Advance Journal of Food Science and Technology 8(4): 267-272, 2015
DOI:10.19026/ajfst.8.1506
ISSN: 2042-4868; e-ISSN: 2042-4876

Submitted: December 20, 2014 Accepted: January 27, 2015 Published: May 20, 2015

Research Article

The Characteristic of Energy Metabolism and Nutritional Supplement of Volleyball Athletes

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Abstract: Substantial metabolism and energy metabolism is the base of the normal operation for every organ. Nutrition arrangement instructed by the knowledge about the regularities of metabolism is very significant. The purpose of the presented study was the examination of nutrition intake influence on energy metabolism in young volleyball players. The study was performed in twenty four 16-18 years old male volleyball players in the competition period. Subjects were divided into 2 groups, depending on the calcium intake: more than 1300 mg/day in the first group (13 athletes); and less than 1300 mg/day in the second group (11 athletes). The nutrition mode assessment was based on the 24-h dietary history using the recall method. In the blood serum concentrations of osteocalcin, alkaline phosphatase (bALP), C-terminal telopeptide of collagen I (ICTP), insulin-like growth factor-1 (IGF-1), insulin-like-growth factor-binding protein-3 (IGFBP-3), growth hormone (hGH) and ionized calcium and magnesium were determined. Statistical analysis showed significant differences between both groups investigated in respect to the calcium ($p<0.01$) and protein ($p<0.05$) intake and the bALP and (IGFBP-3) concentrations ($p<0.05$). The results of the study led us to conclude that low calcium and protein intake together with systematic sport activity negatively influenced the bone formation level. At last to improve the capacity of sports man we give some advice such as the methods of volleyball train and supplying some nutrient matter in the training.

Keywords: Energy metabolism, nutritional supplement, substantial metabolism, volleyball athletes

INTRODUCTION

Volleyball is an explosive, quick power driven sport. What propels the ball over the net is energy, primarily anaerobic muscle energy, for serving, spiking, blocking, digging and rolling. Long rallies and training sessions are fueled by a combination of anaerobic glycolysis and aerobic metabolism-a combination of fuels from the breakdown of muscle sugars called glycogen and a balanced diet containing carbohydrates, protein and fats (Bass *et al*., 1998). The key to peak performance volleyball nutrition is pre game fuel, intermatch replenishment and consistent glycogen building-keeping the ball airborne means keeping the players fed and hydrated.

Generally, young athletes may be inclined to stress fracture. Proper nutrition can play a valuable role in avoiding such injuries, as inappropriate nutrition may contribute to sport injuries. Adequate intake in calories and nutrients also may prevent hormonal disturbances, such as oligomenorrhea, delayed menarche and amenorrhea (Baxter, 1993). Unfortunately, improper nutrition appears to be a common problem among young athletes. Several researchers suggest that athletes do not meet their nutritional needs and perhaps it is for this reason that these athletes have not reached their potential maximum performance.

Volleyball demands a combination of both aerobic and anaerobic energy. Proper nutrition is critical in order to enable the volleyball player to reach his or her peak performance and replace the lost energy (Beardsworth *et al*., 1990). Very limited data are available concerning the nutritional intake of volleyball players, either adults or adolescents, although there are review studies covering good nutrition for volleyball.

Available literature contains very few papers studying the physiological and biochemical changes induced by heavy physical exercise performed by players during matches. According to literature, both single exercise stimulation and sport training may absolutely influence exercise metabolism and insulin resistance. However, excessive synthesis of reactive oxygen species has been noted during the competition period (characterized by physical and psychological loads) and along with mechanical injuries of the skeletal muscles, affects both insulin resistance and transmembrane transport (Bourrin *et al*., 2000). Therefore, the aim of this study was to analyze the effects of the annual training cycle on carbohydrate metabolism parameters and oxidative stress measures after supra-maximal exercise in members of the national beach volleyball team. Their anaerobic power was determined by means of the Wingate test, while aerobic capacity was measured by maximum oxygen uptake (Delany *et al*., 1994).

