohrt, Barry, & Schwartz, 2009).

Various sports activities have been found to affect Bone properties in children; for example, combat sports (Nasri *et al.*, 2013). Girls practicing gymnastics, where loading of body weight on the upper body muscles is eminent, were found to develop substantial upper bone strength (Tournis, Michopoulou, Fatouros, Paspatis, Michalopoulou, Raptou, .., Zouvelou, 2010), while girls dancing ballet, thereby loading weight on the lower body, developed greater strength in their lower body bones (Matthews, Bennell, McKay, Khan, Baxter-Jones, Mirwald, & Wark, 2006). Similar results were reported in boys: amateur football players maintained a significant advantage in lower body bone

measurements, while tennis players maintained a significant advantage in upper body bone measurements (Sanchis-Moysi, Dorado, Olmedillas, Serrano-Sanchez, & Calbet, 2010). MS is defined as the ability of the muscle to exert force during an activity (United States Department of Health & Human Services, 1996). Strong muscles are considered to be the foundation of the ability to perform motor skills, to improve other components of physical fitness such as endurance, and to foster good posture. MS is essential for injury prevention and for children's future participation in sporting activities (DiStefano, Padua, Blackburn, Garrett, Guskiewicz, & Marshall, 2010).

Several studies revealed a positive relationship between MS and extensive participation in sports activities high level gymnasts girls significantly strengthened their upper body muscles (Burt, Naughton, Greene, & Ducher, 2011), and boys who maintained an amateur handball training regimen strengthened their limbs more than boys who participated in a general physical education program (Oxyzoglou, Kanioglou, Rizos, Mavridis, & Kabitsis, 2007).

MC is the degree to which various parts of the body are synchronized to perform one task aimed at attaining the most efficient movement outcomes (Karabourniotis, Evaggelinou, Tzetzis, & Kourtessis, 2002). Sufficient coordination enables movement to be executed with greater efficiency, and thus new motor skills can be learned. Lack of coordination, on the other hand, results in activity avoidance and sedentary behavior (Wrotniak, Epstein, Dorn, Jones, & Kondilis, 2006).

At a young age, motor coordination becomes increasingly more efficient as a function of growth and practice. The more a child practices a variety of goal-oriented physical movements, accompanied by constructive and meaningful feedback and over a relatively long period of time, the greater the improvement in coordination (Lubans, Morgan, Cliff, Barnett, & Okely, 2010; Morgan, Barnett, Cliff, Okely, Scott, Cohen, & Lubans, 2013; Todorov & Jordan, 2002; Vandorpe, Vandendriessche, Vaeyens, Pion, Lefevre, Philippaerts, & Lenoir, 2012). Research on the effects of EPA on coordination in young children is scant, due to the extensive variety in exercise and sporting activities (Fransen, Pion, Vandendriessche, Vandorpe, Vaeyens, Lenoir, & Philippaerts, 2012) and the relatively long period of time required to improve coordination (Erceg, Zagorac, & Katić, 2008).

Notably, most of the research on the effects of PA on health components has dealt with children from the fourth grade and up. The aim of this study was to examine the effect of EPA on BS, MS, and MC in younger children; specifically, second and third graders, who are at the initial stages of development and in a transition between learning fundamental movement skills and working on specific sport-related motor skills.

2. METHODS AND MATERIALS

2.1 Participants

A G-Power analysis (Faul, Erdfelder, Lang, & Buchner, 2007) for MANOVA with four simultaneous dependent variables and a small effect size $f^2(v) = 0.05$, $\alpha = 0.05$, and power $(1 - \beta) = 0.85$, resulted in a sample size of $N = 136$, with a critical $F = 1.78$. The current study sample comprised second- and third-grade students from two schools in which the children are mostly from middle-class families. The parents were asked to sign a consent form for their children to take part in the study; 75% of the parents complied with the request. The participants were 114 boys (ranging in age from 6 years and 11 months to 9 years, $M_{age} = 7.60$, $SD = 0.58$) and 108 girls (ranging in age from 6 years and 11 months to 9 years, $M_{age} = 7.50$, $SD = 0.60$). The children took part in mandatory physical education classes twice a week throughout the entire school year. Examination of these students' EPAs indicated that girls and boys engaged in different PAs, and so in our analysis EPAs were rated differently for girls and for boys. Specifically, boys' activities included ball games ($n = 53$), martial arts ($n = 17$), and tennis ($n = 13$); 31 boys did not participate in any kind of organized EPA. Girls, on the other hand engaged in ball games ($n = 14$), dance ($n = 35$), and gymnastics ($n = 20$); 39 girls did not participate in any kind of organized EPA.

