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Original scientific paper

Relationships between Anthropometric, Body Composition and Bone Mineral Parameters in 7-8-year-old Rhythmic Gymnasts Compared with Controls

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A B S T R A C T

The aim of the study was to investigate the relationships between specific anthropometric (9 skinfolds, 13 girths, 8 lengths and 8 breadths), body composition (body fat %, fat free mass [FFM], fat mass [FM]) parameters and bone mineral parameters (bone mineral density [BMD], bone mineral content [BMC]) in young rhythmic gymnasts and same age controls. Eighty nine 7-8-year-old girls participated in this study and were divided to the rhythmic gymnast's (n=46) and control (n=43) groups. Body composition was determined by dual energy X-ray absorptiometry (FFM, FM, body fat %, BMD and BMC). Body fat % and FM were lower and BMD and BMC values at lumbar spine (L2-L4) and femoral neck were higher in rhythmic gymnasts compared with controls. All measured skinfold thicknesses were thicker in controls. In girths, lengths and widths there were only few significant differences between the groups. Stepwise multiple regression analysis indicated that skinfold thicknesses (supraspinale and medial calf) influenced L2-L4 BMD only in controls 38.2% (R^2x100). Supraspinale and iliac crest skinfold thicknesses characterised L2-L4 BMC 43.9% (R^2x100). Calf girths influenced BMD in L2-L4 52.3% (R^2x100) in controls. BMC in L2-L4 was dependent only on mid-thigh girths 35.9% (R^2x100). BMD in L2-L4 was dependent on tibiale-laterale height 30.0% (R^2x100). Biiliocristal breadths together with sitting height characterised BMC in L2-L4 BMD 62.3% (R^2x100). In conclusion, we found that the relationships between anthropometry, body composition and bone parameters in young rhythmic gymnasts are weak. In control group first of all lower body anthropometric parameters significantly correlated with BMD and BMC in spine.

Key words: *anthropometrics, body composition, bone mineral density, bone mineral content, prepubertal girls, rhythmic gymnasts*

Introduction

Better bone mineral density (BMD) in childhood might prevent osteoporosis in later life[1]. Prepubertal years are an opportune time to increase BMD through exercise[2]. High-impact exercise has a strong impact on BMD and bone mineral content (BMC)[3]. Rhythmic gymnastics is known as high-impact bone loading sport because gymnasts perform a lot of jumps. Rhythmic gymnasts are taller and thinner than untrained controls[4,5]. Elite rhythmic gymnasts are very thin and have low body fat mass (FM) because this sport requires this kind of aesthetic ideal[6]. Elite rhythmic gymnasts compared to sub-elite rhythmic gymnasts are taller, have longer leg length and sitting height and have lower body mass (BM) and fat free mass (FFM) but there are no significant differences in body mass index (BMI) and FM[7].

Rhythmic gymnastics stimulates bone resorption activity and bone turnover[8], and higher rate of bone turnover in rhythmic gymnasts compared with untrained controls induces a higher BMC[6]. Impact loading sport increases the BMD in the stressed sites of the skeleton[9] and there is also a dose-dependent relationship between BMD and hours *per* week of impact activity[10]. Mechani-

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cal loading has site-specific impact through muscle mass and strength because muscle and bone are biomechanically linked[11,12].

There is a significant relationship between BM and BMD regardless whether it is FM or FFM[13], although the relationship between body composition and BMD seems to be site-specific in premenarcheal girls[13,14]. A significant relationship between FFM and BMD has been found in healthy girls[15]. In addition, relationships between FFM and BMC[16], and between FM and BMD[17] have been found in gymnasts. FM is an independent risk factor for osteoporosis but has also a positive effect on bone mass through the weight-bear-loading[18]. However, rhythmic gymnasts are very lean.

Only few studies have investigated the impact of the specific anthropometric parameters (skinfolds, girths, lengths, breadths) on BMD and BMC values in young healthy women. For example Slameda et al.[19] found a significant relationships between skinfold thicknesses and BMD in adult females. Trivitayaratana et al.[20] found that arm span is not significantly correlated with BMD in young women. BMD is dependent on trunk skeletal parameters and leg skinfolds[21].

