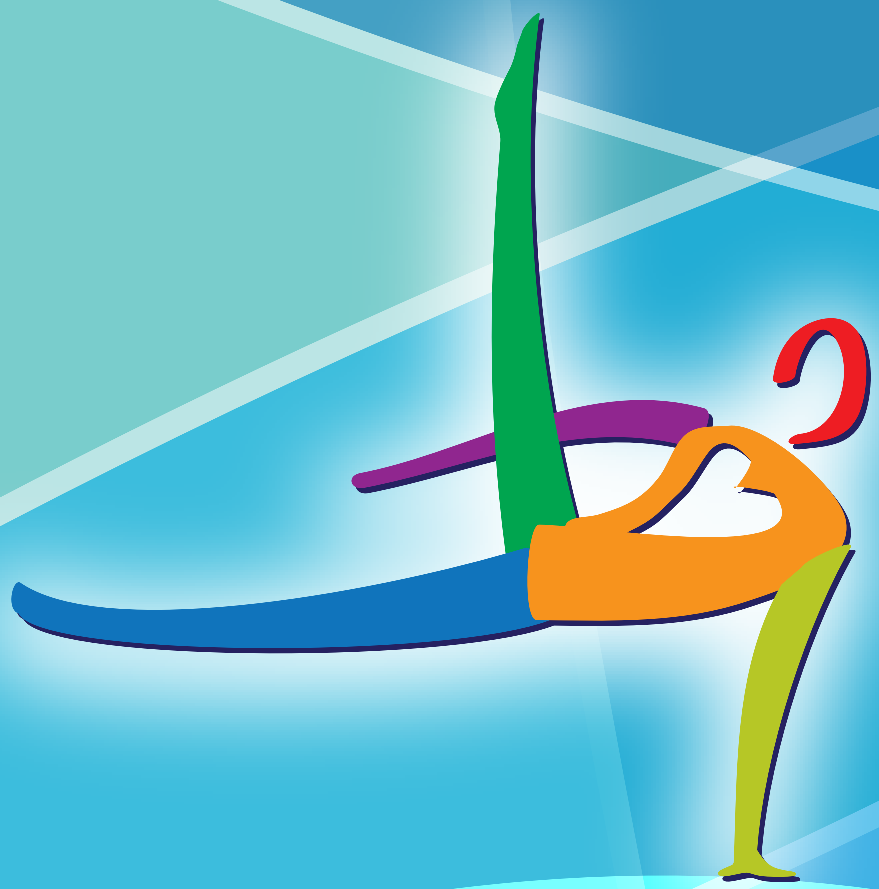
# SCIENCE OF GYMNASTICS JOURNAL

vol. 6, num. 1, year 2014



Published by Department of Gymnastics, Faculty of Sport, University of Ljubljana ISSN 1855-7171

# Science of Gymnastics Journal (ScGYM®)

Science of Gymnastics Journal (ScGYM®) (abrevated for citation is SCI GYMNASTICS J) is an international journal that provide a wide range of scientific information specific to gymnastics. The journal is publishing both empirical and theoretical contributions related to gymnastics from the natural, social and human sciences. It is aimed at enhancing gymnastics knowledge (theoretical and practical) based on research and scientific methodology. We welcome articles concerned with performance analysis, judges' analysis, biomechanical analysis of gymnastics elements, medical analysis in gymnastics, pedagogical analysis related to gymnastics, biographies of important gymnastics personalities and other historical analysis, social aspects of gymnastics, motor learning and motor control in gymnastics, methodology of learning gymnastics elements, etc. Manuscripts based on quality research and comprehensive research reviews will also be considered for publication. The journal welcomes papers from all types of research paradigms.



**Science of Gymnastics Journal is indexed in**
EBSCOhost SPORTDiscus, SCOPUS, COBISS (IZUM), SIRC (Canada), OPEN. J-GATE, GET CITED, ELECTRONIC JOURNALS INDEX, SCIRUS, NEW JOUR, GOOGLE SCHOLAR, PRO QUEST and INDEX COPERNICUS.
ScGYM® (ISSN 1855-7171) is an international online journal published three times a year (February, June, October). 

**Front page design:** Sandi Radovan, Slovenia.

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**Science of Gymnastics Journal is supported by Foundation for financing sport organisations in Slovenia, Slovenian Research Agency and International Gymnastics Federation.**

