



PASIG MONTHLY CITATION BLAST: No.64

September 2011

Dear PASIG members:

Abstract acceptances have been sent out and we hope to see many of you presenting in Chicago at CSM on Feb. 8-11, 2011. Let me know if you are presenting performing arts-related material and I will be sure to include you in our calendar in our January Blast. Please remind your students that the PASIG sponsors an annual student research scholarship. This award is to recognize students, who have had an abstract accepted to CSM, for their contribution to performing arts medicine and research. For more information on the research award please check our webpage (www.orthopt.org/sig_pa.php). Students with additional questions can contact Amy Humphrey (amy@lancasterpt.com)

PERFORMING ARTS CONTINUING EDUCATION AND CONFERENCES

****Performing Arts Independent Study Courses****

Orthopaedic Section Independent Study Course. *20.3 Physical Therapy for the Performing Artist.*

Monographs are available for:

- Figure Skating (J. Flug, J. Schneider, E. Greenberg),
- Artistic Gymnastics (A. Hunter-Giordano, Pongetti-Angeletti, S. Voelker, TJ Manal), and
- Instrumentalist Musicians (J. Dommerholt, B. Collier).

Contact: Orthopaedic Section at: www.orthopt.org

Orthopaedic Section Independent Study Course. *Dance Medicine: Strategies for the Prevention and Care of Injuries to Dancers.*

This is a 6-monograph course and includes many PASIG members as authors.

- Epidemiology of Dance Injuries: Biopsychosocial Considerations in the Management of Dancer Health (MJ Liederbach),
- Nutrition, Hydration, Metabolism, and Thinness (B Glace),
- The Dancer's Hip: Anatomic, Biomechanical, and Rehabilitation Considerations (G. Grossman),
- Common Knee Injuries in Dance (MJ Liederbach),
- Foot and Ankle Injuries in the Dancer: Examination and Treatment Strategies (M. Molnar, R. Bernstein, M. Hartog, L. Henry, M. Rodriguez, J. Smith, A. Zujko),
- Developing Expert Physical Therapy Practice in Dance Medicine – (J. Gamboa, S. Bronner, TJ Manal).

Contact: Orthopaedic Section at: www.orthopt.org

International Association for Dance Medicine and Science (IADMS) 21st Annual Meeting
October 13 – 16, 2011, Washington DC
Contact: www.iadms.org

For this September Citation BLAST, Krissy Sutton has compiled the topic, “Rhythmic gymnastics.” The format is an annotated bibliography of articles generally from the last decade. The PASIG Research Committee initiated this monthly Citation BLAST on performing arts-related topics in June 2005 in the hopes of encouraging our members to stay current in the literature and, perhaps, consider conducting research themselves. Each month we send a new list of performing arts (PA) citations to members of the PASIG to further the pursuit of PA-related scholarship. (Information about EndNote referencing software can be found at <http://www.endnote.com>, including a 30-day free trial).

A big welcome to new Research Committee members Annette Karim and Susan Fain! If you are interested in joining the Research Committee or putting your name forward as the new Research Chair, please contact me. I will step down in February 2012, but am willing to mentor the new chair if they would like me to do so. The President and Vice President will appoint my replacement at CSM 2012. As always, your comments, suggestions, and entry contributions to these Citation BLASTs are welcome. Please drop me an e-mail anytime.

Regards,
Shaw

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Rhythmic Gymnastics

Rhythmic gymnastics has historically been considered an Eastern European pastime. However, recently there has been an increase in the popularity of the sport in the United States, especially in metropolitan areas such as Chicago and New York. A significant portion of the current research regarding rhythmic gymnastics has been conducted in Greece, Italy and Canada, but because of similar training styles the results are applicable to gymnasts in the US. The major topics discussed over the past 10 years include injury prevalence, pre-performance preparation and the effect of gymnastics on bone mineral density.