A one-way analysis of variance (one-way ANOVA) revealed no difference between the non-participants and the three types of sport participant groups in the students' demographic variables, for both boys and girls, as follows: Boys: age $F(3,110) = 1.85$; weight $F(3,110) = 0.80$; height $F(3,110) = 0.35$; BMI $F(3,110) = 1.05$; BMI%, $F(3,110) = 1.18$; Girls: age, $F(3,104) = 0.96$; weight $F(3,104) = 0.62$; height $F(3,104) = 0.64$; BMI $F(3,104) = 0.69$; BMI% $F(3,104) = 0.62$; all p values for both genders were non-significant. Table 1 presents the children's demographic and anthropometric data.

Table 1: Mean values and SDs for the sample demographic variables by gender and physical activity

Boys	Non-participant (n=31)		Ball Games (n=53)		Martial Arts (n=17)		Tennis (n=13)		Total (N=114)	
	M	SD	M	SD	M	SD	M	SD	M	SD
Age (yrs)	7.62	0.62	7.70	0.55	7.36	0.68	7.82	0.59	7.64	0.60
Weight (kg)	29.95	8.08	28.55	5.55	27.94	4.38	30.65	5.60	29.08	6.19

Height (cm)	128.71	7.37	128.68	5.82	127.00	6.27	128.77	5.99	128.45	6.30
BMI	17.85	3.44	17.12	2.38	17.29	2.13	18.41	2.61	17.49	2.70
BMI, %	66.00	30.60	61.87	27.59	67.78	23.99	77.27	17.59	65.63	27.13

Girls	Non-participant (n=39)		Ball Games (n=14)		Dance (n=35)		Gymnastics (n=20)		Total (N=108)	
	M	SD	M	SD	M	SD	M	SD	M	SD
Age (yrs)	7.62	0.63	7.41	0.63	7.45	0.55	7.66	0.68	7.55	0.61
Weight (kg)	28.31	8.38	28.46	7.06	26.89	6.61	26.05	4.36	27.43	6.98
Height (cm)	126.08	6.47	127.79	6.72	125.71	4.96	126.15	5.12	126.20	5.75
BMI	17.55	3.80	17.20	2.91	16.87	3.17	16.32	2.14	17.05	3.21
BMI, %	60.87	31.53	61.69	32.67	55.54	32.43	50.07	31.12	57.18	31.73

2.2 Measurements

2.2.1 Bone SOS (BS): Bone measurements were performed using a quantitative ultrasound method (QUS). The device, Sunlight Omnisense, is manufactured by Sunlight Medical Ltd. (Israel). and consists of a main unit and hand-held probes designed to measure BS at specific skeletal sites (Falk, Bronshtein, Zigel, Constantini, & Eliakim, 2003).

Bone properties was determined bilaterally (dominant and non-dominant sides) at the distal one-third of the radius and at the mid-shaft of the tibia. The dominant limb was determined by asking participants which hand they used for writing and which leg they preferred for kicking. All measurements were performed by the same technician after a daily calibration, according to specific methods, as follows:

2.2.1.1 The Radial Bone SOS Test (RBST): A line is drawn midway between the olecranon process of the elbow and the extended third phalanx. A probe is placed parallel to the radius on its medial surface, and a 140° scan is performed from side to side (70° to each side).

2.2.1.2 The Tibia Bone SOS Test (TBST): A line is drawn midway between the apex of the top of the knee and the plantar aspect of the foot, with the participant in a sitting position. A probe is placed parallel to the bone surface, 3 to 4cm medial to the tibial crest, and a scan is performed from that point to the crest.