Fundacija za šport

Slovenian Research Agency

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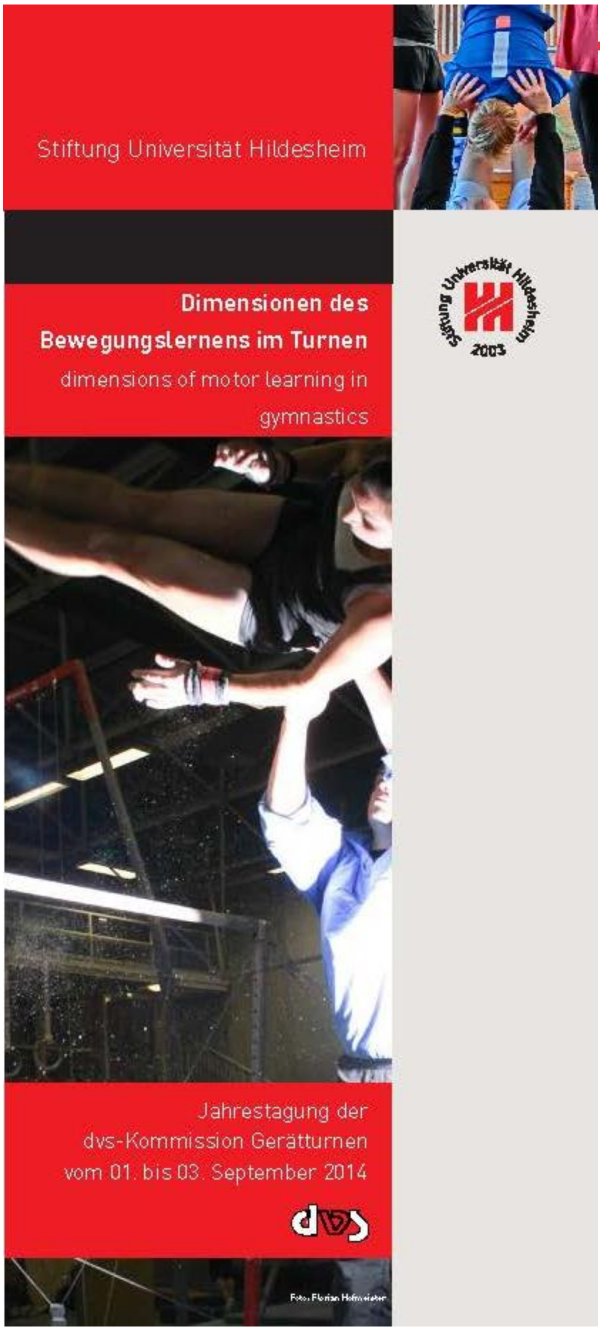


## Information

The concept of »dimension« is one inherent component of motor learning in gymnastics. Exploring the third dimension in space can be seen as a fundamental characteristic of performing simple and complex skills in gymnastics. Specific options for acting in the environment are generated, which enable the performer to gain particular experiences that can hardly be gained outside the area of gymnastics.

This argumentation highlights specific demands in the area of organized sports (clubs, schools) when putting motor learning theory into practice. In addition, this argumentation raises specific questions concerning the exploration of »dimensions« when discussing motor learning in areas, such as Parkour or Freerunning.

One aim of the conference is to analyze and discuss »dimensions of motor learning in gymnastics« from a multifaceted scientific perspective. Different settings of motor learning in gymnastics should be analyzed. Last but not least, it will be discussed how theory and application in motor learning in gymnastics can be related by means of practical examples.

The conference takes place at the University of Hildesheim from September 1st to September 3rd 2014. Further information can be found on the conference homepage: www.uni-hildesheim.de/fb1/institute/institut-fuer-sportwissenschaft/veranstaltungen-und-tagungen/dvs-tagung-geraetturnen-2014/

### Tagungsprogramm

**Montag, 1. September 2014**

| | |
|---|---|
| bis 13.45 Uhr | Anreise und Registrierung |
| 14.00-14.45 Uhr | Eröffnung und Begrüßung |
| 15.00-18.45 Uhr | Vorträge und Praxisworkshops |
| ab 19.00 Uhr | Abendveranstaltung |

**Dienstag, 2. September 2014**

| | |
|---|---|
| 9.00-12.30 Uhr | Vorträge und Praxisworkshops |
| 14.00-17.15 Uhr | Vorträge und Praxisworkshops |
| 17.30-18.30 Uhr | Laborbesuch |
| ab 19.00 Uhr | Abendveranstaltung |

**Mittwoch, 3. September 2014**

| | |
|---|---|
| 9.00-10.30 Uhr | Vorträge und Praxisworkshops |
| 11.00-12.30 Uhr | Mitgliederversammlung |
| 12.30 Uhr | Ende der Tagung |

**EDITORIAL**

Dear friends,

Despite our best intentions to publish this issue on 1 February, there was some delay due to the exhibition on 150 years of *Sokolism* prepared by our team in the Slovene National Council which opened on 10 February. Additionally, we are organizing a *Sokol* meeting on 27 February. The Sokols and gymnastics have for the first time appeared in the national parliament.

Since our last issue, a Gymnastics Fedaration Conferences were held in Portugal and Slovenia. The Conferences brought a lot of interesting papers, files will be made available on their respective web sites. The Faculty of Sport in Ljubljana held a scientific conference on 150 years of *Sokolism*; the presented papers will soon be available but only in the printed form and in Slovenian with English abstracts. Stiftung Universität Hildesheim, Institut für Sportwissenschaft is organizing a conference titled Dimensions of Motor Learning in Gymnastics for 1 September 2014.

