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BODY MASS INDEX AS A PREDICTOR OF IMPORTANT DECREASE OF BONE MINERAL DENSITY

INDEKS TELESNE MASE KOT NAPOVEDOVALEC ZMANJŠANJA MINERALNE GOSTOTE KOSTI

Abstract

The research was conducted on a sample of 40 players members of the *Železničar Niš* football club (professional athletes) and on the Faculty of Occupational Safety student population (40 non-athletes) in order to determine the body mass index (BMI) and bone composition condition of the research subjects. The research included the measurement of bone mineral density (BMD) in the lumbar region of the spinal column and hip articulation of the subjects. None of subjects had previously participated in any such research. The measuring device used for the evaluation of BMD was a state-of-the-art Lunar DPX Dual Energy X-ray Absorpciometry-DEXA densitometer. This research also examined whether BMI can be a predictor of important decrease of bone mineral density values near the spinal column and near the hip articulation.

Key words: body mass index (BMI), bone mineral density (BMD), prediction.

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Povzetek

V raziskavo je bilo vključenih 40 poklicnih igralcev nogometnega kluba *Železničar Niš* in 40 študentov Fakultete za varnost pri delu, ki niso bili vrhunski športniki. Pri obeh skupinah smo določili indeks telesne mase (BMI) in stanje sestave kosti. Raziskava je vključevala merjenje mineralne gostote kosti (BMD) v ledvenem delu hrbtenice in kolku. Nihče izmed merjencev predhodno ni sodeloval v podobni raziskavi. Merilna naprava za določanje BMD je bil poseben DXP Dual Energy rentgenski Absorpciometry-DEXA merilnik gostote. V raziskavi smo ugotavljali tudi, ali je BMI lahko napovedovalec zmanjševanja mineralne gostote kosti na področji hrbtenice in kolkov.

Ključne besede: indeks telesne mase (BMI), mineralna gostota kosti (BMD), napovedovanje

INTRODUCTION

Regular physical activities exert direct and positive influence on the health and physical condition of people. Exercise reduces the risks of developing certain chronic diseases and contributes significantly to a longer life expectancy.

The skeletal system should be strong enough to support body weight as well as the efforts and loads to which people are exposed in life, as well as excess loads in certain situations including sports trainings and competitions. Various phenomena negatively influence the skeletal system; one of the most common is osteoporosis.

Osteoporosis means "porous bones" and causes feebleness and brittleness of bones so that minimal physical activity could induce fracture. Generally, the skeletal system declines when a person possesses low levels of vitamin D, calcium, phosphor and other minerals in the bones. Osteoporosis can also be a consequence of the disturbances in the functioning of the endocrine system or the consequence of intensive administration of medicine, such as corticosteroids.

Most fractures caused by osteoporosis are in the area of spinal column, hip and wrist.

Bones are constantly changing by the process of remodelling in which the new bone tissue replaces the existing one (Bubanj, S. & Obradović, 2002). Bones develop from new binding tissue called mesenhim which grows two types of cells, new bone cells (osteoblasts) and large bone cells (osteoclasts). Osteoblasts generate bone tissue, and osteoclasts cause decay of bone tissue. Both types of cells act continuously and simultaneously, which is important for the normal development and formation of bone tissue (Bubanj, R., 1997 a; 1997 b). A complete cycle of bone remodelling lasts from two to three months. In a younger person, new bone cells are formed more rapidly and in larger quantity than the existent ones, which are reabsorbed so that the total bone mass increases. Bone mass reaches its peak in the middle thirties.

The main aims of this research were to determine possible existence of important decrease of bone mineral density (BMD) in subjects, and if body mass index (BMI) can be a predictor of important decrease of BMD in subjects, in the case of osteopenia or osteoporosis determination.

METHOD

Participants

The research was conducted on the sample of 80 male subjects. The sample was comprised of 40 non-athletes chosen from the students population of the Faculty of Occupational Safety in Niš, who were not engaged in systematic sports training, aged between 19 and 35, and 40 football players of the Železničar football club in Niš, aged between 17 and 34, who have played this sport professionally for at least three years, and are competing in the First Serbian Football League.

Measurements of body height, body weight and bone mineral density were performed in Radon Rehabilitation Centre in Niška Banja.