The Sunlight Omnisense's ability to diagnose bone strength was tested and evaluated in in vivo studies (Barkmann, Kantorovich, Singal, Hans, Genant, Heller, & Glüer, 2000; Falk *et al.*, 2003; Falk, Bronshtein, Zigel, Constantini, & Eliakim, 2004). Intra-observer and inter-observer precision errors ranged from 0.2% to 0.3% and from 0.3% to 0.7%, respectively, for triplicate measurements with repositioning (Barkmann *et al.*, 2000).

2.2.2 Muscle Strength (MS): An extensive review of the muscle strength measurement methods available resulted in the selection of four commonly-used MS measurements. Though the selected measures are not ecologically valid (i.e., do not completely isolate variables such as body mass and motor coordination), they are known to be reliable and valid measures of MS (Milliken, Faigenbaum, Loud, & Westcott, 2008).

2.2.2.1 Standing Long-Jump Test (SLJT): Measures the strength of the lower extremities. The participant takes off on two legs, jumping as far as possible from a marked line on the floor onto a mat. The distance of the jump is then measured with a yardstick. The best of three attempts, performed one minute apart, is taken as the maximal measure (Castro-Piñero, Ortega, Artero, Girela-Rejón, Mora, Sjöström, & Ruiz, 2010). Test-retest reliability was reported to be 0.97 (Almuzaini & Fleck, 2008; Castro-Piñero *et al.* 2010).

2.2.2.2 Vertical Jump Test (VJT): Measures the vertical strength of the lower extremities. The participant stands in starting position, with side of body against the wall, both feet on the ground. One arm is extended against the wall, hand high above the head, holding a piece of chalk. A vertical blackboard affixed to the wall enables the participant to mark the height of the hand. The participant then jumps as high as possible, using the chalk to mark the blackboard at the highest point reached. A measuring tape is affixed vertically to the wall to accurately measure the jump's height. The VJT is performed three times, at one minute intervals, and the best of the three attempts is recorded (Castro-Piñero *et al.*, 2010; DiStefano *et al.*, 2010). The temporal stability of the VJT was reported to be very high ($r = 0.93$) (Almuzaini & Fleck, 2008).

2.2.2.3 Static Pull-Up Test (SPUT): Measures the strength and endurance of the upper extremities. The participant hangs by his or her hands from a horizontal bar, feet off the ground, elbows bent, and chin above the bar, until involuntary exhaustion (e.g., the inability to maintain the position any longer). A stopwatch is used to measure the time the participant remains in this position. Temporal stability of the test was reported to be 0.85 (Pate, Burgess, Woods, Ross, & Baumgartner, 1993).

2.2.2.4 Modified Pull-up Test (MPUT): Similar to the SPUT, the MPUT is used to measure the strength of the upper extremities. The measurement is executed as

the participant assumes a supine position on a mat beneath a horizontal bar. Before the measurement is taken, the participant extends his or her arms straight upwards in order to adjust to the height of the bar. The participant then grabs the bar and pulls him- or herself up, heels on the floor, elbows bent, and chin above the bar. The participant then lowers him or herself back to a supine position on the mat, and then begins again. The pull-ups are performed as many times as possible without a rest, and the number of pull-ups is recorded. The test is over when the participant voluntarily stops or experiences pain or discomfort. Temporal stability of the MPUT was reported to be 0.99 (Saint-Romain & Mahar, 2001).

2.2.3 Motor Coordination (MC): MC was measured using three components of the Kiphard and Schilling (2007) body coordination test for children (KTK). This test is used extensively by field researchers despite the fact that the effect of muscle strength and body mass are not partialled out (Catenassi, Marques, Bastos, Basso, Ronque, & Gerage, 2007). The test was developed for German children, and was found to be reliable (temporal stability = 0.97) and valid for children 5-15 years old (Vandorpe, Vandendriessche, Lefèvre, Pion, Vaeyens, Matthys,, & Lenoir, 2011).

