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Original research article

CORRELATIONS OF THE MUSCLE STRENGTH AND THE BONE DENSITY IN YOUNG ATHLETES AND NON-ATHLETES

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Abstract. *The aim of this study was to explore the nature of relationships between lower limb muscle strength and bone density parameters in a group of young athletes and non-athletes, aged 17-18. Athletes that were divided into three experimental groups (EG1, EG2, and EG3) underwent a nine-month long resistance training program of low, medium and high level of external loads, respectively. Non-athletes made up the control group (CS). We hypothesized that muscle strength would significantly correlate to bone mineral density (BMD), in a positive and an increasing way in EG1, EG2, and EG3 participants, respectively, and that these correlations will be greater in relation to correlations determined within the control group of non-athletes. Mean jump HEIGHT values, as one of the most significant indicators of explosive strength, as well as mean POWER, FORCE and VELOCITY values, decreased at the end of resistance program in EG1, EG2, and EG3 participants. On the other hand, mean HS1RM values increased at the end of resistance program in ES participants, as well as bone density parameters in all the participants. At the same time, mean POWER, FORCE and VELOCITY values, increased at the final assessment, while mean HS1RM value decreased in CS participants. No correlation between HEIGHT and HS1RM on the one hand, and bone density at the other was determined in the entire sample. Correlations occurred only in EG1 (60%1RM) and EG3 (85%1RM) participants, as positive and negative correlations, respectively, and they were more frequent at the initial assessment, i.e. most of them disappeared at the final assessment.*

Key words: *adolescents, resistance training program, muscle strength, BMD.*

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INTRODUCTION

Implementing strategies to enhance explosive strength in young athletes and non-athletes could be useful in preventing osteoporotic changes later in life. And although recent studies from the reason of increased risk for stress fractures challenge the traditional assumption that "more exercise is better" (Magness, Ambegaonkar, Jones, & Caswell, 2011), being not (or not enough) physically active is correlated with bone loss (Alexandre & Vico, 2015; Emaus, Wilsgaard, & Ahmed, 2014; Emaus, Wilsgaard, & Ahmed, 2014; Kemmler, Bebenek, von Stengel, & Bauer, 2015). Hence, from a training and exercise perspective, the correlation between muscle strength and bone mineral density (BMD) is fertile ground for further study, since it might provide us with arguments on how to exercise as youths (Ribom et al., 2004). The correlations between explosive strength and bone density are quite intriguing, and related to each other in both a positive and negative way. A positive relationship is reported in prepubescent soccer players (Vicente-Rodriguez et al., 2003), strength-trained women (Sööt, Jürimäe, Jürimäe, Gapeyeva, & Pääsuke, 2005), while a negative one is reported in untrained individuals, although as an early response of bone i.e., transient decrease in bone formation and resorption due to the negative effects of lactic acidosis on calcium and bone metabolism (Ashizawa et al., 1998). According to Hinton, Nigh, & Thyfault (2015), the increases in BMD observed following exercise interventions likely have clinical significance, as small increases in BMD result in much larger gains in bone strength. In a noteworthy 20-year follow-up study conducted by Barnekow-Bergkvist Hedberg Pettersson, & Lorentzon (2006), it was determined that the muscular fitness is the main physical fitness component in adolescence that correlates to adult bone mineral content. The prophylactic benefits of resistance training that provides muscular fitness appear to occur among others, by attenuating loss of muscle strength and improving or reducing loss of BMD (Ciolac, & Rodrigues-da-Silva, 2016). Although evidence suggests that high-load and high-rate of loading impact exercise (e.g. sprint running, jumping) provide greater bone density and explosive power (Gast et al., 2013) there seems to be a lack of controlled trials that examine the correlations between explosive strength and bone density in adolescent athletes and non-athletes.