Variables

The used variables included body mass index (BMI), reported in kg/m^2; bone mineral density near the spinal column (BMDSPINE), reported in g/cm^2; and bone mineral density near the hip articulation (BMDHIP), reported in g/cm^2.

Instruments

Stadiometer was used for the measurement of body height, length of lower extremity, span of upper extremities and sitting height. It measured with accuracy of 0.1 cm. An abbreviated stadiometer was used for the measurement of body segments (length of lower extremity, upper extremity, feet, hand etc.). Medical scales which measure with an accuracy of 0.1 kg were used. Before measuring, the scales were placed on hard flat surface. The accuracy of measurement was verified by using weights 10 or 20 kg placed on the scales before measurement (Đurašković, 2002).

The instrument for the evaluation of bone mineral density, when using the DEXA method was a Lunar DPX densitometer of current technology, which is based on dual photon absorptiometry of X-rays (Dual Energy X-ray Absorpciometry – DEXA apparatus). The accuracy and reproducibility of this instrument amounts to 1%. Anterior-posterior examination of lumbar vertebras L1-L4 was performed. The obtained data were processed by Lunar Software. Absolute values of bone mineral density (bone mineral density-BMD) were obtained, reported in g/cm² for each examined vertebra, mean values of vertebras density L1-L4 are reported in absolute values (g/cm²).Values which were +/- one standard deviation upon 100% of values, i.e. +/-12%, were conceived normally (Dimić, M, 2005).

Procedures

With a view of representing the distribution of analyzed variables, descriptive statistics were applied. A t-test for independent samples was used, as well as method of survival analyses in aim of diagnosis the important decrease of BMD based on BMI.

RESULTS

Table 1: Descriptive statistics of BMD variables in subjects with confirmed osteopenia near the spinal column (N=6), and hip articulation (N=3) and non-affected subjects (absolute values of BMD in g/cm²).

Variables		Valid N	Mean	Std. Dev.	Std. Error Mean
bmdspine	.00	74	1.3404	.11480	.01334
	1.00	6	1.0188	.04010	.01637
bmdhip	.00	77	1.3208	.13861	.01580
	1.00	3	.8753	.07836	.04524

Table 1 shows descriptive statistics of BMD variables, upon examination near the spinal column and hip articulation. Osteopenia was confirmed in six subjects (one athlete and five non-athletes) near the spinal column, and in three subjects (non-athletes) near the hip articulation.

Table 2: Descriptive statistics of BMI variable (in kg/m²) of subjects with confirmed osteopenia near the spinal column (N=6) and non-affected subjects (N=74)

Variable	N	Mean	Std.Deviation	Std. Error Mean
BMI .00	74	24.0621	2.71096	0.31514
BMI 1	6	21.4739	1.76204	0.71935

Table 2 gives descriptive statistics of BMI variables, after examination in region of spinal column (L_1-L_4), of subjects in whom the important decrease of BMD values was confirmed (N=6), and non-affected subjects (N=74).

Table 3: T-test for independent samples and testing of the existence of differences in BMD values between subjects in whom the important decrease of BMD values was confirmed (N=6), and non-affected subjects (N=74), near the spinal column

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
BMD SPINE	Equal variances assumed	4.505	.037	15.224	13.445	.000	.32155	.02112	.27607	.36702

To test the existence of differences of BMD variable near the spinal column among subjects in whom the important decrease of BMD values was confirmed (N=6) and non-affected subjects (N=74), a t-test for independent samples was applied. The results are presented in Table 3. The significance of the t-test ($p=0.000<0.05$), indicates the existence of statistically important differences of BMD values between these two groups of subjects.

Table 4: T-test for independent samples and testing of the existence of differences in BMD values between subjects in whom the important decrease of BMD values was confirmed (N=3), and non-affected subjects (N=77), near the hip articulation

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
BMD HIP	Equal variances assumed	1.044	.310	5.509	78	.000	.44545	.08085	.28448	.60642

To test the existence of differences of the BMD variable near the hip articulation, among subjects in whom the important decrease of BMD values was confirmed (N=3), and non-affected subjects (N=77), a t-test for independent samples was applied. The results are presented in Table 4. The significance of the t-test ($p=0.000<0.05$), indicates the existence of statistically important differences of BMD values between these two groups of subjects.