It is well recognized that bone mass is controlled by genetic factors, as well as largely by such environmental and lifestyle factors as nutrition and physical activity. Among nutrients calcium is the most important for attaining peak bone mass. The calcium component of bone mineral increases from about 25 g at birth to about 1000g by 15-20 years of age, which indicates that the inhibition in mineral accrual during the years of growth results in a deficit in the peak bone mineral content. Dietary calcium intake and physical activity interact with each other and their combined effects determine the extent to which the bone density genotype influences the peak bone mass achieved in young adulthood (Fehily *et al*., 1992). However, competitive sport requires intensive physical conditioning and nutritional demands are increased in active youths.

The present study was aimed, therefore, at an examination of calcium and other nutrients intake influence on bone metabolism in young male volleyball players.

MATERIALS AND METHODS

Materials: The study was performed in twenty four 16-18 years old male volleyball players in the competition period. The subjects, training for 2-9 years (mean 5.1±2.77), were divided into two groups depending on the calcium intake per day. The intake of calcium in the first group (13 athletes) was more than 1300 mg/day and in the second group (11 athletes) less than 1300 mg/day. The nutrition mode assessment was based on the 24-h dietary history using the recall method.

Research methods: During the competition period the volleyball players were training every day. The collective questionnaire for load recording and the record of training method groups were used. During the competition period the athletes trained at intensity levels I-V. The total volume of training in this period was 32.4 hours on the average (3.6h at the intensity level I, 5.4h - level II, 7.9h- level III, 7.2h - level IV and 8.3h - level V).

The venous blood was drawn for analysis in a fasting state, between 8 and 9 a.m. In the blood serum, concentrations of bone formation markers – osteocalcin and alkaline phosphatase (bALP)-were determined with the Metra Biosystem (USA) ELISA immunoenzyme method, while concentrations of the bone resorption marker-C-terminal telopeptide of collagen I (ICTP) and growth hormone (GH) were determined with Orion Diagnostica (Finland) radioimmunological tests. Concentrations of insulin-like growth factor-1 (IGF-1) and insulin-like growth factor-binding protein-3 (IGFBP-3) were analyzed using a radio immunological test produced by BioSource Europe. Concentrations of ionized calcium and magnesium were measured with Cormay tests.

Mann Whitney test was used for statistical analysis of the obtained results. Spearman correlation coefficients were calculated and were used to determine the relationships between the variables. The study got the approval of the Local Committee of Ethics in Scientific Research.

RESULTS AND DISCUSSION

Results display: Table 1 presents the mean values of anthropological parameters and biochemical indices for the two groups as well as their comparative analysis. No statistically significant differences were found with respect to age, age of puberty, body weight and BMI

Table 1: Mean values (±SD) and comparative analysis of anthropological and biochemical parameters in both groups of volleyball players

Parameter	The first group (Ca intake>1300 mg/d)	The second group (Ca intake <1300 mg/d)	p-value
Chronological age (years)	16.60±0.920	17.2±0.970	0.22
Age of puberty (years)	13.80±0.560	13.8±0.690	0.82
Weight (kg)	75.40±8.010	75.9±9.150	0.57
Height (cm)	183.7±7.210	185.1±6.35	0.79
BMI (kg/m^2)	22.40±2.770	22.11±2.28	0.79
Osteocalcin (ng/mL)	43.60±19.96	36.2±18.56	0.24
bALP (u/l)	56.80±25.58	39.0±12.61	0.03
ICTP (ug/l)	7.600±2.310	6.4±2.0600	0.27
IGF-1(ng/mL)	638±151.600	571±97.30	0.18
IGFBP-3(ng/mL)	3594±524.00	3207±297	0.04
GH (ulU/mL)	7.1±10.9700	5.2±8.720	0.49
Ca (mg/dl)	10.2±0.6500	11.1±1.40	0.27
Mg (mg/dl)	2.5±0.30000	2.5±0.410	0.98