To our knowledge, there is not available any information about the relationships between specific anthropometric parameters and the BMD and BMC in prepubertal rhythmic gymnasts. The aim of the study was to investigate the relationships between specific anthropometric (skinfolds, girths, lenghts and breadths), body composition (body fat %, FM, FFM) parameters and bone mineral parameters (BMD and BMC) in young rhythmic gymnasts and same age controls. We hypothesised that first of all FM and skinfold thicknesses correlate significantly with BMD and BMC in young prepubertal girls. Probably these relationships are higher in controls compared with rhythmic gymnasts because they have more body fat.

Materials and Methods

Subjects

Participants of this study were 89 7-8-year-old girls from different schools and sport clubs in Tartu (Estonia). They were divided to rhythmic gymnasts (n=46) and controls (n=43). Gymnasts practiced rhythmic gymnastics and ballet lessons 4–7 times *per* week (6–12 hrs/wk). They had trained regularly for the last 1 to 3 years. Control group had 2–3 times a week compulsory physical education lessons (45 minutes each) at school and they did not participate in any kind of sports after school. All participants were free from present or past diseases known to affect skeletal metabolism, and none of the girls were receiving medications known to affect bone. Girls were also asked not to change their eating habits. All rhythmic gymnasts, controls and their parents gave their written informed consent. The study was approved by the Medical Ethics Committee of the University of Tartu (Estonia).

Anthropometric measurements

Body height was measured using a Martin metal anthropometer in cm (±0.1 cm). BM was measured with electronic medical scales (±0.1 kg, A&D Instruments, Ltd, UK) and BMI (kg/m^2) was calculated. The girls were dressed in light clothing and wearing no shoes.

Anthropometric parameters were measured according to the protocol recommended by the International Society for Advancement of Kinanthropometry (ISAK)[22]. Nine skinfolds (triceps, subscapular, biceps, iliac crest, supraspinale, abdominal, front thigh, medial calf and mid-axilla) were measured using Holtain (Crymmych, UK) skinfold caliper. Thirteen girths: head, neck, arm relaxed, arm flexed and tensed, forearm, wrist, chest, waist, gluteal (hip), mid-thigh, thigh (mid trochanter-tibiale-laterale), calf and ankle, eight lengths (acromiale-radiale, radiale-stylion, midstylion-dactylion, iliospinale height, trochanterion height, trochanterion-tibiale laterale, tibiale-laterale height, tibiale mediale-sphyrion tibiale) and eight breadths (biacromial, biiliocristal, foot length, sitting height, transverse chest, anterior-posterior chest depth, biepicondylar humerus, biepicondylar femur) were measured using the CENTURION KIT instrumentation (Rosscraft, Surrey, BC, Canada). All the measurements were performed by a well-trained anthropometrist (Level 1 ISAK anthropometrist) and the mean of two trials was used in the analysis.

Body composition and bone measurements

Body composition (body fat %, FM, and FFM) was measured by dual energy X-ray absorptiometry (DXA: DPX-IQ; Lunar Corporation, Madison, USA). BMD (g/cm^2) and BMC (g) from lumbar spine (L2-L4) and femoral neck were also determined by DXA. DXA measurements and results were evaluated by the same examiner. Girls were scanned in light clothing while lying flat on their backs with arms at their sides.

Statistical analysis

The Statistical Package for the Social Sciences (SPSS) version 15.0 (SPSS Inc, Chicago, USA) was used. Mean ($\bar{X}$) and standard deviation (±SD) were calculated by using standard statistical methods. Differences between groups were calculated using one-way analysis of variance (ANOVA). Pearson product moment correlation and stepwise multiple regression analysis was applied to identify the relationship between anthropometric, body composition parameters and BMD and BMC. The level of significance was set at $p<0.05$ for all statistical analysis.