Table 5: T-test for independent samples and testing of existence of differences in BMI values between subjects in whom the important decrease of BMD values was confirmed (N=6), and non-affected subjects (N=74), upon examination near the spinal column

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
BMI	Equal variances assumed	0.301	0.585	2.292	78	0.025	2.58827	1.12924	0.34013	4.83641

To test the existence of differences of BMI variable near the spinal column, among subjects in whom the important decrease of BMD values was confirmed (N=6), and non-affected subjects (N=74), a t-test for independent samples was applied. The results are presented in Table 5. The significance of the t-test ($p=0.025<0.05$) indicates the existence of statistically important differences of BMI values between these two groups of subjects. The existence of differences indicates that variable BMI could be indicator of important decrease of bone mineral density values near the spinal column. In order to confirm this hypothesis, ROC analysis was performed (Diagram 1 and Table 6).

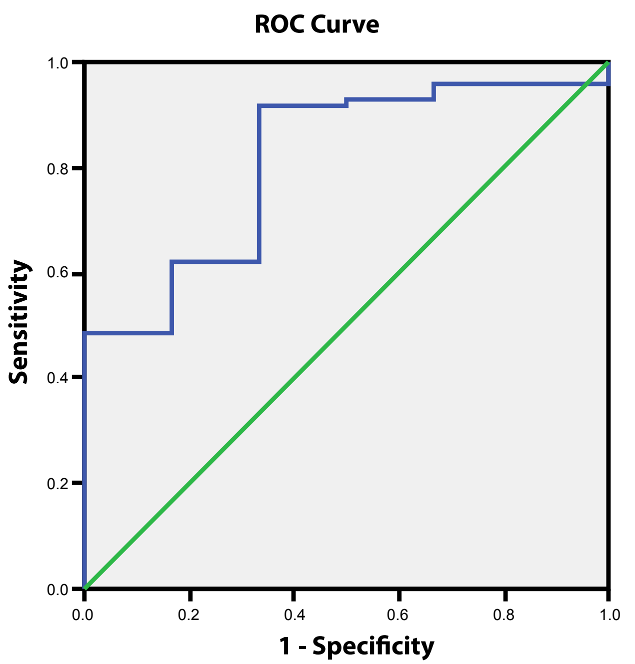

Diagram 1: ROC curve (blue) refers to the area below curve

Table 6: ROC analysis of BMI variable, upon BMD examination near the spinal column

Area	Std. Error(a)	Asymptotic Sig.(b)	Asymptotic 95% Confidence Interval	
			Lower Bound	Upper Bound
0.813	0.082	0.011	0.652	0.975

a) Under the nonparametric assumption
b) Null hypothesis: true area = 0.5

Based on the results of ROC analysis (Diagram 1 and Table 6), a conclusion can be drawn that the area below ROC curve (0.813) is significantly larger than 0.5 by reason of test significance, which is $p=0.011<0.05$. The test significance indicates that BMI can be an indicator of the important decrease of bone mineral density values near the spinal column.

Table 7: Values of BMI variable of all examined subjects are presented from minimum to maximum, upon BMD examination near the spinal column

Coordinates of the Curve						
Test Result Variable(s): BMI						
BMI	Sensitivity	1 - Specificity		BMI	Sensitivity	1 - Specificity
17.11541	1	1		23.78711	0.527027	0.166667
18.8603	0.986486	1		23.84862	0.513514	0.166667
19.61421	0.972973	1		23.90665	0.486486	0.166667
19.74588	0.959459	1		23.93217	0.486486	0
19.87619	0.959459	0.833333		23.96318	0.472973	0
20.19947	0.959459	0.666667		24.0219	0.459459	0
20.522	0.945946	0.666667		24.07495	0.432432	0
20.62231	0.932432	0.666667		24.1035	0.418919	0
20.73847	0.932432	0.5		24.13865	0.405405	0
20.91144	0.918919	0.5		24.19175	0.391892	0
21.13131	0.918919	0.333333		24.30564	0.378378	0
21.24864	0.905405	0.333333		24.40256	0.364865	0
21.39795	0.891892	0.333333		24.45193	0.351351	0
21.50127	0.878378	0.333333		24.5027	0.337838	0
21.5663	0.864865	0.333333		24.54673	0.324324	0
21.65423	0.851351	0.333333		24.63461	0.310811	0
21.69844	0.837838	0.333333		24.7635	0.297297	0
21.75876	0.824324	0.333333		24.87548	0.283784	0
21.98005	0.810811	0.333333		24.94618	0.27027	0
22.20879	0.783784	0.333333		25.01818	0.256757	0
22.26975	0.77027	0.333333		25.09357	0.243243	0
22.29597	0.756757	0.333333		25.18858	0.22973	0
22.35238	0.743243	0.333333		25.27813	0.216216	0
22.42171	0.72973	0.333333		25.30779	0.202703	0
22.4816	0.716216	0.333333		25.47444	0.189189	0