The three components of the test used are:

2.2.3.1 Jumping Sideways Over a Wooden Beam (JSWT): The participant performs consecutive jumps from side to side over a small beam (60cm long, 4cm wide, and 2cm high). The participant stands with both feet on one side of the beam, and at a designated signal begins jumping from one side to the other side for 15 seconds at maximum speed. The participant is instructed to keep his or her feet together. The number of correct jumps is recorded, and the final score is the sum of the number of jumps performed in two trials (Kiphard & Schilling, 2007; Vandorpe *et al.*, 2011).

2.2.3.2 Moving Sideways on Boxes (MSBT): The participant begins by standing with both feet on a platform (25cm x 25cm x 2cm) that is supported by four legs (3.7cm high), holding an identical platform in his or her hands. The participant is instructed to place the identical platform alongside the one he or she is standing on, and to step onto it. The first platform is then lifted and placed alongside the second and the participant steps onto it. This sequence is repeated for 20 seconds. Each successful transfer from one platform to the other is awarded two points (e.g., one for shifting the platform, the other for transferring the body). The number of points awarded during the 20s test is recorded. If the participant falls off a platform in the process, he or she gets back on the platform and continues the test. Each participant is given two 20s attempts, and the better of the two is taken as the test result (Vandorpe *et al.*, 2011).

2.2.3.3 High Jump on Right Foot and Left Foot (HJRT and HJLT): Hopping on one leg over an obstacle, which is a stack of foam squares, each square 60 cm wide; 20 cm deep; and 5 cm high. The participant is instructed to hop on one foot at a time. The height of the stack is increased by adding one square to the top of the stack each time. The participant performs three attempts at each height and on each foot. The height of the final successful jump is recorded (Vandorpe *et al.*, 2011).

2.2.4 Anthropometric Measurements – Body Mass Index (BMI): Children in light clothing, without shoes, were weighed twice to the nearest 0.1 kg on a portable medical electronic scale. Height was measured twice to the nearest 0.1 cm using a wall-mounted stadiometer, with the children standing straight against the wall without shoes, to align the spine with the stadiometer. The head was positioned with the chin parallel to the floor. The means of the two weight and height measurements were used to calculate BMI, defined as weight in kilograms divided by the square of the height in meters ($\text{kg} \cdot \text{m}^{-2}$).

2.2.5 Questionnaire on extracurricular physical activities: Items from the Physical Activity Questionnaire for Children (PAQ-C) (Almuzaini & Fleck, 2008; Crocker, Bailey, Faulkner, Kowalski, & McGrath, 1997; Janz, Lutuchy Wenthe, & Levy, 2008) were used to determine involvement in EPAs. Participants were asked to consider all of the different types of activities they are involved in, how many times a week they take part in them, when the activity began, and when it ended (i.e., its duration) the time it ended. Participation in EPAs was defined as performing PA at least twice a week, for 45 minutes each time, starting at least one year prior to the research, and continuing up until the end of the year, when data collection took place. The qualified examiners read the questionnaire questions to the children and wrote down their answers.

Since it usually is difficult to obtain accurate answers about participants' activities in the more distant past (Choi & Pak, 2005), we limited our questionnaire to cover the activities of the year preceding the research.

2.3 Procedures

The study was approved by the national education authorities and by the Ethics Committee of the Hillel Yaffe Medical Center, Israel. All children from the participating schools, and their parents, received information about the study through school meetings and written information. At least one parent of each child signed the informed consent forms.

Before the physical tests were administered, an examiner read to each child the questions from the questionnaire. The researchers had no control over the content of the PAs reported on, nor did they have any detailed knowledge about the intensity of the activities performed as part of the EPAs. The children answered the oral questions in the classroom with the assistance of the examiners, while the physical and motor coordination measurements were performed in the school gymnasium. The tests were performed at testing stations where four examinees and two examiners were present. Qualified examiners provided standardized instructions and demonstrations, according to the test's guidelines. The children were encouraged to perform to the best of their ability. At a pre-arranged signal, all children at all stations moved on to the next station. The measurements were taken and the oral questions were answered simultaneously, on consecutive days, starting in the morning and lasting throughout the school day. The tests were performed over a period of one week in each school.