The aim of this study was to explore the nature of the relationships between lower limb muscle strength and bone density parameters that occur under the influence of a nine-month long resistance training program in a group of young athletes aged 17-18. Athletes that were divided into three experimental groups (EG1, EG2, and EG3) underwent a resistance training program of low, medium and high levels of external loads, respectively, while their sedentary peers, non-athletes made up the control sub-sample (CS). We hypothesized that muscle strength would significantly correlate to BMD, in a positive and an increasing way in EG1, EG2, and EG3 participants, respectively, and that these correlations will be greater in relation to the correlations determined within the control group of non-athletes.

METHODS

Participants

Athletes and non-athletes (N=60), matched according to gender (male), age (17-18 years), body height, and body mass were divided into an experimental (ES, sprinters of the AC "Prijedor" from Prijedor and AC "Banja Luka" from Banja Luka, N=45) and control sub-sample (CS, non-athletes, N=15). The ES was further divided into three groups of 15 sprinters each: EG1 of body height 177,87±8,53 cm, body mass 65,20±11,04 kg and body mass index 20,00±2,88 (Mean±Std.Dev.); EG2 of body height 176,77±7,14 cm, body mass 67,97±8,56 kg and body mass index 21,20±1,86 (Mean±Std.Dev.); and EG3 of body height 175,53±4,67 cm, body mass 67,12±7,50 kg and body mass index 21,27±1,91 (Mean±Std.Dev.). The CS participants had an average body height of 170,87±24,51 cm, body mass 69,35±7,56 kg and body mass index 21,53±2,33 (Mean±Std.Dev.). Inclusion criteria for athletes included three years of sprint running before the start of the study, while absence of illness or used medication that could negatively influenced bone metabolism referred to all the participants.

Measurements

Muscle strength assessment. According to Hannman, Deere, Worral, Hartley &, Tobias (2016) muscle performance needs to be taken into account when assessing relationships between high-impact physical activity and the skeleton, as well as providing objective measurement of vertical impacts through measurement of vertical axis accelerations. Accelerometers attached to the center of mass can also be employed to evaluate various aspects of muscle performance, such as explosive and maximum muscle strength. In that sense, the "Myotest" accelerometer (Sion, Switzerland), was safely positioned: 1) to a participant by Velcro belt in order to determine explosive strength of hip extensors and flexors, knee extensors and flexors, and ankle extensors and flexors, by the means of Counter Movement Jump without the arm swing (CMJ); 2) or to a barbell in order to determine maximum muscle strength by the means of Half Squat in Smith machine that allows only vertical movements (Liang et al., 2007). Muscle strength was recorded as HEIGHT (jump height expressed in cm), POWER (jump power expressed in W/kg), FORCE (jump force expressed in N/kg), VELOCITY (jump velocity expressed in cm/s), and HS1RM (half squat one repetition maximum expressed in kg). Assessments of HS1RM and the vertical jump, respectively, were performed on the same day, both at the beginning and the end of a nine-month resistance training program. Five minutes of recovery were taken in between two mentioned exercises. Both while performing the half squat and vertical jump the trunk was kept as straight as possible. The last acceptable lift with the highest possible external load was used in HS1RM calculation. For the vertical jump, 3 trials were performed with 3 min of recovery between trials and 5 CMJ within the trial. The best trial performance was recorded, i.e., mean value of 5 CMJ within the best trial. Five minutes of rest were given to participants between the half squat and vertical jump performance.

Bone tissue assessment. The bone tissue assessment was carried out by using a clinical sonometer Sahara (Hologic, Inc., MA 02154, USA) that uses ultrasound to assess bone density at calcaneus. In this study, both left and right heel bones were subjected to measurement. Data obtained by sonographic measuring of the heel bone, as part of the skeleton that is the most mechanically loaded during moderate daily and severe training physical activities, are reliable and valid as reported earlier (Kauppi et al., 2009; Haara et al., 2005). Bone density was recorded as SOS (speed of sound expressed in m/s), BUA (broadband ultrasound attenuation expressed in dB/Mhz) and BMD (bone mineral density expressed in g/cm^2).