Rhythmic gymnastics is an aesthetically pleasing combination of ballet and acrobatics. However, the movements place stress throughout both the upper and lower extremities, thus, injuries may occur at any point along the kinetic chain. As a physical therapist it is important to understand the global prevalence of injury in a specific population in order to guide preventative conditioning programs. In 2007, Cupisti *et al.*, reported that 38% of injuries occurred in the foot and ankle complex, followed by 22% in the back. On average gymnasts were able to return to physical activity after four days due to the moderate severity of injury. With regard to the foot and ankle complex, Biedert *et al.* in 2003 reported the possibility of a higher prevalence than may be expected of sesamoid stress fractures among rhythmic gymnasts. As the US strives to compete at a higher international level, rhythmic gymnasts will increase the number of holds, leaps and turns, placing more torque and load on the foot, predisposing them to injuries. The low back is the second leading anatomical site for injuries. Hutchinson *et al.*, 1999 agreed by stating that rhythmic gymnasts are at an elevated risk for suffering from low back injuries due to the nature of the sport. However, in 2004, Cupisti *et al.* found that control subjects reported more low back pain when compared to rhythmic gymnasts. Regardless of the contradicting evidence, Piazza *et al.*, in 2009, reported that former elite rhythmic gymnasts demonstrated a similar prevalence of low back pain when compared to control subjects. In this study, former rhythmic gymnasts reported earlier onset of pain after retiring from competition. Therefore, addressing preventative methods to manage low back pain early with these individuals may help improve long term quality of life. Although there was no mention of knee injuries in the previously cited articles, Dragoni *et al.* in 2009 performed a case study on two gymnasts with ganglion cysts in their knees. Although the ankle/foot and low back injuries are most prevalent in this athletic population, this reminds us to keep our mind open to evaluate the patient more globally.

A number of studies looked at the effects of pre-performance preparation on muscle stiffness and the resulting influence on performance. Di Cagno *et al.* in 2008 and 2009 stated that elite rhythmic gymnasts differ from sub-elite gymnasts in both anthropometric characteristics and muscle stiffness. Muscle stiffness was measured by the ability to achieve decreased ground contact time when performing consecutive hops and leaps. In 2010, Di Cagno *et al.*, compared the ground contact time, flight time and judges scores for performing technical leaps and hops following static stretching or a dynamic warm up. The study showed a significant increase in ground contact time as well as a decrease in judges' scores following static stretching. Therefore, static stretching before leaping may negatively affect competition judges' scores. Guidetti *et al.* indirectly complemented this work by showing that a high-intensity warm-up prior to competition when alternated with active flexibility exercises may help improve a gymnast's competition performance. The conclusive recommendation in these articles suggested that rhythmic gymnasts may improve competition performance by performing static stretching 60 minutes prior to competition followed by a dynamic warm up approximately 45 minutes prior to competition.

The overwhelming majority of research has looked at anthropometric characteristics, the effects of restricted dietary intake and bone mineral density content. Vicente-Rodriguez *et al.* in 2007, compared artistic gymnasts to rhythmic gymnasts, finding that artistic gymnasts demonstrate enhanced physical fitness, increased muscle mass, and higher bone density when compared to rhythmic gymnasts. This supports the belief that artistic gymnasts have strong bones due to the repetitive weight bearing activities. However, it raises concern with regard to the bone health of rhythmic gymnasts. Gruodyte *et al.* in 2010 found a correlation between low leptin levels, which may be associated with periods of calorie restriction, and low bone mineral density of the femoral neck and low back, as well as low bone mineral content in the femoral neck.

Calorie restriction may result in a number of adverse effects. According to Georgopoulos *et al.* in 2010, both rhythmic and artistic gymnasts experienced a shift in pubertal development

possibly due to decreased energy availability as a result of dietary restrictions and high levels of physical activity during pre pubertal stages. In a study comparing rhythmic gymnasts to an age matched control, Klentrou *et al.* 2003, found that rhythmic gymnasts experienced a significant delay in age of menarche. In this sampling of greek and canadian rhythmic gymnasts, the authors reported that 78% of the former and 34% of the later were amenorrhoric. Pre-menarcheal gymnasts were found to have a lower body mass index, less body fat and train more frequently than the menarcheal gymnasts. Menarchial gymnast may have slightly higher levels of body fat, leading to further calorie restriction, in turn causing lower levels of leptin and poor bone density.

In conclusion, more research is necessary to determine the magnitude these factors on gymnasts in the US.

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Biedert R, Hintermann B (2003). Stress fractures of the medial great toe sesamoids in athletes. *Foot Ankle Int.* 24(2): 137-141.