2.4 Statistical Analyses

Analyses of the EPAs were performed separately for boys and girls, and pertained to three clusters: BS, MS, and MC. Within each of these clusters, each variable was examined for normality assumption via skewness ($SK < [2.0]$) and kurtosis ($K < 7.00$) procedures. When normality assumptions were violated, a log-linear transformation was applied and distribution assumptions were tested again. Multiple analysis of variance (MANOVA) was then performed on the variables within each cluster, using activity-type groups as a between-participant variable. This procedure was followed by an ANOVA. Tukey's post hoc multiple comparison tests were performed when the F -test was significant ($p < 0.05$). Significant differences are presented as Cohen's standardized values.

3. RESULTS

Results of the analyses pertaining to each cluster of measures are presented by EPA participation group for boys and girls separately.

3.1 Findings – Boys

3.1.1 Bone SOS: Two variables, radius bone SOS (RBST) and tibia bone SOS (TBST), were subjected to a MANOVA procedure using EPA participation as a 4-level BS factor (i.e., non-participant, ball games, martial arts, and tennis). The MANOVA revealed a non-significant effect of the EPA participation grouping, $Wilks' \lambda = .97$, $F(6, 200) = .58$, $p = .75$, $\eta^2 = .02$. Follow-up ANOVA performed

separately for RBST and TBST and the various EPAs revealed non-significant effects ($p < .78$ and $p < .84$, respectively), indicating equality in mean BS values of the non-participants and the three EPA participant groups. Table 2 presents these mean values and the associated SD coefficients.

Table 2: Mean values and SDs for boys' bone strength, muscle strength, and motor coordination by physical activity

Variable	Non-participant (n=31)		Ball Games (n=53)		Martial Arts (n=17)		Tennis (n=13)	
	M	SD	M	SD	M	SD	M	SD
<i>Bone Strength</i>								
RBST (<i>sos</i>)	3800.48	73.79	3787.36	121.10	3778.00	104.18	3833.15	77.80
TBST (<i>sos</i>)	3660.50	115.97	3677.19	123.92	3700.76	85.93	3687.00	146.06
<i>Muscle Strength</i>								
SPUT (<i>min</i>)	0.09	0.10	0.23	0.23	0.13	0.17	0.18	0.22
MPUT (<i>rep</i>)	2.33	2.26	3.74	3.15	2.29	2.14	3.23	2.92
SLJT (<i>cm</i>)	128.27	14.04	135.62	19.84	126.24	18.03	130.38	23.80
VJT (<i>cm</i>)	182.80	11.81	183.17	9.54	177.94	10.54	184.15	11.15
<i>Motor Coordination</i>								
HJLT (<i>rep</i>)	5.13	3.66	6.75	3.72	5.41	4.00	4.77	4.09
HJRT (<i>rep</i>)	5.77	3.87	7.40	3.69	4.71	3.58	5.54	4.29
JSWT (<i>rep</i>)	44.47	13.10	48.04	15.18	42.12	14.98	45.54	16.03
MSBT (<i>rep</i>)	23.37	6.99	24.79	9.95	23.06	8.69	27.85	12.79

RBST – Radial Bone Strength Test; **SOS** – Speed Of Sound; **TBST** – Tibia Bone Strength Test; **SPUT** – Static Pull-Up Test; **MPUT** – Modified Pull-up Test; **SLJT** – Standing Long-Jump Test; **VJT** – Vertical Jump Test; **HJLT** – High Jump on Left Foot; **HJRT** – High Jump on Right Foot; **JSWT** – Jumping Sideways Across a Wooden Slate; **MSBT** – Moving Sideways on Boxes.