Table 2: Mean values (±SD) and comparative analysis of dietary nutrient contents in both groups of volleyball players

Parameter	The first group (Ca intake>1300 mg/d)	The second group (Ca intake <1300 mg/d)	p-value
Energy (kcal)	3400±1362	2672±808.0	0.270
Protein (g)	156.1±67.5	98.4±19.71	0.012
Protein (g/kg/day)	2.000±0.80	1.30±0.390	0.013
Fat (g)	195.3±101.6	127.4±59.46	0.160
Carbohydrates (g)	490.1±219.9	327.1±155.2	0.052
Total Ca (mg)	2098±630	545±317	0.000
Ca in dairy products (mg)	1754±575	304±237	0.030
Mg (mg)	429.8±212.9	303.5±203.9	0.095

(Body Mass Index). The BMI values show regular body mass in all the subjects.

From biochemical indices, significant differences between two groups were noted for activity of bALP ($p<0.05$) and concentration of IGFBP-3 ($p<0.05$). The mean values of bALP activity and IGFBP-3 concentration in the first group were higher by 17.78 U/L and 387.33 ng/mL, respectively, in comparison with the mean values established in the second group.

Table 2 presents average intake of energy, protein, fat, carbohydrate, total calcium and calcium from dairy products and magnesium for both groups under study. In the first group significantly higher values of the daily intake of protein (by 57.7 g; $p<0.05$), protein calculated per 1kg of body weight (by 0.7 g/kg; $p<0.05$), total calcium (by 1553.0 mg; $p<0.01$) and calcium from dairy products (by 1449.5 mg; $p<0.01$) were observed as compared with the second group.

The negative correlation was noticed between the body weight and ICTP concentration and between BMI and osteocalcin concentration in both groups under study. Spearman's correlation coefficient for the relationship between the ICTP concentration and body weight was -0.609 ($p<0.05$) in the first group and -0.694 ($p<0.05$) in the second group. The values of this coefficient calculated in both groups for the osteocalcin concentration and BMI amounted to -0.842 ($p<0.01$) and -0.666 ($p<0.05$), respectively. In the second group a positive correlation was found between the osteocalcin concentration and protein intake per kg of body weight ($r = 0.920$; $p<0.01$).

The effect of nutrient intake on energy metabolism: There is strong evidence that physical activity in young age contributes largely to the higher peak bone mass. Some results indicate that resistance and high-impact exercise are the most beneficial. However, exercise-specific, local strain environment, systemic factors and diet play an interactive role in modulating the response of immature bone to exercise. In our study all the volleyball players trained in one club and all of them had an identical training regime.

A balanced diet, adequate calories and nutrients intake such as calcium and protein are the most important for attaining peak bone mass. Calcium and protein needs are greater during preadolescence and puberty (ages 9-17) than in childhood or adulthood. This period is characterized by the accelerated muscular, skeletal, endocrine and emotional development. The Institute of Medicine recommends calcium intake of 1300 mg per day for children and adolescents aged between 9 and 17 years. From our study only 54.2% of the volleyball players met these recommendations. The factor contributing to the low calcium intake in the second group, among other things, was dairy products restriction. The bad nutrition in this group may be associated with the fact that the majority of them lived in a boarding-schools and prepared food by themselves.

The statistical analysis showed that the group of volleyball players consuming diet with calcium content above its recommended level obtained higher concentrations of both bone formation markers. However, a significant difference between the groups was found only in respect to the bALP activity. Several previous studies showed that osteocalcin values were not influenced by dietary calcium intake, which can be confirmed by our results.

It is apparent from biochemical studies that the bALP activity depends on the presence of magnesium and zinc and may be decreased when deficits of these elements occur. In our study we determined the blood serum concentration of magnesium as well as the content of this mineral in the volleyball diet, however, we found no difference between both groups in respect to these measurements.