The purpose of this study was to determine whether specific symptoms and findings are present in patients with symptomatic stress fractures of the sesamoids of the great toe and, if so, whether partial sesamoidectomy is sufficient for successful treatment. Five consecutive athletes (five females; mean age 16.8 years [range, 13 to 22 years]) with six feet that were treated for symptomatic stress fractures of the sesamoids of the great toe were included in this study. Four athletes (five feet) performed rhythmic sports gymnastics; the fifth athlete was a long jumper. Some swelling to the forefoot and activity-related pain that increased in forced dorsiflexion, but disappeared at rest was found in all patients. While plain X-rays evidenced fragmentation of the medial sesamoid, MRI (n=2) and frontal plane CT scan (n=3) did not always confirm the diagnosis, but bone scan (n=3) and axial as well as sagittal CT scan were useful to detect the pathology. After failure of conservative treatment measures, surgical excision of the proximal fragment was successful in all patients, and there were no complications. All patients were pain free and regained full sports activity within six months (range, 2.5 to six months). At final follow-up which averaged 50.6 months (range, 20 to 110 months), the overall clinical results were graded as good/excellent in all patients, and there was only one patient with of restriction sports activities. The obtained AOFAS-Hallux-Score was 95.3 (75 to 100) points. Apparently, stress fractures occur more often at the medial sesamoid, and females are mainly involved. When a stress fracture is suspected, bone scan and CT scan are suggested as more reliable in confirming the diagnosis than other imaging methods. When conservative treatment has failed, surgical excision of the proximal fragment is recommended.

Cupisti A, D'Alessandro C, Evangelisti I, Piazza M, Galetta F, Morelli E (2004). Low back pain in competitive rhythmic gymnasts. *J Sports Med Phys Fitness.* 44(1):49-53.

AIM: It has been reported that rhythmic gymnasts are at risk of suffering from low back injuries, because of repetitive lumbar hyperextensions. On the other hand, this sport requires features of leanness, muscular strength and flexibility that should represent protective factors for back pain. METHODS: This cross-sectional study aimed to assess the prevalence of low back pain in 67 club-level competitive rhythmic gymnasts aged 13-19 years. A standardized questionnaire was used to evaluate back-pain symptoms. Anthropometric measurements, time spent in physical activity, psychological testing results, smoking habits and age of

menarche were recorded. One hundred and four age-matched general females served as control group. RESULTS: Low back pain complaints were reported by 7 rhythmic gymnasts and by 27 controls (10.4% vs 26.0%, $p < 0.05$); the prevalent location of back pain was bilateral in gymnasts and central in controls. Gymnasts had lower body weight, body mass index, fat body mass and delayed menarche. The females with low-back pain displayed higher body weight, body mass index, fat body mass, age, a greater smoking habit and more anxious/depressive behavior, both in the gymnast and in the control group. CONCLUSION: Competitive, club-level rhythmic gymnasts show a reduced prevalence of low back-pain. Being younger in age, having greater leanness, not smoking, displaying less anxious/depressive behavior, and developing increased muscle strength and flexibility, all can represent preventive factors for low back pain. This study suggests that rhythmic gymnastics is not a discipline at increased risk of low back pain.

Cupisti A, D'Alessandro C, Evangelisti I, Umbri C, Rossi M, Galetta F, Panicucci E, Lopes Pegna S, Piazza M (2007) Injury survey in competitive sub-elite rhythmic gymnasts: results from a prospective controlled study. *J Sports Med Phys Fitness*.47(2):203-207.

AIM: The aim of this study was to determine the frequency, anatomical site and types of injury incurred in rhythmic gymnastics. METHODS: An 8-month prospective and controlled injury survey was planned, including 70 club-level competitive rhythmic gymnasts, aged 13-19 years. Information on injury events was recorded weekly in an injury record booklet for any event occurring over that week. Height, weight, anthropometric measurements and time spent in physical activity were recorded at baseline. Data from 72 age-matched non-athletic females served as controls. RESULTS: Forty-nine significant injuries were reported by gymnasts and 34 by controls (70% vs. 47%, $P < 0.005$, odds ratio 2.28); gymnasts sustained a rate of 1.08 injuries per 1 000 h of training. The most prevalent anatomical sites sustaining injury were the ankle and the foot (38.9%), followed by back (22.2%). Strains and sprains were frequently reported both in gymnasts and in controls. Gymnasts missed an average of 4.1 days of physical activity as compared to 18.9 days for the control females. Alternatively, modification of training sessions occurred more frequently for the gymnast group (32 vs. 7 cases for controls). The total school days missed were lower for the injured gymnasts than for the injured controls (27 vs. 64 days). CONCLUSION: Competitive, club-level rhythmic gymnastics show a higher prevalence of injuries than non-athletic controls, but considering the high number of hours spent in training sessions, it derives that rhythmic gymnastics is a sport discipline at relatively low risk of severe injuries. These are mainly limited to back and lower limbs, are generally not severe and do not significantly hinder the preparation for the competitions.