3.1.2 Muscle strength: Four variables represented the muscle strength cluster: static pull-up (SPUT), modified pull-up (MPUT), standing long jump (SLJT), and vertical jump (VJT). The scores of the first two variables were log-linearly transformed to satisfy the normality assumption, but are presented in Table 2 as their original values. The MANOVA revealed a non-significant EPA participation grouping effect, *Wilks' λ* = .78. $F(12, 193) = 1.54$, $p = .12$, $\eta^2 = .08$. Despite this omnibus non-significant effect, the four groups differed significantly on SPUT, $F(3, 76) = 3.55$, $p < .02$, $\eta^2 = .12$, and MPUT, $F(3, 76) = 3.45$, $p < .02$, $\eta^2 = .12$, but not on SLJT and VJT ($p < .14$ and $p < .47$, respectively). Comparison of means using the Tukey's post hoc test revealed three significant ($p < .05$) effects: boys playing ball games exhibited higher means scores on SPUT and on MPUT than did non-participant boys ($d = 0.70$ and $d = 0.48$, respectively), and boys playing tennis had higher MPUT scores than did non-participant boys ($d = 0.36$). Table 2 presents mean values and SDs for the four muscle strength variables.

3.1.3 Motor coordination: Four variables defined the MC cluster: high jump on left foot (HJLT), high jump on right foot (HJRT), jumping sideways over a

wooden beam (JSWT), and moving sideways on boxes (MSBT). All four variables were normally distributed. The MANOVA revealed a non-significant grouping effect, *Wilks' λ* = .83. *F* (12, 217) = 1.27, *p* = .23, η^2 = .06. In addition, none of the four univariate BS effects was significant (*p* < .82, *p* < .11, *p* < .49, and *p* < .06, respectively), indicating no evidence of effect of participation on MC. Table 2 presents mean values and SDs for the MC variables.

3.2 Findings – Girls

3.2.1 Bone SOS: Bone SOS was measured in the radius bone (RBST) and tibia bone (TBST). The two variables were normally distributed within the designated values. The grouping variable of EPA participation contained the following independent clusters: non-participant, ball games, dance, and gymnastics. The MANOVA for the two strengths' dependent variables resulted in a non-significant effect of EPA participation grouping, *Wilks' λ* = .91. *F* (6, 1176) = 1.42, *p* = .21, η^2 = .05. The BS univariate F tests for each strength variable also yielded non-significant results (*p* < .37 and *p* < .21, respectively). The analysis revealed that at this age, there is no difference in the radius and tibia bone strength between girls who participate in EPAs and girls who do not. Table 3 present mean values and SDs for the two bone strength tests.

Table 3: Mean values and SDs for girls' bone strength, muscle strength, and motor coordination by physical activity

Variable	Non-participant (n=39)		Ball Games (n=14)		Dance (n=35)		Gymnastics (n=20)	
	M	SD	M	SD	M	SD	M	SD
<i>Bone Strength</i>								
RBST (<i>sos</i>)	3794.81	86.75	3734.79	118.48	3766.00	114.55	3760.16	104.36
TBST (<i>sos</i>)	3670.89	124.91	3688.14	135.98	3640.59	112.62	3631.32	88.34
<i>Muscle Strength</i>								
SPUT (<i>min</i>)	0.15	0.21	0.10	0.11	0.18	0.23	0.40	0.38
MPUT (<i>rep</i>)	2.27	2.26	0.86	1.29	2.09	1.65	4.80	3.25
SLJT (<i>cm</i>)	114.31	18.39	109.21	18.41	111.69	16.93	131.75	19.85
VJT (<i>cm</i>)	175.70	11.69	178.21	12.30	176.00	8.08	179.65	8.95
<i>Motor Coordination</i>								
HJLT (<i>rep</i>)	4.65	3.73	3.50	3.18	3.63	3.16	6.85	2.96
HJRT (<i>rep</i>)	5.32	3.57	3.86	3.51	4.80	3.23	7.45	2.67
JSWT (<i>rep</i>)	44.44	13.39	45.14	16.62	39.53	13.43	49.80	13.34
MSBT (<i>rep</i>)	24.95	9.50	22.93	6.93	24.14	7.41	25.60	8.88

RBST– Radial Bone Strength Test; **SOS** – Speed Of Sound; **TBST** – Tibia Bone Strength Test; **SPUT** – Static Pull-Up Test; **MPUT** – Modified Pull-up Test; **SLJT** – Standing Long-Jump Test; **VJT** – Vertical Jump Test; **HJLT** – High Jump on Left Foot; **HJRT** – High Jump on Right Foot; **JSWT** – Jumping Sideways Across a Wooden Slate; **MSBT** – Moving Sideways on Boxes.