Results

Mean anthropometric and body composition parameters in rhythmic gymnasts and controls are presented in Table 1. There were not any significant differences between groups in mean age, body height, BM and BMI. Body fat % and FM were significantly lower in rhythmic gymnasts compared with controls. BMD and BMC at

TABLE 1
MEAN (X±SD) ANTHROPOMETRIC AND BODY COMPOSITION DATA AND RELATIONSHIPS WITH BONE MINERAL DENSITY (BMD) AND BONE MINERAL CONTENT (BMC) IN RHYTHMIC GYMNASTS (RG) AND CONTROLS (C)

Variables	Rhythmic gymnasts (n=46)	Controls (n=43)	BMD				BMC			
			L2-L4		FN		L2-L4		FN	
			RG	C	RG	C	RG	C	RG	C
Age (y)	8.0±0.6	8.2±0.6	0.093	0.357*	–0.373*	–0.032	0.216	0.312*	–0.208	–0.030
Body height (cm)	130.2±5.2	129.6±5.4	0.310*	0.599**	–0.287	0.014	0.687**	0.696**	–0.391**	–0.122
Body mass (kg)	27.2±3.3	27.9±5.1	0.202	0.721**	–0.190	0.044	0.522**	0.657**	–0.306*	0.121
BMI (kg/m²)	16.0±1.3	16.5±2.2	0.003	0.583**	0.013	0.078	0.113	0.422**	–0.080	0.274
FM (g)	5162.3±1963.7	6694.4±2896.5**	0.115	0.584**	–0.119	0.050	0.262	0.505**	–0.083	0.173
FFM (g)	20410.8±2008.6	19771.4±2381.4	0.209	0.746**	–0.168	0.036	0.568**	0.702**	–0.399**	0.039
Fat %	19.8±5.5	24.3±7.0***	0.051	0.437**	–0.064	0.064	0.126	0.353*	0.003	0.211

*p<0.05, **p<0.01, ***p<0.001

L2-L4 and femoral neck were significantly higher in rhythmic gymnasts (Table 2). All measured skinfold thicknesses were significantly thinner in rhythmic gymnasts (Table 3). Neck, forearm and thigh girths (Table 4), acromiale-radiale length (Table 5) and sitting height (Table 6) from measured breadth parameters were lower (p<0.05) in rhythmic gymnasts compared with controls.

TABLE 2
MEAN (X ± SD) LUMBAR SPINE (L2-L4) AND FEMORAL NECK BONE MINERAL DENSITY (BMD) AND BONE MINERAL CONTENT (BMC) IN RHYTHMIC GYMNASTS AND CONTROLS

Variables	Rhythmic gymnasts (n = 46)	Controls (n = 43)	p
Lumbar spine (L2-L4)			
BMD (g/cm²)	0.748±0.07	0.7±0.08	≤0.000
BMC (g)	17.7±2.4	16.2±3.0	≤0.05
Femoral neck			
BMD (g/cm²)	0.778±0.07	0.712±0.07	≤0.000
BMC (g)	2.84±0.34	2.69±0.36	≤0.05

From the basic anthropometric and body composition parameters only body height correlated significantly with BMD in L2-L4 (r=0.310) in rhythmic gymnasts and in controls with all measured parameters (r=0.357–0.746, Table 1). As a rule, BMD in femoral neck did not correlate significantly with basic anthropometric and body composition parameters in either group. In controls BMC in L2-L4 significantly correlated with all measured basic anthropometric and body composition parameters (Table 1, r=0.312–0.702). In rhythmic gymnasts body height (r=0.687), BM (r=0.522) and FFM (r=0.568) significantly correlated with BMC in L2-L4 (Table 1). On the other hand, in rhythmic gymnasts, femoral neck BMC correlated negatively with body height (r=–0.391), BM (r=–0.306) and FFM (r=–0.399).

TABLE 3
MEAN (X±SD) SKINFOLD THICKNESSES AND RELATIONSHIPS WITH L2-L4 AND FEMORAL NECK BONE MINERAL DENSITY (BMD) AND BONE MINERAL CONTENT (BMC) IN RHYTHMIC GYMNASTS (RG) AND CONTROLS (C)