The higher level of bone synthesis in the first group as compared to the second group may be a result of higher calcium intake as well as the higher protein consumption. In the first group the average level of daily protein intake was 2.05 g per 1 kg of body mass and in the second group only 1.32 g/kg. The current recommended allowances for high quality dietary protein range from about 1.0 g/kg/d in adolescents to 0.75 g/kg/d in adults. There is a proposal to increase the protein intake in sport activity even by about 100%. Williams recommends the protein intake at the level from 1.4-1.8 g/kg/d in adult athletes. Based on these recommendations we may conclude that protein nutrition is sufficient in the first group and deficient in the second group. Dietary protein intake clearly determines the rates at which tissues synthesize and metabolize endogenous proteins. When protein nutrition is restricted in experimental animals, skeletal morphology is affected. The protein as well as calcium intake were correlated with bone mineral density even in well-nourished groups. In our study we also found a positive correlation between protein intake and the osteocalcin concentration but only in the group whose food protein contents was very poor.

The mechanism of energy metabolism: The mechanism of regulating bone metabolism by nutrients may be multifactorial. The insulin-like growth factor system can play a role in this mechanism. The IGF-1 blood concentration is modulated, among other things, by dietary protein contents. The effects of IGF-1 on bone are anabolic and stimulate longitudinal growth and bone mass. IGF-1 has both systemic and autocrine actions in bone. In spite of insignificant differences between the groups under study in relation to IGF-1 concentrations we found tendency to its higher level in the first group. However, the concentration of IGFBP-3 was significantly higher in this group as compared to the second group. The synthesis of IGFBPs is regulated by IGFs and other growth factors. IGFBP-3 levels best reflect the total IGF concentration, as IGFBP-3 in adults carries 80% of IGFs. Hayden *et al*. (1995) showed that the bioactivity of IGFs in bone tissue is modulated by several IGFBPs, mainly IGFBP-3, -4, -5. Therefore, the higher bone synthesis rate in the first group of volleyball players could be associated with a higher IGFBP-3 concentration and it cannot be excluded that it may be a result of dietary protein intake. IGFBP-3 is the predominant binding protein in serum and is a marker of growth hormone action. The growth hormone effect on bone formation may be mediated via regulation of the local production of IGFBPs in osteoblasts. However, in our study we observed no significant differences between GH concentrations in both groups.

Bone turnover markers levels are variable depending on the age. Its level peak at an approximate age of 14 years in boys represents the average age of peak linear growth in children. In our study this finding is confirmed by the negative correlation between the concentration of bone turnover markers, body weight and BMI. This is probably due to the decrease in the rate of anabolic processes in boys with higher values of body weight, caused by the completion of intensive growing up. Several studies showed that the gain in bone mass at adolescence was more a function of pubertal stage than chronological age. Because no differences between groups under study in respect to the chronological and biological age as well as the height and weight of subjects were found, we can suggest that anthropological factors did not contribute to different levels of bone biomarkers.

The results described in this study show that low calcium and protein intake together with systematic sport activity negatively influence the bone formation level. The decrease of the bone formation rate during human maturation may lead to lower peak bone mass.

Exercise and energy metabolism: Although exercise metabolism of muscle cells plays a significant role in the muscle's ability to perform work, recent studies have concentrated on other factors limiting exercise ability. One group of such factors is reactive oxygen species generated during physical exercise and another is adipokines that participate in carbohydrate metabolism and in inflammatory reactions.