Exercise program

A nine-month long program of resistance exercises with different external loads was applied by ES in between the initial and final measurement, in addition to regular athletic training. EG1, EG2 and EG3 sprinters were subjected to the program of resistance exercises with a low level (60%1RM, 8-12 repetitions), medium level (70%1RM, 5-8 repetitions); and high level (85%1RM, 2-4 repetitions) of external loads, respectively. In the first five months, the program of resistance exercises was realized three times a week (64 training sessions). In the last four months, the training and program of resistance exercises was performed two times a week (36 training sessions). The total number of training sessions in this nine-month cycle was 100 (one hundred). Since the experimental groups performed large volumes of weight-bearing physical activity, in a prolonged period of time, one might expect that they would have shown some degree of determined correlation between muscle strength and bone density parameters, or at least a slightly better muscle strength and bone density results than the population of non-athletes.

Statistical Analyses

The means, standard deviations, maximum and minimum values were calculated for muscle strength and bone density data. Correlations between muscle strength and bone density data are given as Pearson correlation coefficients. The data were analyzed with the statistical package Statistics 13,0 (Pallant, 2007).

RESULTS

Descriptive results of muscle strength variables (HEIGHT, POWER, FORCE, VELOCITY, HS1RM) and bone density variables (SOS_LL, SOS_RL, BUA_LL, BUA_RL, BMD_LL, BMD_RL) are shown in Table 1.

Table 1 Descriptive statistical parameters of muscle strength and bone density

		Initial				Final			
		EG1	EG2	EG3	CS	EG1	EG2	EG3	CS
HEIGHT (cm)	Mean	34.90	36.99	39.24	32.34	33.80	35.15	34.67	30.95
	SD	5.05	4.05	3.87	4.80	4.85	3.27	3.95	3.01
	Min	28.50	31.60	34.20	26.00	26.20	29.80	29.40	26.80
	Max	50.40	44.00	46.80	42.10	45.80	45.00	44.00	36.00
POWER (W/kg)	Mean	40.99	41.51	41.53	44.67	38.60	37.63	37.25	48.67
	SD	7.75	6.85	6.37	11.21	7.77	7.07	7.95	12.40