Variables	Rhythmic gymnasts (n = 46)	Controls (n = 43)	L2-L4				Femoral neck			
			BMD		BMC		BMD		BMC	
			RG	C	RG	C	RG	C	RG	C
Triceps (cm)	9.4±2.8	11.9±3.5***	0.080	0.500**	0.080	0.431**	0.156	0.096	0.199	0.282
Subscapular (cm)	5.6±1.9	7.5±3.0***	0.020	0.529**	–0.055	0.444**	0.013	–0.010	0.088	0.251
Biceps (cm)	6.4±2.4	7.7±2.9*	0.037	0.460**	0.024	0.382**	0.111	0.057	0.076	0.147
Iliac crest (cm)	7.7±2.6	11.1±4.4***	0.181	0.431**	0.072	0.380*	–0.059	0.064	–0.024	0.258
Supraspinale (cm)	4.9±1.7	7.0±3.1***	0.157	0.560**	0.140	0.609**	–0.170	0.002	–0.120	0.061
Abdominal (cm)	7.0±3.0	9.3±4.6**	0.126	0.519**	0.202	0.519**	–0.112	–0.021	0.056	0.041
Front thigh (cm)	13.1±3.6	17.1±5.5***	–0.034	0.505**	–0.026	0.441**	0.108	–0.058	0.195	0.093
Medial calf (cm)	8.6±2.7	10.9±3.7***	0.093	0.533**	0.146	0.359*	0.043	–0.136	0.037	0.021
Mid-axilla (cm)	4.6±1.3	7.0±2.9***	–0.005	0.470**	–0.023	0.496**	–0.099	0.109	–0.134	0.294

TABLE 4
MEAN (X±SD) GIRTHS AND RELATIONSHIPS WITH L2-L4 AND FEMORAL NECK BONE MINERAL DENSITY (BMD) AND BONE MINERAL CONTENT (BMC) IN RHYTHMIC GYMNASTS (RG) AND CONTROLS (C)

Variables	Rhythmic gymnasts (n=46)	Controls (n=43)	L2-L4				Femoral neck			
			BMD		BMC		BMD		BMC	
			RG	C	RG	C	RG	C	RG	C
Head (cm)	52.3±1.5	52.8±2.2	0.164	0.503**	0.166	0.457**	0.147	–0.085	0.147	0.076
Neck (cm)	26.3±1.0	27.7±1.9***	0.216	0.502**	0.267	0.405**	0.184	0.090	0.184	0.209
Arm (relaxed) (cm)	18.6±1.3	19.4±2.4	0.118	0.651**	0.223	0.499**	0.044	0.243	0.044	0.365*
Arm (flexed) (cm)	19.8±1.3	20.5±2.4	0.077	0.668**	0.148	0.520**	–0.012	0.197	–0.012	0.318*
Forearm (cm)	18.3±0.8	18.9±1.5*	0.045	0.652**	0.242	0.523**	–0.042	0.112	–0.042	0.198
Wrist (cm)	12.7±0.7	12.9±1.0	–0.073	0.662**	0.169	0.565**	0.087	0.100	0.087	0.129
Chest (cm)	61.2±3.2	61.3±9.1	0.248	0.389**	0.303*	0.164	–0.135	0.124	–0.135	0.300
Waist (cm)	54.8±3.4	55.8±5.1	0.012	0.535**	–0.089	0.456**	0.053	–0.047	0.053	0.140
Gluteal (hip) (cm)	66.7±3.5	68.7±6.3	0.161	0.693**	0.315*	0.591**	–0.093	0.159	–0.093	0.272
Thigh (cm)	39.4±2.7	40.9±4.5*	–0.023	0.682**	0.193	0.567**	0.015	0.147	0.015	0.280
Mid-thigh (cm)	36.3±2.0	36.7±3.9	0.040	0.676**	0.197	0.599**	0.031	0.094	0.031	0.208
Calf (cm)	26.3±1.6	26.6±2.4	0.097	0.723**	0.241	0.539**	0.086	0.072	0.086	0.187
Ankle (cm)	17.8±1.1	18.3±1.5	–0.140	0.557**	0.032	0.457**	0.095	0.112	0.095	0.123

TABLE 5
MEAN (X±SD) LENGTHS AND RELATIONSHIPS WITH L2-L4 AND FEMORAL NECK BONE MINERAL DENSITY (BMD) AND BONE MINERAL CONTENT (BMC) IN RHYTHMIC GYMNASTS (RG) AND CONTROLS (C)