Regular physical exercise increases insulin sensitivity since it stimulates the muscular uptake of glucose related to muscular contraction. It is also associated with an increased expression and their coding mRNA and with the enhancement of signal cascade element expression such as substrate-1 of the insulin receptor and the receptor itself. Our previous studies revealed that regular physical exercise increases the affinity of insulin receptor to its agonists. During the third (competitive) phase, however, the insulin resistance index was above this reference threshold. This increase in the insulin resistance index resulted from muscle injuries which took place during competition. Volleyball matches are characterized by numerous myofibrillar injuries, which induce weakened insulin signaling and decrease transmembrane transport of glucose. Since skeletal muscles are responsible for about 85% of post-exercise glucose uptake, their injuries induce a decrease in insulin sensitivity. Increased insulin resistance in volleyball players during the competitive phase compared to the training period was described by Kuo *et al*. (2006). In this study, the authors compared the curve of glucose tolerance after one week of matches with the respective curve after one week of volleyball training. An increase in insulin resistance was observed after the competitive phase and accompanied by higher activities of creatinine kinase - an enzyme which is an indicator of muscle injury.

In our study, resting blood insulin concentrations during the competitive phase were highest when compared to other phases, confirming the findings of Kuo *et al*. (2006). It should be noted that in our study, however, both glucose and insulin blood concentrations fit within respective reference limits in each studied phase. Studies on resistin and visfatin dealt mainly with their roles in the reduction of obesity-related insulin resistance. The visfatin has been shown to have insulin-mimetic activity, since binding to insulin receptor causes phosphorylation of protein tyrosine kinases Akt (protein kinase B) and MAPK (mitogen-activated protein kinase), with no influence on insulin binding itself. In this study, resting visfatin concentrations determined during the pre-competitive phase were twice as high as during the first and second preparatory phases and nearly three times higher when compared to the competitive and transitional phases. The test of maximal power was reflected by a decrease in the blood concentration of this compound in each of the study periods. This data is consistent with the results obtained by Jürimäe *et al*. (2009) who analyzed the effects of 2-hour low intensity exercise on visfatin concentrations in rowers. They observed a significant decrease in visfatin concentrations compared to baseline values at rest and to controls, 30 minutes after exercise testing was completed. Further research is needed to explain these findings.

The role of resistin in modulating insulin resistance is still controversial. It has been suggested that resistin plays a role in inflammatory reactions since its over-expression has been observed in human macrophages. Additionally, a study by Reilly *et al*. (2005), revealed a relationship between resistin concentration and levels of inflammatory factors: IL-6 and C-Reactive Protein (CRP).

Resistin concentrations at rest ranged from 7.4±1.64 to 10.1±2.76 ng/mL. After exercise they ranged from 8.1±1.55 to 9.6±3.06 ng/mL. The highest values were measured during the competitive phase of the training cycle, i.e., at the highest exercise overload. However, exercise test was shown to have no significant effects on resistin concentrations, irrespective of training cycle phase. The increase in resistin concentrations observed during the competitive phase may be related to excessive overload, resulting in the expression of proinflammatory cytokines. It is showed that intense physical exercise induces a 2 to 3 fold increase in TNF-α and IL-1β levels, while Pedersen and Hoffman-Goetz revealed that it may modulate dramatic increases in IL-6 levels.

Statistical analysis showed a significant inverse relationship between concentrations of visfatin and insulin ($p<0.05$) and between visfatin and resistin ($p<0.05$) during the preparatory phase of the training cycle. During the transitional phase, significant inverse associations were noted between resistin concentrations and HOMAIR ($p<0.05$) and between visfatin concentrations and BMI ($p\leq0.01$). These findings are in opposition to the results obtained by Perseghin who did not find any correlations in runners with a high sensitivity to insulin. Discrepancies between our results and those published by Perseghin also include differences in blood resistin concentrations and values of the insulin resistance index (WBISI). We used HOMAIR to determine the levels of insulin resistance in our study, while the aforementioned authors calculated WBISI using formula proposed by Matsuda and DeFronzo. Resistin concentrations observed across the annual training cycle ranged from 7.4±1.64 to 10.1±2.76 ng/ml in our study, whereas Perseghin claimed a mean value of 4.5±1.6 ng/mL in elite runners. Although one original article claimed that there was an association between resistin concentration and insulin resistance in obese rodents, further studies by Perseghin and Utzschneider did not find similar relationships in humans. Our study showed an inverse correlation between resistin concentrations and glucose tolerance, which may result from the fact that our study group was comprised of healthy, lean players. We also observed an inverse correlation between resistin and visfatin concentrations, along with correlations between visfatin concentrations and insulin levels or BMI. Other authors, such as Rubin, showed that a significant correlation exists between peak oxygen uptake and resistin concentration ($r = -0.37$, $p<0.05$) and between resistin concentration and HOMAIR ($r = 0.29$, $p<0.05$) in boys 10 to 14 years of age with elevated body weight. Similar associations were found by Tokuyama *et al*. (2007) in their study on Japanese women with type 2 diabetes.