	Min	27.00	29.60	28.80	23.20	26.70	27.20	24.60	30.40
	Max	54.20	54.60	50.60	66.60	54.40	50.40	50.00	85.80
FORCE (N/kg)	Mean	25.29	25.55	24.79	29.40	23.82	25.01	24.77	30.34
	SD	3.46	2.93	3.64	5.31	2.21	3.15	3.50	5.09
	Min	18.00	22.00	20.60	20.80	19.50	19.10	19.00	20.70
	Max	30.00	31.00	32.20	40.50	28.00	29.30	32.10	41.80
VELOCITY (cm/s)	Mean	227.47	230.80	230.07	232.33	222.74	219.96	211.00	244.36
	SD	26.28	22.37	24.33	32.12	31.62	23.25	34.08	32.55
	Min	165.00	188.00	178.00	156.00	164.00	177.00	148.00	203.00
	Max	270.00	270.00	280.00	280.00	282.00	258.00	263.00	342.00
HS1RM (kg)	Mean	102.22	110.05	132.54	85.67	107.47	127.11	153.99	84.17
	SD	12.09	16.55	11.63	17.55	12.07	20.53	9.69	17.66
	Min	72.00	85.30	117.30	60.00	80.00	106.70	140.00	56.00
	Max	124.00	138.70	154.70	116.00	126.70	169.30	170.70	113.30
SOS_LL (m/s)	Mean	1573.12	1579.00	1575.57	1536.77	1586.00	1595.54	1575.77	1547.87
	SD	34.62	20.05	28.14	18.10	41.66	26.04	26.49	13.58
	Min	1531.06	1553.83	1524.37	1508.91	1529.76	1547.92	1533.30	1524.37
	Max	1662.87	1612.10	1623.37	1567.12	1693.30	1645.70	1619.69	1579.40
SOS_RL (m/s)	Mean	1572.24	1579.25	1579.19	1543.30	1581.58	1593.72	1576.53	1545.84
	SD	30.50	25.67	28.22	25.95	28.07	28.87	21.36	18.42
	Min	1522.21	1551.51	1530.67	1510.01	1548.60	1546.72	1529.10	1511.98
	Max	1642.85	1633.18	1630.90	1593.38	1641.80	1652.00	1615.71	1584.10
BUA_LL (dB/Mhz)	Mean	70.62	86.34	82.09	64.29	95.59	101.24	91.78	76.33
	SD	23.07	14.47	14.49	11.75	23.88	13.50	12.30	9.97
	Min	45.18	54.70	59.77	47.31	57.65	74.79	69.10	60.50
	Max	138.75	108.46	111.71	87.37	154.50	129.90	116.38	95.50
BUA_RL (dB/Mhz)	Mean	70.89	87.55	84.31	68.87	92.83	102.65	91.36	76.98
	SD	18.98	15.98	14.33	14.13	20.31	18.12	10.47	9.86
	Min	48.84	64.69	64.96	47.37	64.40	68.76	67.60	62.10
	Max	106.55	125.25	122.19	99.46	127.80	133.10	114.32	98.00
BMD_LL (g/cm^2)	Mean	.57	.63	.61	.46	.67	.71	.64	.52
	SD	.14	.08	.11	.07	.16	.10	.10	.05
	Min	.42	.51	.42	.35	.50	.52	.47	.43
	Max	.98	.74	.79	.59	1.10	.92	.81	.66
BMD_RL (g/cm^2)	Mean	.57	.63	.63	.49	.65	.71	.64	.52
	SD	.12	.10	.11	.10	.12	.12	.08	.07
	Min	.39	.51	.45	.35	.51	.50	.45	.40
	Max	.85	.87	.86	.70	.90	.94	.80	.67