Variables	Rhythmic gymnasts (n=46)	Controls (n=43)	L2-L4				Femoral neck			
			BMD		BMC		BMD		BMC	
			RG	C	RG	C	RG	C	RG	C
Acromiale-radiale (cm)	22.5±1.6	23.4±1.6**	–0.199	0.407**	–0.073	0.565**	0.052	0.051	–0.038	–0.185
Radiale-stylion (cm)	19.2±1.2	18.9±1.0	0.095	0.325*	0.160	0.355*	–0.203	0.074	–0.190	0.043
Midstylion-dactylion (cm)	14.1±1.1	14.2±0.9	0.233	0.487**	0.397**	0.591**	–0.427**	–0.012	–0.470**	–0.125
Iliospinale height (cm)	72.5±4.9	72.5±3.8	0.326*	0.496**	0.542**	0.535**	–0.383**	0.031	–0.406**	–0.073
Trochanterion height (cm)	65.4±4.2	65.4±3.6	0.423**	0.452**	0.567**	0.563**	–0.420**	–0.021	–0.374*	–0.174
Trochanterion-tibiale laterale (cm)	28.0±2.4	28.7±2.2	0.206	0.280	0.389**	0.351*	–0.448**	–0.066	–0.460**	–0.120
Tibiale-laterale height (cm)	35.9±3.1	37.1±2.3	0.315*	0.547**	0.561**	0.524**	–0.431**	–0.100	–0.455**	–0.204
Tibiale mediale-sphyrion tibiale (cm)	26.6±1.9	26.6±1.7	0.156	0.531**	0.240	0.516**	–0.124	–0.086	–0.245	–0.181

*p<0.05, **p<0.01, ***p<0.001

All measured skinfold thicknesses correlated significantly with BMD and BMC in L2-L4 in control group (r=0.359–0.609, Table 3). However, these relationships in rhythmic gymnasts were not significant. In both rhythmic gymnasts and controls, no significant relationships were established between femoral neck BMD, BMC and skinfold thicknesses.

Lumbar spine BMD and BMC as a rule correlated significantly with all measured girths (except between chest and BMC) in controls (Table 4) but there were only two significant relationships between femoral neck and BMC (arm relaxed and arm flexed). In rhythmic gymnasts there were no significant relationships between girths and lumbar spine and femoral neck BMD and BMC. Only chest (r=0.303) and gluteal girth (r=0.315) had significant relationships with lumbar spine BMC in rhythmic gymnasts.

Spine (L2-L4) BMD and BMC correlated significantly with all (except in trochanterion-tibiale laterale) measured length parameters in control group (Table 5). In the same group femoral neck BMD and BMC did not have significant relationships with length parameters. In

TABLE 6
MEAN (X±SD) BREADTHS AND RELATIONSHIPS WITH L2-L4 AND FEMORAL NECK BONE MINERAL DENSITY (BMD) AND BONE MINERAL CONTENT (BMC) IN RHYTHMIC GYMNASTS (RG) AND CONTROLS (C)

Variables	Rhythmic gymnasts (n=46)	Controls (n=43)	L2-L4				Femoral neck			
			BMD		BMC		BMD		BMC	
			RG	C	RG	C	RG	C	RG	C
Biacromial (cm)	29.8±1.5	29.2±1.9	0.226	0.686**	0.211	0.627**	–0.029	–0.027	0.281	0.105
Biiliocristal (cm)	20.5±1.5	20.5±1.2	0.050	0.601**	0.102	0.707**	0.031	–0.053	0.133	0.011
Foot length (cm)	20.2±1.0	20.4±1.1	0.220	0.560**	0.467**	0.619**	–0.326*	0.020	0.495**	–0.106
Sitting height (cm)	64.5±5.2	68.4±2.9***	–0.037	0.601**	0.199	0.657**	–0.086	0.024	0.170	0.147
Transverse chest (cm)	19.4±0.9	19.3±1.1	0.434**	0.657**	0.459**	0.553**	0.094	–0.072	0.546**	0.115
Anterior-posterior chest depth (cm)	33.1±0.9	33.2±0.9	0.009	0.490**	0.124	0.391**	0.130	0.000	0.216	–0.070
Humerus (cm)	5.3±0.3	5.2±0.4	–0.009	0.439**	0.004	0.403**	0.075	–0.108	0.007	–0.158
Femur (cm)	7.6±0.3	7.7±0.5	–0.014	0.385*	0.216	0.430**	–0.088	–0.155	0.254	–0.085

rhythmic gymnasts as a rule lower limbs lengths correlated significantly with spine and femoral neck BMD and BMC (Table 5).