BMI	Sensitivity	1 - Specificity		BMI	Sensitivity	1 - Specificity
22.55151	0.702703	0.333333		25.88135	0.175676	0
22.61761	0.689189	0.333333		26.17851	0.162162	0
22.82	0.675676	0.333333		26.24976	0.148649	0
23.1193	0.662162	0.333333		26.28076	0.135135	0
23.27354	0.648649	0.333333		26.40419	0.121622	0
23.31761	0.635135	0.333333		27.3184	0.108108	0
23.3614	0.621622	0.333333		28.24626	0.094595	0
23.3981	0.621622	0.166667		28.38129	0.081081	0
23.43215	0.608108	0.166667		28.40162	0.067568	0
23.4823	0.594595	0.166667		28.97252	0.054054	0
23.509	0.581081	0.166667		29.72688	0.040541	0
23.52904	0.567568	0.166667		30.18733	0.027027	0
23.60957	0.554054	0.166667		32.86126	0.013514	0
23.71834	0.540541	0.166667		36.26476	0	0

The value of the BMI variable that separates two groups of examined subjects (with osteopenia and without significant decrease of bone mineral density values), upon BMD examination near the spinal column is 21.13 kg/m² (Table 7).

Table 8: Prediction effectiveness of significant decrease of bone mineral density values by using variable BMI of both groups of examined subjects, upon BMD examination near the spinal column

	BMI test		Total
	0	1	
OSTSPINE .00	68	6	74
1.00	2	4	6
Total	70	10	80

With the application of this prediction, the existence of significant decreases of bone mineral density values was not confirmed in 68 of the 74 subjects, without significant decrease of bone mineral density values near the spinal column. In four of the six subjects with osteopenia, significant decreases of bone mineral density values near the spinal column were confirmed, which represents 88% of prediction effectiveness, by using BMI variable (Table 8).

Table 9: Descriptive statistics of BMI variable (in kg/m^2) of subjects with confirmed osteopenia and non-affected subjects, upon BMD examination near the hip articulation

Variable	N	Mean	Std. Deviation	Std. Error Mean
BMI .00	77	23.8789	2.74862	.31323
BMI 1	3	23.5877	2.71910	1.56988

Table 9 presents descriptive statistics of BMI variables upon examination near the hip articulation, in subjects with confirmed significant decreases of bone mineral density values (N=3) and non-affected subjects (N=77).

Table 10: T-test for independent samples and testing of the existence of differences in BMI values between subjects with confirmed osteopenia (N=3) and non-affected subjects (N=77), upon examination near the hip articulation

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
BMI	Equal variances assumed	.000	.992	.180	78	.858	.29128	1.61709	-2.92811	3.51066

To test the existence of differences of BMI variable near the hip articulation, between subjects with confirmed osteopenia (N=3) and non-affected subjects (N=77), a t-test for independent samples was applied, the results of which are presented in Table 10.

The significance of t-test (p=0.858>0.05), does not indicate the existence of statistically important differences of BMI values between these two groups of subjects.

The non-existence of significant differences indicates that variable BMI could not be an indicator of important decrease of bone mineral density values near the hip articulation, which represents the result of ROC analysis (Diagram 2 and Table 11).