Table 2 Cross-correlations between lower limb muscle strength and bone density parameters at the initial and final measurement

I/F	Groups		SOS_LL (m/s)	SOS_RL (m/s)	BUA_LL (dB/Mhz)	BUA_RL (dB/Mhz)	BMD_LL (g/cm^2)	BMD_RL (g/cm^2)
HEIGHT (cm)	EG1	R	.172/.278	.261/.375	.261/.250	.328/.201	.215/.273	.306/.309
		Sig	.541/.315	.348/.168	.347/.368	.232/.474	.443/.325	.268/.262
	EG2	R	-.199/-.227	-.237/-.194	.034/-.164	.080/-.266	-.111/-.211	-.122/-.226
		Sig	.478/.416	.394/.489	.903/.560	.776/.339	.694/.449	.666/.418
	EG3	R	.101/-.064	.102/.038	-.078/-.127	.086/.124	.041/-.085	.099/.068
		Sig	.719/.820	.718/.892	.783/.653	.761/.660	.884/.762	.727/.811
	CS	R	-.002/-.049	.220/-.299	-.178/-.290	.069/-.122	-.077/-.142	.171/-.243
		Sig	.995/.862	.430/.279	.525/.295	.807/.664	.784/.614	.541/.382
POWER (W/kg)	EG1	R	**.516***/.386	**.681****/**.629***	**.638***/.310	**.746****/**.650****	**.584***/.365	**.753****/**.653****
		Sig	**.049**/.155	**.005**/**.012**	**.010**/.261	**.001**/**.009**	**.022**/.182	**.001**/**.008**
	EG2	R	-.227/-.262	-.195/-.212	-.144/-.249	-.062/-.230	-.211/-.265	-.152/-.224
		Sig	.415/.346	.487/.447	.609/.371	.827/.410	.451/.340	.590/.422
	EG3	R	-.450/.099	**-.514**/.235	-.456/.055	**-.578***/.331	-.463/.086	**-.547***/.272
		Sig	.092/.725	**.050**/.399	.088/.846	**.024**/.229	.083/.759	**.035**/.327
	CS	R	-.136/-.240	-.132/-.196	-.258/-.287	-.241/-.307	-.200/-.281	-.175/-.240
		Sig	.630/.389	.640/.485	.353/.300	.386/.266	.475/.310	.533/.389
FORCE (N/kg)	EG1	R	.348/.434	.482/**.610***	.369/.279	**.577***/**.545***	.368/.383	**.553***/**.597***
		Sig	.204/.106	.069/**.016**	.177/.314	**.024**/**.036**	.177/.159	**.033**/**.019**
	EG2	R	-.166/-.106	-.145/.006	-.180/-.096	-.181/-.105	-.189/-.106	-.168/-.038
		Sig	.553/.706	.605/.984	.522/.733	.518/.710	.501/.707	.550/.894
	EG3	R	**-.564***/.117	**-.610***/.221	-.371/.136	-.480/.317	-.510/.125	**-.579***/.257
		Sig	**.029**/.677	**.016**/.430	.173/.630	.070/.250	.052/.657	**.024**/.354
	CS	R	.043/-.185	-.056/-.078	-.063/-.169	-.148/-.286	.002/-.231	-.091/-.154
		Sig	.879/.508	.842/.781	.824/.546	.599/.302	.996/.408	.747/.583
VELOCITY (cm/s)	EG1	R	.479/.280	**.669****/**.539***	**.649****/.243	**.757****/**.608***	**.565***/.269	**.749****/**.582***
		Sig	.071/.312	**.006**/**.038**	**.009**/.383	**.001**/**.016**	**.028**/.333	**.001**/**.023**
	EG2	R	-.077/-.306	-.101/-.198	-.030/-.301	.009/-.240	-.063/-.313	-.062/-.219
		Sig	.785/.268	.719/.479	.915/.276	.974/.390	.823/.256	.826/.433
	EG3	R	-.186/.270	-.248/.407	-.249/.202	-.378/.488	-.212/.252	-.299/.443
		Sig	.506/.330	.372/.132	.371/.471	.165/.065	.447/.365	.280/.098
	CS	R	-.148/-.183	-.125/-.240	-.284/-.397	-.265/-.361	-.219/-.282	-.179/-.289
		Sig	.599/.513	.657/.389	.305/.143	.339/.187	.433/.309	.523/.296
HS1RM (kg)	EG1	R	-.056/-.020	-.102/-.063	.134/-.124	.175/.067	.020/-.078	.005/-.008
		Sig	.842/.945	.719/.825	.634/.659	.533/.812	.942/.783	.987/.979
	EG2	R	-.233/-.066	**-.516***/-.337	.195/.054	-.142/-.221	-.059/-.026	-.393/-.299
		Sig	.403/.814	**.049**/.219	.487/.847	.614/.429	.834/.927	.147/.280
	EG3	R	-.209/.124	-.222/.116	-.260/.157	-.178/-.086	-.231/.136	-.212/.051
		Sig	.455/.674	.427/.693	.350/.592	.526/.771	.407/.643	.449/.863
	CS	R	-.054/.072	.026/.278	-.243/.406	.011/.267	-.139/.248	.022/.281
		Sig	.849/.798	.925/.315	.383/.133	.969/.337	.621/.374	.939/.310

*Abbrev. I/F-Initial/Final measurement; HS1RM-one repetition maximum in half squat; SOS-speed of sound; BUA-broadband ultrasound attenuation; BMD-bone mineral density; _LL-left leg; _RL-right leg