Di Cagno A, Baldari C, Battaglia C, Brasili P, Merni F, Piazza M, Toselli S, Ventrella AR, Guidetti L (2008). Leaping ability and body composition in rhythmic gymnasts for talent identification. *J Sports Med Phys Fitness*. 48(3):341-346.

Aim of this study was to investigate leaping ability and morphological characteristics in rhythmic gymnastics, in order to verify which parameters are useful indicators for the talent identification. METHODS: Twenty-five national gymnasts of international level (age 14.7 \pm 2.2 years) underwent three testing sessions: anthropometric measurements, vertical jumps (counter movement jump and hopping test), and three technical split leaps with stretched legs (SL), with ring (RG) and with back bend of the trunk (BBT). RESULTS: Elite had significantly different values ($P < 0.05$) of stature (1.65 \pm 0.03 vs. 1.55 \pm 0.09 m), thigh length (0.42 \pm 0.03 vs. 0.39 \pm 0.02 m) and FFM(42.42 \pm 2.81 vs. 35.84 \pm 5.66 kg) compared to sub-elite. The height of hopping test was significantly higher in elite than sub-elite gymnasts (0.34 \pm 0.05 vs. 0.27 \pm 0.04 m; $P < 0.05$), but no significant differences in counter movement jump between two groups were found. Ground contact time of hopping test was significantly correlated ($P < 0.01$) with SL ($r = 0.613$), RG ($r = 0.632$), and BBT ($r = 0.542$) values. By multiple regression analysis, among anthropometric and vertical jump variables, the hopping

ground contact time was the strongest predictor of ground contact time of the three technical leaps (SL, RG, BBT) accounting for 26-37% of variance. CONCLUSION: Some anthropometric measurements are good indicators for the better performance in rhythmic gymnastics. Level of muscle compliance (stiffness) evaluated by hopping test is a good parameter for athletes selection and for monitoring leaps training.

Di Cagno A, Baldari C, Battaglia C, Monteiro MD, Pappalardo A, Piazza M, Guidetti L (2009). Factors influencing performance of competitive and amateur rhythmic gymnastics--gender differences. *J Sci Med Sport*. 12(3):411-416.

During last decade, male athletes were involved in official rhythmic gymnastics (RG) competitions. Aim of this study was to examine anthropometric characteristics and motor skills of male rhythmic gymnasts to identify guidelines in talent identification, selection and development training plans. Twenty-four gymnasts (age range 22+/-4 years), 12 male athletes and 12 female athletes, underwent two testing sessions: the previous session to assess anthropometric measures, and the second one to evaluate jumping ability using Optojump. Three vertical jumps: squat jump (SJ), counter-movement jump (CMJ), hopping test (HT) and three different technical jumps (Split Leap with stretched legs (SL); Cossack with 180 degrees of rotation (CK); Jeté with turn (JWT)) were evaluated. Male gymnasts had significant higher values in each anthropometric measure than females ($p < 0.01$) except for sitting height/stature ratio, sitting height and fat mass (no significant differences). Female athletes were selected for their lowest fat mass. Height and ground contact time of technical leaps, squat jump and counter-movement jump, were significantly higher in male athletes than females. Height of hopping test (evaluating stiffness), and of difference between CMJ and squat jump (evaluating elastic properties of muscles) were no different between genders. Ground contact time of hopping test was significantly correlated ($p < 0.05$) with ground contact time of technical leaps. Results of the present study suggest that similar anthropometric characteristics have to be researched for both gymnasts' gender. Reactivity and elastic muscle properties of the legs have to be research both in male and female athletes.