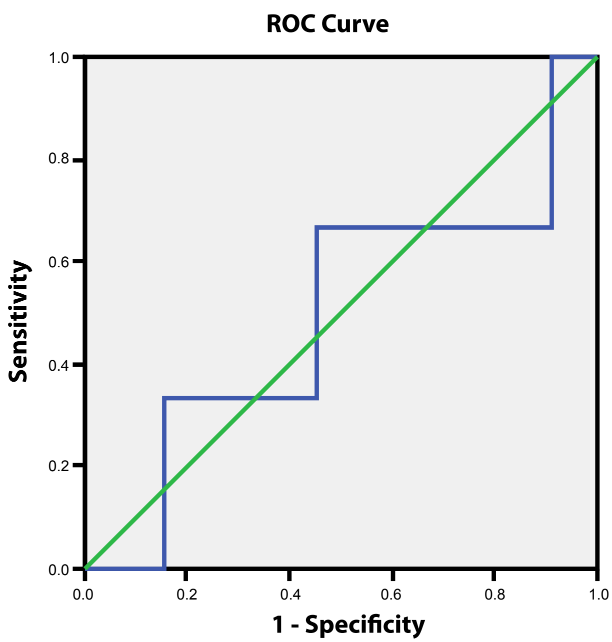

Diagram 2: ROC curve (blue) refers to the area below curve

Table 11: ROC analysis of BMI variable, upon BMD examination near the hip articulation

Area	Std. Error(a)	Asymptotic Sig.(b)	Asymptotic 95 % Confidence Interval	
			Lower Bound	Upper Bound
.494	.183	.970	.136	.851

a) Under the nonparametric assumption
b) Null hypothesis: true area = 0.5

Based on the results of ROC analysis (Diagram 2 and Table 11), that conclusion can be drawn that area below ROC curve (0.494) is not significantly different in relation to 0.5 (p=0.970>0.05).

DISCUSSION

Concerning the values of body mass index (BMI), the confirmed important decrease of BMD, i.e. osteopenia in one athlete and five non-athletes near the spinal column, and in three non-athletes near the hip articulation, the discussion is given below.

In spite of high levels of professional sport physical activity, the determined important decrease of BMD near the spinal column (osteopenia) in one athlete is the most likely a consequence of genetics factors i.e., family case-history (mother has osteoporosis),

The determined important decrease of BMD near the spinal column i.e. osteopenia in five non-athletes and determined important decrease of BMD near the hip articulation i.e. osteopenia in three non-athletes is most likely a consequence of several factors, such as lower level of physical activity, factors which have exerted influence before the commencement of their recreational sports activities and quotidian physical activities i.e. genetic factors, hormonal factors related to the phase of growth (puberty), presence of risk factors (smoking, alcohol, chronic diseases, administration of certain drugs, etc.), apparently influenced the BMD values.

The existence of significant differences in values of variable BMI (p=0.025), between examined subjects in whom it was confirmed important decrease of bone mineral density values (N=6) and examined subjects in whom it was not the case (N=74) near the spinal column indicates that variable BMI is an indicator of important decrease of bone mineral density (BMD) near the spinal column,

The non-existence of significant differences in values of variable BMI (p=0.858), between examined subjects in whom it was confirmed important decrease of bone mineral density values (N=3) and examined subjects in whom it was not the case (N=77) near the hip articulation, points out to the fact that variable BMI is not an indicator of important decrease of bone mineral density (BMD) near the hip articulation.

In research conducted by Galvan et al. (2009), the authors concluded that BMD is negatively associated with the adiponectin levels in men older than 60 years and this relationship is greater in those men with BMI >27, which suggests a plausible connection between bone and fat tissue. Bundred (2009) concluded that risk factors for premature bone loss and fracture include a low BMI, family history or personal history of fragility fracture after the age of 50, oral corticosteroid use more than six months and cigarette smoking. In research conducted by Garcia-Carrasco et al. (2009), authors indicated that chronic disease damage, low BMI, and cumulative corticosteroid dose are risks factors for low BMD in pre-menopausal patients with systemic lupus erythematosus (SLE).

In research conducted by Nar-Demirer et al. (2009), the authors stated that patients with radial and/or lumbar and/or hip osteoporosis had a longer duration of diabetes, were older, and had a lower BMI, compared with non-osteoporotic subjects. In research conducted by Christo et al. (2008), the authors found that athletes with amenorrhea had lower bone-density z-scores at the spine and whole body, compared with athletes with eumenorrhea and control subjects, and lower hip z-scores, compared with athletes with eumenorrhea. Also, athletes with amenorrhea had lower BMI z-scores than athletes with eumenorrhea and lower insulin-like growth factor I-levels than the control subjects. In research conducted by Naka et al. (2005), the authors found significant positive correlations between BMD at every skeletal site and height, weight and grip strength in pre- and post-pubertal boys and girls. In research conducted by Misra et al. (2004), the authors found that all measures of bone mineral density (z-scores) were lower in girls with anorexia nervosa (AN) than in control subjects, with lean body mass, body mass index, and age at menarche emerging as the most important predictors of bone density. In research conducted by Barondess et al. (1997), the authors found that whole body bone mineral content (WBBMC), WBBMC/height, and whole body bone mineral density (WBBMD) were strongly and significantly correlated with weight, body mass index (BMI), and body composition.