Nutritional supplement forvolleyball athletes: Food energy, calories from foods and fluids are not uniquely different from other power team sports. A high carbohydrate diet of approximately 50-65% of total calories fuels both anaerobic and aerobic energy needs. The type of high carbohydrate foods that meet these needs include fruits, veggies, whole grain cereals, breads and pastas and low-fat dairy. Ten to twenty five (10-25%) of calories from protein provides additional power strength for muscle repair. Main meal foods such as lean meats, chicken, turkey, fish, nonfat cheeses, dairy and egg whites or egg beaters or protein fortified smoothies or trail mixes can meet these daily needs. Less than 30% from healthy fats are recommend for managing ideal competitive weights and can be met through snacks of nuts, nut butters, fish oils, avocado, soy and vegetable oil based salad dressings.

While carbohydrates are key to performance, special attention should be given to mineral rich carb choices to manage electrolyte losses from sweating. Replacement of sodium, potassium with sport drinks, lightly salted foods such as baked chips or pretzels, calcium fortification with low fat dairy snacks such as nonfat milk or yogurt and iron rich foods such as lean meats, poultry, fortified cereals, beans, or peas can assist with energy utilization, efficient muscle contraction and prevention of hyponatremia (low blood sodium) and hypokalemia (low blood potassium) which can impair performance. In addition, antioxidants vitamins E and C from a combination of nut and fruit snacks have been shown to assist in muscle repair and recovery in competitive athletes.

Volleyball nutrition is not complete without addressing fluid intake. The typical volleyball player may lose up to one or more pounds during practice or the equivalent of 16 oz of fluid. Therefore, a minimum of 2 cups of fluid prior to playing, 4-6 oz of fluid every 15 min of play and an additional 2 cups of fluid after practice should be consumed to management symptoms of dehydration. Athletes training and residing in warmer climates need to ensure round-the-clock hydration in order to prevent the cumulative effects of dehydration on training and performance.

The challenge to peak performance during competitive match means getting enough nutritious food while traveling. Players should prepare by taking a stash of sport or breakfast bars, shakes, sport drinks, crackers, trail mix, healthy soups like vegetable, bean, noodle or minestrone, small cereal boxes, fresh fruit and mini bagels on the bus or plane. Pregame meals should be light in fat, moderate in protein and carbohydrate based. Pasta with grilled chicken or shrimp, lean meat with baked potato or a lean meat, mayo-free 6-inch whole wheat sub will also work 2-3 hours before game time. If extra fuel is needed before play, a cup or two of sport drink, water with ½ a sport bar 1 hour before play may help the hungry player however whatever foods are consumed before competitive play should be tested beforehand in practice.

Volleyball requires explosive power, quickness, strength, endurance and precision. Competitions can last several hours and tournaments can go on for days. The team with the most endurance and strength is usually the winner. In order to perform their best, volleyball players must consume a diet that can meet all their energy needs. Most of this energy is used up in anaerobic activities, such as serving, spiking, digging and blocking. "Anaerobic" means "without oxygen" or in this case, parts of the body (such as the muscles) that don't need oxygen in order to function. While the major part of a volleyball player's diet should be rich in carbohydrates, it also must supply the player with foods rich in protein and healthy fats. In addition, water and sports drinks are needed to re-hydrate the system or replenish the electrolytes in the body that are lost while sweating.