Di Cagno A, Baldari C, Battaglia C, Gallotta MC, Videira M, Piazza M, Guidetti L (2010). Preexercise static stretching effect on leaping performance in elite rhythmic gymnasts. *J Strength Cond Res*. 24(8):1995-2000.

The aim of this study was to examine the acute effects of static stretching (SS) on technical leaps performance in rhythmic gymnastics. Thirty-eight gymnasts (age 14.13 +/- 3.2 years), competing at the international and national levels, performed vertical jumps (squat jump, countermovement jump, hopping test [HT]) and technical leaps (split leap with leg stretched [SL], split leap with ring [RG], split leap with back bend of the trunk [BBT]) assessed in 2 different conditions: after SS and after their usual typical warm-up (TWU) as control conditions. Jumps and leaps flight time (FT) and ground contact time (GCT) parameters were evaluated by OptoJump. Leap performance was simultaneously evaluated by scores awarded by judges. For each dependent variable, the effect of warm-up condition (TWU and SS) was examined by a paired-sample t-test. A multiple regression analysis determined the amount of variance in judges' scores from the FT and GCT variables. Results revealed that vertical jumps FT was not affected by SS warm-up. Ground contact time of HT significantly increased after SS warm-up ($p < 0.01$). Static stretching reduced significantly ($p < 0.01$) the technical leap FT (decrements: SL = 7.1%, RG = 7.2%, and BBT = 6.4%). The results showed no significant effects of SS on technical leaps GCT. Static stretching significantly reduced ($p < 0.001$) the scores awarded by the judges. The FT was the main predictor of scores of the 3 technical leaps accounting for 9-30% of variance in both warm-up conditions. This study suggests that SS before leaping performance may negatively affect rhythmic gymnastics judges' evaluation.

Dragoni S, Giombini A, Di Cesare A, Ripani M (2008) A synovial ganglion of the knee: two cases in athletes. *Int J Sports Med.* 29(8):692-695.

The objective of the study is to describe two cases of proximal tibiofibular ganglion cysts in high level athletes. In May 2003 and March 2005 two athletes (one tennis player in the top eighty of the Italian national ranking and a gymnast belonging to the Italian rhythmic gymnastics national team) were referred to our institution complaining of postero-lateral knee discomfort and the presence of localized swelling over the fibular head and the antero-lateral aspect of the leg, with a clinically suspected diagnosis of ganglion cyst of the proximal tibiofibular joint. Ultrasonography clearly detected the fluid-filled structures while magnetic resonance imaging confirmed the diagnosis, also showing precisely the anatomic relationship between the ganglions and the surrounding structures. Both athletes underwent surgical excision and the histological examination was compatible with a proximal tibiofibular joint ganglion cyst; as yet they have had no recurrence.

Georgopoulos NA, Roupas ND, Theodoropoulou A, Tsekouras A, Vagenakis AG, Markou KB (2010). The influence of intensive physical training on growth and pubertal development in athletes. *Ann N Y Acad Sci.* 1205:39-44.

Genetic potential for growth can be fully expressed only under favorable environmental conditions. Although moderate physical activity has beneficial effects on growth, excessive physical training may negatively affect it. Sports favoring restricted energy availability, in the presence of high energy expenditure, are of particular concern. In gymnastics, a different pattern in skeletal maturation and linear growth was observed, resulting in an attenuation of growth potential in artistic gymnasts (AG), more pronounced in males than in females. In female rhythmic gymnasts (RG), the genetic predisposition to growth was preserved owing to a late catch-up growth phenomenon. In all other sports not requiring strict dietary restrictions, no deterioration of growth has been documented so far. Intensive physical training and negative energy balance alter the hypothalamic pituitary set point at puberty, prolong the prepubertal stage, and delay pubertal development and menarche in a variety of sports. In elite RG and AG, prepubertal stage is prolonged and pubertal development is entirely shifted to a later age, following the bone maturation rather than the chronological age.

Grudyte R, Jürimäe R, Cicchella A, Stefanelli, Passariello C, Jürimäe T (2010). Adipocytokines and bone mineral density in adolescent female athletes. *Acta Paediatr.* 99:1879–1884.