The adjusted research considered a young, male population, with relatively good social status. Although body mass index (BMI) is related to bone mineral density (BMD), the potential mechanism(s) of this relation have yet to be defined. The results obtained by the research indicate the role of oestrogen and other hormonal factors in mediating fat mass effects on the skeleton.

REFERENCES

Barondess, D. A., Nelson, D. A., Schlaen, S. E. (1997). Whole body bone, fat, and lean mass in black and white men. Journal of Bone and Mineral Research,12(6): 96 –71.

Bubanj, R. (1997a). *Basics of applied biomechanics in sports.* Niš: SIA.

Bubanj, R. (1997b). *Basics of applied biomechanics in kinesiology.* Niš: SIA.

Bubanj, S., Dimić, A., Stanković, R., Obradović, B., Bubanj, R., Bubanj, M. & Bojanić, V. (2007). Influence of isometric and ballistic muscular potential on differences in bone mineral density in region of spinal column and hip articulation at sportsmen and non-sportsmen. *Balneoclimatologia,* 31(4), 169–181.

Bubanj, S. & Obradović, B. (2002). Mechanical force and bone density. *Facta Universitatis series Physical Education and Sport,* 1(9): 37–50.

Bundred, N. (2009). Aromatase inhibitors and bone health. *Current Opinion in Obstetrics and Gynecology,* 21(1): 60–67.

Christo, K., Prabhakaran, R., Lamparello, B., Cord, J., Miller, K., Goldstein, M., Gupta, N., Herzog, D., Klibanski, A. & Misra, M. (2008). Bone Metabolism in Adolescent Athletes with Amenorrhea, Athletes with Eumenorrhea, and Control Subjects. *Pediatrics,* 121(6): 1127–1136.

Dimić, M. (2005). *The influence of anticonvulsive drugs on bone metabolism of children affected by epilepsy.* Unpublished doctoral dissertation, Niš: Faculty of Medicine.

Đurašković, R., (2002). *Sports medicine.* Niš: SVEN.

Galvan, R., Cordova, N., Saucedo, R., Vargas, C., Campos, S., Halley, E., Avelar, F. & Zarate, A. (2009). Adiponectin is associated with low bone mineral density in elderly men. *European Journal of Endocrinology,* 160(2): 289–293.

Garcia-Carrasco, M., Sandoval-Cruz, H., Escarcega., O., Jimenez-Hernandez, M., Etchegaray-Morales, I., Soto-Vega, E., Munoz-Guarneros, M., Lopez-Colombo, A., Deleze-Hinojosa, M., Cervera, R. (2009). Risks factors for low bone mineral density in pre-menopausal Mexican women with systemic lupus erythematosus. *Clinical Rheumatology,* 28(1): 65–70.

Misra, M., Aggarwal, A., Miller, K. K., Almazan, C., Worley, M., Soyka, L. A., Herzog, D. B. & Klibanski, A. (2004). Effects of anorexia nervosa on clinical, hematologic, biochemical, and bone density parameters in community-dwelling adolescent girls. *Pediatrics,* 114(6): 1574–1583.

Nar-Demirer, A., Bascil-Tutuncu, N. & Ertorer, E. (2009). *Prevalence of osteoporosis and factors affecting bone mineral density among postmenopausal Turkish women with type 2 diabetes.* Journal Of Diabetes And Its Complications, 23: 12– 7.

Naka, H., Iki, M., Morita, A. & Ikeda, Y. (2005). *Effects of pubertal development, height, weight, and grip strength on the bone mineral density of the lumbar spine and hip in peripubertal Japanese children: Kyoto kids increase density in the skeleton study (Kyoto KIDS study).* J. Bone Miner. Metab., 23(6): 463–9.