3.2.2 Muscle strength: The girls' results on the static pull-up (SPUT), modified pull-up (MPUT), standing long jump (SLJT), and vertical jump (VJT) tests were subjected to MANOVA according to EPA participation groups after log-linearly transforming the first two variables to avoid violation of normality assumption. The MANOVA revealed a significant main effect of the participation grouping factor, *Wilks' λ* = .71. *F* (12, 153) = 1.80, *p* = .05, η^2 = .11.

Follow-up MS univariate *F* tests were performed for each of the MS variables, as well as a Tukey's multiple comparison test of means. The analysis revealed a significant participation grouping effect on SPUT (*F* (3, 61) = 3.42, *p* < .02, η^2 = .14): Girl gymnasts scored significantly higher on SPUT than did non-participant girls (*d* = 0.88), girls who play ball games (*d* = 0.95), and dancers (*d* = 0.75). The BS univariate *F* test for MPUT also revealed a significant participation grouping effect (*F* (3, 61) = 5.38, *p* < .002, η^2 = .21): Non-participants and gymnasts scored higher on MPUT than girls who play ball games (*d* = 0.69 and *d* = 1.49, respectively). The univariate *F* test applied to SLJT resulted in a significant participation effect as well (*F* (3, 61) = 2.76, *p* < .05, η^2 = .12): Gymnasts did significantly (*p* < .05) better on SLJT than dancers, ball players, and non-participant girls (*d* = 1.17, *d* = 1.11, and *d* = 1.06, respectively). Finally, the BS *F*-test for VJT failed to reveal any significant participation effect (*F* (3, 61) = 0.50, *p* < .68, η^2 = .02), which indicates that EPA-participant girls do not differ, at this age, from their non-participant counterparts in their VJT performance as they do in SLJT. Table 3 presents mean values and SDs of the MS variables for each of the participation clusters.

3.2.3 Motor coordination: A MANOVA was performed on the four variables comprising motor coordination: high jump on left foot (HJLT), high jump on right foot (HJRT), jumping sideways over a wooden beam (JSWT), and moving sideways on boxes (MSBT), and resulted in a non-significant participation effect, *Wilks' λ* = .81. *F* (12, 198) = 1.37, *p* = .18, η^2 = .07. The BS univariate *F* tests showed non-significant differences among the four groups of students, except with respect to HJRT (*p* < .34, *p* < .03, *p* < .19, and *p* < .85, respectively). Gymnasts scored higher on HJRT than did girls who played ball games (*d* = 1.18) and dancers (*d* = 0.87). Finally, non-participant girls scored higher than ball-game girls on the HJRT (*d* = 0.41). Table 3 presents mean values and SDs for the motor coordination variables according to the girls' participation groupings.

4. DISCUSSION

The present study examined the effects of EPAs on BS, MS, and MC components in young children. Boys and girls were considered separately, due to the fact that they participated in different EPAs in the study.

Two measurements represented bone SOS, namely RBST and TBST. Both revealed no significant effects of EPAs on bone strength for the four boy PA clusters (i.e., ball games, martial arts, tennis, and non-participants) and for the four girl PA clusters (i.e., ball games, dance, gymnastics, and non-participants). These findings contradict findings in other studies that revealed significant effects of PA on BS in children who participate in gymnastic activities (e.g., Courteix, Lespessailles, Peres, Obert, Germain, & Benhamou, 1998; Tournis *et al.*, 2010), martial arts (Nasri *et al.*, 2013), and football (Falk, Braid, Moore, Yao, Sullivan, & Klentrou, 2010; Sanchis-Moysi *et al.*, 2010). We attribute the current findings to the limited and insufficient physical impact of the specific EPAs noted in our study, as well as to their short duration (Kemper, Twisk, van Mechelen, Post, Roos, & Lips, 2000) - two components that were not experimentally controlled due to the nature of the study (i.e., a survey). We also note that the children in the current research were very young, and therefore were prevented from taking part in high-impact activities during their EPAs. Moreover, according to Gunter, Almstedt, and Janz, (2012), children should perform impact activities three times a week, for 10-20 minutes each practice session. In our study, most of the children exercised only twice a week; insufficient for impacting BS above its natural increase.