Aim: To evaluate the relationships of visfatin, adiponectin and leptin with bone mineral density (BMD) and bone mineral content (BMC) in adolescent female athletes with different training patterns. Methods: This study involved 170 healthy 13–15-year-old girls divided into six groups based on activity: sport games (i.e. basketball, volleyball, badminton) (n = 49), track sprint (n = 24), rhythmic gymnastics (n = 23), swimming (n = 24), cross-country skiing (n = 17) and sedentary controls (n = 33). BMD and BMC at femoral neck and lumbar spine (L2–L4) were measured using dual-energy X-ray absorptiometry. Visfatin, adiponectin, leptin, insulin and glucose were measured, and the insulin resistance index was calculated using homeostasis model assessment. Results: There were no relationships found between visfatin concentrations and bone mineral parameters in adolescent female athletes or controls. Adiponectin was inversely correlated to BMD and BMC of femoral neck and lumbar spine ($r=0.47-0.62$) in the swimmer group only, but after adjustments for age, height and body mass these associations disappeared. Leptin concentrations correlated with bone mineral parameters even after adjusting for age, height and body mass ($r = 0.42-0.63$) in the gymnast group only. Conclusion: We may conclude that after adjustment, leptin is the only adipokine of those measured that correlates to femoral neck and lumbar spine BMD and femoral neck BMC in the rhythmic gymnast group.

Guidetti L, Di Cagno A, Gallotta MC, Battaglia C, Piazza M, Baldari C (2009). Precompetition warm-up in elite and subelite rhythmic gymnastics. *J Strength Cond Res.* 23(6):1877-82.

The aim of this study was to investigate which precompetition warm-up methodologies resulted in the best overall performance in rhythmic gymnastics. The coaches of national and international clubs (60 elite and 90 subelite) were interviewed. The relationship between sport performance and precompetition warm-up routines was examined. A total of 49% of the coaches interviewed spent more than 1 hour to prepare their athletes for the competition, including 45 minutes dedicated to warm-up exercises. In spite of previous studies' suggestions, the time between the end of warm-up and the beginning of competition was more than 5 minutes for 68% of those interviewed. A slow run was the activity of choice used to begin the warm-up (96%). Significant differences between elite and subelite gymnasts were found concerning the total duration of warm-up, duration of slow running, utilization of rhythmic steps and leaps during the warm-up, the use of dynamic flexibility exercises, competition performances repetition ($p < 0.01$), and utilization of imagery ($p < 0.05$). A precompetition warm-up in rhythmic gymnastics would include static stretching exercises at least 60 minutes prior to the competition starting time and the active stretching exercises alternated with analytic muscle strengthening aimed at increasing muscle temperature. Rhythmic gymnastics coaches at all levels can use this data as a review of precompetition warm-up practices and a possible source of new ideas. PRACTICAL APPLICATIONS: This article describes warm-up precompetition practices of rhythmic gymnasts of the best national and international clubs. The results of this study indicated that high-intensity warm-up prior to competition alternated with active flexibility exercises (41), a new tendency of elite coaches, could be shared and extended to subelite gymnasts to improve their competition performance. A precompetition warm-up should last more than 45 minutes to prepare the athletes physically (2) and technically (18,38). Fatigue due to warm-up is a problem of untrained athletes (39); in fact, elite gymnasts who trained more than subelite are prepared to sustain a longer period of warm-up without having fatigue. SS should be performed 60 minutes before competition or more (15) to attain better jumping performance in rhythmic gymnastics. Rhythmic gymnastics coaches now have a source of data describing warm-up precompetition practices as they occur at the sport's highest talent level. Coaches at all levels can use this data as a review of precompetition warm-up practices and a possible source of new ideas. In addition to this new source of professional practice knowledge, researchers are encouraged to continue to empirically investigate aspects of an important and delicate phase of rhythmic gymnastics training.

Hutchinson MR (1999). Low back pain in elite rhythmic gymnasts. *Med Sci Sports Exerc.* 31(11):1686-1688.