In control group as a rule all breadth parameters correlated significantly with BMD and BMC in L2-L4 but there were no significant relationships between breadth parameters and femoral neck BMD and BMC (Table 6). In rhythmic gymnasts transverse chest (r=0.434) had significant correlations with spine BMD; foot length (r= 0.467) and transverse chest (r=0.459) had significant relationships with lumbar spine BMC; foot length (r= –0.326) with femoral neck BMD; foot length (r=0.495), transverse chest (r=0.546) with femoral neck BMC.

Stepwise multiple regression analysis indicated that skinfold thicknesses influenced L2-L4 BMD only in controls. Probably most important is supraspinale and medial calf skinfold thickness which characterised spine BMD 38.2% (R^2x100). Supraspinale and iliac crest skinfold thicknesses characterised L2-L4 BMC 43.9% (R^2x 100). Calf girths are the most important parameter influencing BMD in L2-L4 52.3% (R^2x100) in controls. However, BMC in L2-L4 dependent only on mid-thigh girths 35.9% (R^2x100). BMD in L2-L4 was dependent on tibiale-laterale heights 30.0% (R^2x100). Interestingly different breadths influenced to a great extent L2-L4 BMD and BMC (Table 6). Biiliocristal breadths together with sitting height characterised BMC in L2-L4 BMD 62.3% (R^2x100).

Discussion

The main finding of the current study was that very young rhythmic gymnasts have similar values with controls in body height, BM, BMI and FFM. However, body fat % and FM are significantly higher and BMD and BMC in L2-L4 and femoral neck are significantly lower in controls than in rhythmic gymnasts. From the anthropometric parameters skinfold thicknesses are thicker in controls, on the girths, lengths and breadths there are very few significant differences between rhythmic gymnasts and controls. Lower body anthropometrical parameters are sensitive to BMD and BMC in L2-L4 in controls. Similar relationships absent in rhythmic gymnasts.

Rhythmic gymnasts are usually taller and thinner than untrained controls[4,5]. In our study there were no differences in body height and BM between young rhythmic gymnasts and sedentary controls. However, our rhythmic gymnasts had significantly lower FM and fat percentages (Table 1). Courteix et al.[6] also found significantly lower FM among rhythmic gymnasts and there were no significant differences between FFM compared to controls in his study.

There is few information available about the detailed anthropometric parameters in very young rhythmic gymnasts. Surprisingly, there were only few significant differences in anthropometric parameters between rhythmic gymnasts and controls. All skinfold thicknesses were thicker in controls. This is understandable because controls FM and fat % were higher too.

Di Cagno et al.[7] compared elite rhythmic gymnasts to sub-elite rhythmic gymnasts and found longer leg length and sitting height in elite rhythmic gymnasts. However, in our study rhythmic gymnasts had significantly lower values in sitting height compared to controls and there were no differences in leg length between the groups. All these different results in our study compared to the other authors might be caused by all the girls in our study being very young and the differences in anthropometric parameters, for example in leg length, body height and BM, might occur in later life.

Anthropometric parameters correlated significantly with BMD and BMC in L2-L4 (but not in femoral neck) only in control group. Higher skinfold thicknesses in trunk increased both BMD and BMC. Interestingly some lower body girths, lengths and breadths were critical parameters influencing spine BMD and BMC in controls. These are the first results indicating that especially lower body anthropometrical parameters are sensitive to the spine BMD and BMC in 7–8-year-old nonathletic girls. In rhythmic gymnasts with high spine and femoral neck BMD and BMC detailed anthrpometric parameters did not correlate significantly with BMD and BMC.

In our study rhythmic gymnasts had significantly higher BMD and BMC values in lumbar spine (L2-L4) and femoral neck compared to controls (Table 2). Courteix et al.[6] also found higher BMD and BMC values in the whole body and lumbar spine in gymnasts. Our results confirm that rhythmic gymnastics as a high-impact activity has a strong impact on BMD and BMC[3,23,24] and rhythmic gymnastics has therefore similar effect on bone like Dowthwaite et al.[23] found in artistic gymnastics. On the other hand, there is one study[16] available where artistic gymnastics had higher osteogenic stimulus than rhythmic gymnastics. To our knowledge, no study has yet reported morphological differences in 7–8-year-old rhythmic gymnasts. Relatively short time (1–3 years) intensive exercising decreasing their body fat and increasing BMD and BMC.