Four measurements represented MS in this study, namely SPUT, MPUT, SLJT, and VJT. The analyses revealed non-significant omnibus effects of PA on these physical components. Nevertheless, boys who played ball games showed a significant ($p<0.05$) advantage over non-participant boys and the other PA clusters in upper extremity measures - MPUT and SPUT, and boys who played tennis were significantly ($p<0.05$) better at MPUT than non-participant boys and boys in the martial arts cluster. The effects of playing ball and tennis on the MS of the upper extremities are important, since the upper extremities are generally weaker than the lower extremities, and are not given the same opportunities to strengthen (van Praagh & Doré, 2002). Girl gymnasts scored significantly ($p<0.05$) higher on SPUT and MPUT than non-participant girls and those who participated in ball games or dance. Moreover, the gymnasts were significantly ($p<0.05$) better on SLJT than dancers, ball players, and non-participant girls. The advantage of girl gymnasts over the other PA clusters in both the lower and upper extremities is similar to the findings reported in other studies (e.g., Burt *et al.*, 2011; Erlandson, Kontulainen, & Baxter-Jones, 2011).

A large body of research reveals a causal relationship between BS and MS in adults (e.g., Binkley, Berry, & Specker, 2008; Schoenau, Neu, Beck, Manz, & Rauch, 2002), but this was not verified in the present study. At a young age, muscles are not yet strong enough to affect BS (Kohrt *et al.*, 2009), and the EPAs

failed to offer sufficient number of opportunities for impact exercises to strengthen the body to a greater degree (Kemper *et al.*, 2000).

Four measurements were used to estimate MC, namely HJLT, HJRT, JSWT, and MSBT, none of which showed differences among the PA clusters in boys. In girls, no significant differences were revealed among the four EPA activity clusters except for HJRT. Gymnasts scored higher on HJRT than did girls in the ball-playing and dancing clusters. Our study revealed that girls who do gymnastics scored better on partial MC tests compared to all the other PA clusters. This effect seems obvious since more coordination practice is required in gymnastics than in the other activities (Vandorpe *et al.*, 2012).

In general, we found that EPAs do affect, to some degree, the physical health components we tested. The children in our research may have taken part in activities that focused primarily on muscle strength and not on the other components examined in the study. The main limitations of the research pertain to the small sample of children examined and the use of a limited number of health component tests, which prevented to examine a broader physical health contribution of EPAs.

A follow-up on the results of this study is required, and the notion that EPAs are an important component of school activities should be further tested. In addition, we recommend assessing the character and intensity of children's EPAs in non-organized activities, to examine their effect on the children's physical and mental health. To further study the benefits of exercise on muscle and bone health, experimental and controlled studies are recommended that engage more children in various PAs for longer periods of time.

5. CONCLUSIONS

Our research makes a contribution in two main areas. The first concerns the age of the research population, namely a young population of early elementary school age (7-8). There is currently a lack of research on this age range that links physical activities offered to children as part of their daily routine to health components in general, and to the health components we studied, in particular. Within these age cohort children develop muscle and bone strength, as well as starting to acquire physical activity habits. Our research constitutes a modest addition to the existing knowledge on this age cohort.

The second challenge involves the measurement of bone properties. The measurement technology commonly used in most research laboratories is dual X-ray energy absorptiometry (DXA). This method yields accurate information about bone mineral content (BMC), but is available only at medical and research facilities, in addition to being expensive. In our study we used the quantitative

ultrasound method (QUS), which examines bone properties and offers the advantage of not being biased about bone size and surrounding soft tissue in younger children. This method does not involve radiation, is portable, is inexpensive, and therefore it is appropriate for use with children in a school setting. Although failing to show a relationship between extracurricular activity and bone properties, our research can be considered as the first initiative for other studies to expand and explore these relations.

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