BACKGROUND: Rhythmic gymnastics is a sport that blends the athleticism of a gymnast with the grace of a ballerina. The sport demands both the coordination of handling various apparatus and the flexibility to attain positions not seen in any other sport. To attain perfection and reproducibility of their routines, the athletes must practice and repeat the basic elements of their routines thousands of times. In so doing, the athlete places herself at risk of a myriad of overuse injuries, the most common being low back pain. METHODS: To document the presence and severity of low back pain in elite rhythmic gymnasts, a prospective study of seven national team members was undertaken that documented injuries and complaints with daily medical reports over a 7-wk period. These findings were correlated with a retrospective review of 11 elite level gymnasts followed over a 10-month period whose complaints ultimately required evaluation by a physician. RESULTS: Eighty-six percent of the gymnasts in the prospective study complained of back pain at some point over the course of the study. The only injury recorded that required a time loss from sport was a low back injury. The most common complaint requiring a physician's evaluation was low back pain with the diagnoses varying from muscle strains to bony stress reaction or complete fracture of the pars inter-articularis (spondylolysis). No athlete had a spondylolisthesis or ruptured disk. Two

had mild scoliosis which did not appear to be associated with their low back pain.

CONCLUSIONS: It would appear that rhythmic gymnasts are at relative increased risk of suffering low back complaints secondary to their sport.

Klentrou P, Plyley M (2003). Onset of puberty, menstrual frequency, and body fat in elite rhythmic gymnasts compared with normal controls. *Br J Sports Med.* 37(6):490-494.

OBJECTIVES: To assess the prevalence of delayed menarche and abnormal menstrual patterns, as well as the association of menstrual status with physical training in elite rhythmic gymnasts from Greece and Canada. METHODS: Fifteen Greek (mean (SEM) age 14.5 (0.2) years) and 30 Canadian (mean (SEM) age 14.7 (0.4) years) rhythmic gymnasts were surveyed for age at menarche, menstrual frequency, and training profile, and measured for height, weight, and percentage body fat (%BF). Seventy eight healthy adolescents served as country specific non-active controls: 38 Greek non-athletes (mean (SEM) age 14.5 (0.1) years) and 40 Canadian non-athletes (mean (SEM) 14.2 (0.1) years). RESULTS: Of the Greek gymnasts, 79% had not yet menstruated compared with 34% of the Canadian gymnasts. Menarche was significantly ($p < 0.01$) delayed in the rhythmic gymnasts (composite mean 13.8 (0.3) years, $n = 45$) compared with the controls (composite mean 12.5 (0.1) years, $n = 78$). There was no significant difference between Greek and Canadian gymnasts for the age at menarche (14.2 (0.3) v 13.6 (1.2) years respectively). Menstrual irregularities were reported in 78% (61% oligomenorrhoeic and 17% amenorrhoeic) of the menarcheal athletes. Menarcheal gymnasts were found to be significantly ($p < 0.05$) taller and heavier, with a higher %BF and a lower training frequency and training duration ($p < 0.05$) than the premenarcheal gymnasts. Overall, the mean %BF of the gymnasts was significantly lower ($p < 0.05$) than that of the control subjects. The Canadian controls exhibited a significantly ($p < 0.05$) greater %BF than the Greek controls of the same age. CONCLUSION: Delayed menarche, menstrual irregularities, and low body fat are common in elite rhythmic gymnasts. Premenarcheal gymnasts train more often and for longer, and have a lower body mass index and less body fat, than menarcheal gymnasts. Prospective studies are needed to explore further these and other factors associated with delayed menarche and menstrual irregularities in female athletes.

Piazza M, Di Cagno A, Cupisti A, Panicucci E, Santoro G (2009). Prevalence of low back pain in former rhythmic gymnasts. *J Sports Med Phys Fitness.* 49(3):297-300.

Purpose: It is still debated as to whether rhythmic gymnastics is a discipline at risk of low back pain, because the concern for the extreme and repetitive hyperextension of the column may be counteracted by protective factors which are distinctive of rhythmic gymnasts, namely: leanness, lumbar flexibility and muscle strength. This study aimed to assess the prevalence of low back pain in a cohort of former elite-level rhythmic gymnasts of the Rhythmic Gymnastics National Team. METHODS: The Study Group included 60 adult females who were former rhythmic gymnasts of the Italian National Team. The Control Group included 60 adult females comparable for age, who were never involved in high level sport competitions. A standardized questionnaire was used to evaluate low back-pain symptoms. RESULTS: Low back pain complaints were reported by 22 former rhythmic gymnasts and by 28 controls (36.6% vs. 46.6%, p : n.s.); in the ex-gymnasts the age of onset of pain was earlier than in controls. The former rhythmic gymnasts complaining low back pain reported a higher prevalence of symptoms also during the time of competitions, and retired earlier than those without pain. CONCLUSIONS: Former elite rhythmic gymnasts reported a prevalence of low back-pain similar to sex and age matched general population. However, the rhythmic gymnasts who complained back pain during the sport activity are at risk of an early onset of symptoms after they retire from competitions. This study suggests that rhythmic gymnastics is not associated with increased risk of low back pain in the adult age.