Impact-loading sport can increase the BMD in the stressed sites of the skeleton[9] and the correlation between body composition and BMD seems to be also site-specific[13–14]. Our results confirmed this. Besides the site-specific effect body composition seems to have more effect on controls than gymnasts. Total BM is a good predictor for bone mass in children[25]. In our study there were no significant relationships between femoral neck and L2-L4 BMC and BM (Table 1). These results are surprising, but we can explain this with relatively low BM which is specific in rhythmic gymnasts. Probably the intensive high-volume exercising is a more powerful predictor of bone parameter than body composition parameters.

Higher FM promotes higher BMD through the weight bearing[18]. In gymnasts changes in body fat are related to changes in BMD[17]. In this study rhythmic gymnasts had significantly lower values in FM and fat % compared with controls but they had significantly higher values in BMD (in all measured sides) compared to controls. Controls had higher values in FM and they had also more significant correlations with BMD. These results show clear relationship between FM and BMD. Gymnasts have higher values in BMD and BMC because of the influence of gymnastics.

There were no differences in FFM between the rhythmic gymnasts and controls (Table 1). But differences emerged in relationships between FFM and BMD between the two groups in our study. In control group FFM correlated significantly with L2-L4 BMD. Unlike the BMD, BMC was significantly correlated with FFM in gymnasts. There was also significant relationship between FFM and BMC in controls. In previous studies, change in FFM was strongly correlated with the change in BMC during the growth[16,25,26] and FFM is named as best predictor for BMC[16]. The muscle-bone relationship during growth is explained by the indirect osteogenetic effect theory – bigger muscles exert higher tensile forces on the bones they attach[27], and by direct osteogenetic effect theory – exercise stimulate both muscle and bone development[28].

We acknowledge some limitations of our study, the first stemming from the cross-sectional design and secondly, from the relatively small groups of subjects. Thirdly, there was not included an experimental group of same age girls who exercise using not weight-bearing exercises (for example swimming).

In conclusion, we found that the relationships between anthropometry, body composition and bone parameters in young rhythmic gymnasts are weak. In control group first of all lower body anthropometric parameters significantly correlated with BMD and BMC in spine.

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ODNOS IZMEĐU ANTROPOMETRIJSKIH PARAMETARA, TJELESNE GRAĐE I MINERALA U KOSTIMA KOD SEDMO- I OSMOGODIŠNJIH RITMIČKIH GIMNASTIČARA

S A Ž E T A K

Cilj ovog istraživanja bio je proučiti odnos između specifičnih antropometrijskih parametara (devet kožnih nabora, trinaest opsega, osam dužina i osam širina), tjelesne građe (postotak tjelesne masnoće, nemasna masa, masna masa) i minerala u kostima (mineralna gustoća kostiju, mineralni udio u kostima) kod mladih ritmičkih gimnastičara i kontrolne skupine iste dobi. Osamdeset i devet sedmo- i osmogodišnjakinja je sudjelovalo u ovoj studiji i podijeljene su u ritmičke gimnastičarke (n=46) i kontrolnu skupinu (n=43). Tjelesna građa je utvrđena dvoenergijskom apsorpcijometrijom. Udio masnoće u tijelu i udio masne mase je bio niži, a mineralna gustoća kostiju i mineralni udio u kostima u lumbalnom dijelu kralježnice viši kod gimnastičarki nego kod kontrola. Svi mjereni kožni nabori su bili deblji kod kontrola, dok kod opsega, dužina i širina nije bilo značajnih razlika među skupinama. Iz dobivenih rezultata možemo zaključiti da je povezanost antropometrije, tjelesne građe i koštanih parametara kod mladih gimnastičara slaba. Kod kontrolne skupine su prvenstveno antropomoterijski parametri donjeg dijela tijela značajno korelirali s mineralnom gustoćom kostiju i udjelom minerala u koštanoj masi.