Concerning EG1, POWER positively correlates to SOS_LL (r=.516*, p=.049, at initial measurement), SOS_RL (r=.681**/.629*, p=.005/.012, at the initial and final measurement, respectively), BUA_LL (r=.638*, p=.010, at the initial measurement), BUA_RL (r=.746**/.650**, p=.001/.009, at the initial and final measurement, respectively), BMD_LL (r=.584*, p=.022, at the initial measurement), and BMD_RL (r=.753**/.653**, p=.001/.008, at the initial and final measurement, respectively). Concerning EG3, POWER negatively correlates with SOS_RL (r=-.514, p=.050, at the initial measurement), BUA_RL (r=-.578*, p=.024, at the initial measurement), and BMD_LL (r=-.547*, p=.035, at the initial measurement). Concerning EG1, FORCE positively correlates with SOS_RL (r=.610*, p=.016, at the final measurement), BUA_RL (r=.577*/.545*, p=.024/.036, at the initial and final measurement, respectively), and BMD_RL (r=.553*/.597*, p=.033/.019, at the initial and final measurement, respectively). Concerning EG3, FORCE negatively correlates with SOS_LL (r=-.564*, p=.029, at the initial measurement), SOS_RL (r=-.610*, p=.016, at the initial measurement), and BMD_RL (r=-.579*, p=.024, at the initial measurement). Concerning EG1, VELOCITY positively correlates with SOS_RL (r=.669**/.539*, p=.006/.038, at the initial and final measurement, respectively), BUA_LL (r=.649**, p=.009, at the initial measurement), SOS_RL (r=.669**/.539*, p=.006/.038, at the initial and final measurement, respectively), and BUA_RL (r=.757**/.608*, p=.001/.016, at the initial and final measurement, respectively), BMD_LL (r=.565*, p=.028, at the initial measurement), and BMD_RL (r=.749**/.582*, p=.001/.023, at the initial and final measurement, respectively). HEIGHT, and HS1RM do not correlate to bone density variables, with the exception of HS1RM in EG2, that negatively correlates with SOS_RL (r=-.516*, p=.049, at the initial measurement).

DISCUSSION

We started this study by indicating that bone is slow to adapt and seems more responsive to impact forces, and that explosive tasks lead to fast and significant bone deformation (Belavý et al., 2016). Afterwards, the force of muscle contraction must impact on an anatomically related skeletal site or reflect actions of muscles that contract in order to provoke changes in bone and muscle structures. It is important to emphasize that the stimulus to bone is literally the physical deformation of bone cells, rather than the metabolic or cardiovascular stress typically associated with exercise, e.g., % VO2max (Bloomfield, Little, Nelson, & Yingling, 2004). According to Kohrt, Bloomfield, Little, Nelson, & Yingling (2004) changes in BMD, i.e., bone mineralization, occur about 8 months after the application of an exercise training program. In that sense we created a nine-month long resistance training program, and divided athletes into three groups (EG1, EG2, and EG3), that underwent an experimental program of low, medium and high level of external loads (60%1RM, 70%1RM, and 85%1RM), respectively. If we inspect the descriptive parameters, we can see intriguing results: mean jump HEIGHT values, as one of the most significant indicators of explosive strength, as well as mean POWER, FORCE and VELOCITY values, decreased at the end of resistance program in EG1, EG2, and EG3 participants. On the other hand, mean HS1RM values increased at the end of the resistance program in ES participants, as well as bone density parameters in all the participants. At the same time, mean POWER, FORCE and VELOCITY values increased at the final assessment, while mean HS1RM value decreased in CS participants. Improvements in explosive strength, as well as in bone parameters, determined in CS participants, might be related in part to natural maturation or genetics. In addition, no correlation between HEIGHT and HS1RM on the one hand, and bone density on the other was determined in the entire sample. According to Green & Patla (1992), peripheral neuromuscular factors are associated with the force-velocity characteristics of the neuromuscular system. Descriptive results of the jump VELOCITY led us to the assumption that the experimental program might provoke negative neuromuscular adaptations in ES in a way that resistance training with low level (60%1RM), medium level (70%1RM); and high level (85%1RM) of external loads, in EG1, EG2, and EG3, respectively, led to a decreased rate of neural activation of motor units, whereas muscle hypertrophy represented by HS1RM variable, increased. And although descriptive results gave an indication that a nine-month long resistance training program of low, medium and high level of external loads negatively affects explosive strength, but positively affects maximum strength and bone density, it was difficult to separate those effects by means of a correlation analysis. There was not even a slightest hint of program effects in the case of the correlation of the jump HEIGHT and maximum strength (HS1RM) to bone parameters. Namely, correlation analysis data show associations between the lower limbs explosive strength and bone density, i.e., between POWER, FORCE and VELOCITY on one hand and SOS, BUA and BMD on the other. More interestingly, correlations occurred only in EG1 (60%1RM) and EG3 (85%1RM) participants, as positive and negative correlations, respectively, and they were more frequent at the initial assessment, i.e. most of them disappeared at the final assessment. Despite fair correlation coefficients (with an R value that is greater than 0,5) which do indicate a definite trend towards concurrent muscle strength and bone adaptation, the strength of the determined correlations should be taken with precaution, because of the small number of participants within the groups (N=15). Finally, based on the results of HS1RM at the final assessment, we can agree with the recommendations of Faigenbaum et al. (2009), that a properly designed and supervised resistance training program can enhance muscular strength and power in youth. We can add that it can enhance the bone density status, although we cannot be quite sure, based on the results of the correlation analysis, of the extent to which it is due to the resistance training program, maturation process or genetics.