Tournis S, Michopoulou E, Fatouros IG, Paspati I, Michalopoulou M, Raptou P, Leontsini D, Avloniti A, Krekoulia M, Zouvelou V, Galanos A, Aggelousis N, Kambas A, Douroudos I, Lyritis GP, Taxildaris K, Pappaioannou N (2010). Effect of rhythmic gymnastics on volumetric bone mineral density and bone geometry in premenarcheal female athletes and controls. *J Clin Endocrinol Metab.* 95(6):2755-2762.

CONTEXT AND OBJECTIVE: Weight-bearing exercise during growth exerts positive effects on the skeleton. Our objective was to test the hypothesis that long-term elite rhythmic gymnastics exerts positive effects on volumetric bone mineral density and geometry and to determine whether exercise-induced bone adaptation is associated with increased periosteal bone formation or medullary contraction using tibial peripheral quantitative computed tomography and bone turnover markers. **DESIGN AND SETTING:** We conducted a cross-sectional study at a tertiary center. **SUBJECTS:** We studied 26 elite premenarcheal female rhythmic gymnasts (RG) and 23 female controls, aged 9-13 yr. **MAIN OUTCOME MEASURES:** We measured bone age, volumetric bone mineral density, bone mineral content (BMC), cortical thickness, cortical and trabecular area, and polar stress strength index (SSI_p) by peripheral quantitative computed tomography of the left tibia proximal to the distal metaphysis (trabecular) at 14, 38 (cortical), and 66% (muscle mass) from the distal end and bone turnover markers. **RESULTS:** The two groups were comparable according to height and chronological and bone age. After weight adjustment, cortical BMC, area, and thickness at 38% were significantly higher in RG ($P < 0.005-0.001$). Periosteal circumference, SSI_p, and muscle area were higher in RG ($P < 0.01-0.001$). Muscle area was significantly associated with cortical BMC, area, and SSI_p, whereas years of training showed positive association with cortical BMC, area, and thickness independent of chronological age. **CONCLUSIONS:** RG in premenarcheal girls may induce positive adaptations on the skeleton, especially in cortical bone. Increased duration of exercise is associated with a positive response of bone geometry.

Vicente-Rodriguez G, Dorado C, Ara I, Perez-Gomez J, Olmedillas H, Delgado-Guerra S, Calbet JA (2007). Artistic versus rhythmic gymnastics: effects on bone and muscle mass in young girls. *In J Sports Med.* 28(5):386-393.

Thirty-five prepubertal girls, 9 artistic gymnasts and 13 rhythmic gymnasts were compared with 13 nonphysically active controls to study the effect of gymnastics on bone and muscle mass. Lean mass, bone mineral content and areal density were measured by dual energy x-ray absorptiometry, and physical fitness was also assessed. The artistic gymnasts showed a delay in pubertal development compared to the other groups ($p < 0.05$). The artistic gymnasts had a 16 and 17 % higher aerobic power and anaerobic capacity, while the rhythmic group had a 14 % higher anaerobic capacity than the controls, respectively (all $p < 0.05$). The artistic gymnasts had higher lean mass ($p < 0.05$) in the whole body and the extremities than both the rhythmic gymnasts and the controls. Body fat mass was 87.5 and 61.5 % higher in the controls than in the artistic and the rhythmic gymnasts ($p < 0.05$). The upper extremity bmd was higher ($p < 0.05$) in the artistic group compared to the other groups. Lean mass strongly correlated with bone mineral content ($r = 0.84$, $p < 0.001$), and multiple regression analysis showed that total lean mass explained 64 % of the variability in whole body bone mineral content, but only 20 % in whole body bone mineral density. Therefore, recreational artistic gymnastic participation is associated with delayed pubertal development, enhanced physical fitness, muscle mass, and bone density in prepubertal girls, eliciting a higher osteogenic stimulus than rhythmic gymnastic.