CONCLUSION

In conclusion, our athletes consumed an inadequate diet both in quantity and quality. The poor nutritional habits were due to carbohydrate under consumption, which results in a higher fat contribution to energy intake. Nutrition counseling is essential in order for the volleyball players to increase carbohydrates while decreasing the fat content of their diets.

One of the first priorities of coaches and sports nutritionists should be the proper nutrition of their adolescent athletes. Many communication and intervention programs are necessary in order to convince the athletes to follow the scientific guidelines. This is, most of the time, an extremely difficult task. On one hand, the consumption of a high CHO diet is usually impractical and, on the other hand, adolescents are often unwilling to conform to the rules. It should be mentioned that a diet adequate in all macro- and micro-nutrients is of extremely high significance for adolescent athletes. Not only will a good diet boost their growth and performance, but it will act preventively against any future health disturbances.

ACKNOWLEDGMENT

The authors wish to thank the helpful comments and suggestions from my teachers and colleagues in intelligent detection and control lab of HIT at Weihai. And also thank Beijing Up-tech to provide part hardware. This work is supported by the study fund of HIT at Weihai (No. IMVQ02020003 and IMJQ21080002).

REFERENCES

Bass, S., G. Pearce, M. Bradney, E. Hendrick, P. Delmas, A. Harding and E. Seeman, 1998. Exercise before puberty may confer residual benefits in bone density in adulthood: Studies in active prepubertal and retired female gymnasts. J. Bone Miner. Res., 13: 500-507.

Baxter, R.C., 1993. Circulating binding proteins for the insulin-like growth factors. Trends Endocrin. Met., 4: 91-96.

Beardsworth, L.J., D.R. Eyre and I.R. Dickson, 1990. Changes with age in the urinary excretion of lysyl- and pyridinoline, two new markers of bone collagen turnover. J. Bone Miner. Res., 5: 671-676.

Bourrin, S., P. Amman, J.P. Bonjour and R. Rizzoli, 2000. Dietary protein restriction lowers plasma insulin-like growth factor-I (IGF-I), impairs cortical bone formation and induces osteoblastic resistance to IGF-I in adult female rats. Endocrinology, 141: 3149-3155.

Delany, A.M., J.M. Pash and E. Canalis, 1994. Cellular and clinical perspectives on skeletal insulin-like growth factor I. J. Cell. Biochem., 55: 328-333.

Fehily, A.M., R.J. Coles, W.D. Evans and P.C. Elwood, 1992. Factors affecting bone density in young adults. Am. J. Clin. Nutr., 56: 579-586.

Hayden, J.M., S. Mohan and D.J. Baylink, 1995. The insulin-like growth factor system and the coupling of formation to resorption. Bone, 17: 93S-98S.

Jürimäe, J., R. Rämson, J. Mäestu, P. Purge, T. Jürimäe, P.J. Arciero and S.P. von Duvillard, 2009. Plasma visfatin and ghrelin response to prolonged sculling in competitive male rowers. Med. Sci. Sport. Exer., 41(1): 137-143.

Reilly, M.P., M. Lehrke, M.L. Wolfe, A. Rohatgi, M.A. Lazar and D.J. Rader, 2005. Resistin is an inflammatory marker of atherosclerosis in humans. Circulation, 111: 932-939.

Tokuyama, Y., H. Osawa, T. Ishizuka, H. Onuma, K. Matsui, T. Egashira, H. Makino and A. Kanatsuka, 2007. Serum resistin level is associated with insulin sensitivity in Japanese type 2 diabetes. Metabolism, 56(5): 693-698.

Kuo, M.C., C.H. Chou, C.F. Ho, H.H. Lee, W.H. Chang, T.W. Lin, C.W. Hou, K.Y. Chien, T.C. Liu, C.H. Kuo, 2006. Glucose tolerance and insulin sensitivity following an one-week volleyball competition. Chin J Physiol, (49): 147-151.