CONCLUSION

Despite resistance training resulting in increment of bone density variables in ES, this did not translate into superior improvements in CMJ performance, i.e. in jump HEIGHT, POWER, FORCE and VELOCITY. In fact, resistance training showed an increase in half squat (HS1RM) performance, only. Even though sufficient descriptions of resistance exercise programs and training intensities within the actual study have been provided, it cannot be confirmed that any intensity related dose-response relationship is responsible for the observed explosive strength, maximum strength and bone density values at the final assessment. More precisely, from the obtained correlations it is not clear to what extent the actual resistance program affected explosive and maximum strength and bone density parameters. Therefore, further analysis that will determine resistance program effects is needed.

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KORELACIJE SNAGE MIŠIĆA I GUSTINE KOSTIJU MLADIH SPORTISTA I NESPORTISTA

Cilj ovog istraživanja bio je istražiti prirodu veza između snage mišića donjih ekstremiteta i gustine kostiju u grupi mladih sportista i nesportista, starosti 17-18 godina. Sportisti podeljeni u tri eksperimentalne grupe (EG1, EG2, i EG3) sprovodili su devetomesečni program niskog, srednjeg i visokog nivoa spoljašnjeg oterećenja, tim redosledom. Nesportisti su sačinjavali kontrolnu grupu. Pretpostavili smo da će snaga mišića statistički značajno biti povezana sa gustinom koštanog tkiva (BMD), na pozitivan način i sa trendom rasta kod ispitanika EG1, EG2 i EG3, tim redosledom, i da će utvrđene korelacije biti veće u odnosu na korelacije utvrđene kod nesportista iz kontrolne grupe (CS). Srednja vrednost visine skoka (HEIGHT), kao jednog od najznačajnijih indikatora eksplozivne snage, kao i srednje vrednosti snage skoka (POWER), sile skoka (FORCE) i brzine skoka (VELOCITY), opale su na kraju programa sa opterećenjem kod ispitanika EG1, EG2 i EG3. Sa druge strane, srednja vrednost HS1RM porasla je na kraju programa sa opterećenjem kod ispitanika eksperimentalnog subuzorka, kao i vrednosti parametara gustine kostiju svih ispitanika. U isto vreme, srednje vrednosti POWER, FORCE i VELOCITY, porasle su na finalnom merenju, dok je srednja vrednost HS1RM umanjena, kod ispitanika CS. Nije utvrđena povezanost između HEIGHT i HS1RM sa jedne strane, gustine kostiju sa druge strane u celom uzorku ispitanika. Korelacije su utvrđene samo kod ispitanika EG1 (60%1RM) i EG3 (85%1RM), kao pozitivna i negativna, tim redosledom, i bile su učestalije na inicijalnom merenju, t.j., mnoge su nestale na finalnom merenju.

Ključne reči*: adolescenti, program treninga sa opterećenjem, snaga mišića, BMD.*