For the first issue in 2014 our fellow researchers prepared seven articles, from the fields of medicine, psychology, motor development, biomechanics and communications. The first article is a review by Theofanis Siatras and Dimitra Mameletzi, both of Greece. They prepared a paper called the 'Female Athlete Triad in Gymnastics' in which they discus important views relevant to this topic. As we already had a similar article by researchers from Portugal it will be interesting to compare the texts.

The team from Tunisia: Sarra Hammoudi Nassib, Bessem Mkaouer, Sabri Nassib, Sabra Hammoudi Riahi, Yessine Arfa research precompetitive anxiety and its influence on the concentration and performance in rhythmic gymnastics. Even though the sample group was small, it can be concluded that higher anxiety decreases concentration and performance.

The third article was prepared by Vassilis Mellos, George Dallas, Paschalis Kirialanis from Greece and Giovanni Fiorilli and Alessandra Di Cagno from Italy. They did a longitudinal research study on how motor abilities change in gymnasts and their non athletic peers. Spiros Prassas and Olyvia Donti from Greece conducted an interesting study about the giant backward on parallel bars and compared the good and the bad execution. They recognized difficulties in finding the reasons for bad executions.

The fifth article is from Slovenia. Ana Kašček and Matej Supej explored on a case study how humans restore equilibrium after a passive whole-body rotation. As we are dealing with rotations in one direction only, our central nervous system adapts to one-sided load. There is another article from Slovenia: Igor Pušnik and Ivan Čuk investigated what temperature changes occurred in hands when magnesium was used and when it was not. The results were surprising.

The last article is from the USA. The team of Paul MacArthur, James Angelini, Andrew Billings and Alexis March explored TV commentating on NBC during the Olympic Games 2012. It is always interesting (but not necessarily pleasurable) when a mirror is held for you.

Just to remind you, if you quote the Journal: its abbreviation in the Web of Knowledge is SCI GYMNASTICS J.

I wish you pleasant reading and a lot of inspiration for new research projects and articles,

Ivan Čuk
Editor-in-Chief



Exhibition on 150 years of Sokols in Slovenian Council (Parlament House)

# THE FEMALE ATHLETE TRIAD IN GYMNASTICS

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*Review article*

***Abstract***

*The female athlete triad consists of three interrelated components: low energy availability (with or without eating disorders), amenorrhea and osteoporosis. Female gymnastics is a sport characterized by regular exposure to high-impact prolonged physical training at an early age, requiring strict control of energy consumption. Could this lead to the female athlete triad? The bibliographic data bases of PubMed, Scopus and ScienceDirect were used to identify relevant articles, using appropriate key words as Athletic triad, Eating disorders, Amenorrhea, Osteoporosis, Bone mineral density, Bone mass, Gymnastics and Adolescent. One hundred and thirty six papers were selected and their review was mainly focused on the occurrence of eating disorders, amenorrhea and osteoporosis in female gymnasts. The bibliography revealed that in gymnastics, each component of the female athlete triad alone or a combination of them may occur. It was concluded that, even though the mechanical loading on the female gymnast's skeleton has a site-specific beneficial effect on bone mineral density, it cannot offset the detrimental effect of hormonal deficiency on the skeleton caused by chronic energy deficiency. Low energy availability (with or without eating disorders), menstrual disorders and premature osteoporosis may lead to decreased athletic performance and adverse long-term health consequences. A concerted effort among coaches, athletic trainers, parents, athletes, and healthcare personnel is optimal for the prevention, early diagnosis and treatment of the female gymnasts' athlete triad to preserve their health.*

***Keywords****: Eating disorders, Amenorrhea, Osteoporosis, Gymnastics*

## INTRODUCTION

Female adolescents and young women engaged in strenuous sports activities often manifest a health-related syndrome recognized as the female athlete triad. The female athlete triad consists of three inter-related components: low energy availability (with or without eating disorders), amenorrhea and osteoporosis (Nattiv et al, 2007). These clinical conditions may lead to athletic performance deterioration and long-term health consequences, such as diminished quality of life, morbidity and even mortality (Nattiv et al, 2007; Sanborn et al, 2000). The female athlete triad has been identified in all competitive levels and ages, in high school, collegiate, highly competitive and elite athletes (Barrack, Rauh, & Nichols, 2008b; Beals & Hill, 2006; Cobb et al, 2003; Hoch, Stavrakos & Schimke, 2007; Hoch et al, 2009; Korsten-Reck, 2011; Morgenthal, 2002; Nichols et al, 2006; Thein-Nissenbaum & Carr, 2011a; Torstveit & Sundgot-Borgen, 2005 b; Zach, Smith & Hoch, 2011). Inadequate nutrition, menstrual status, training intensity and frequency, body size and composition, psychological and physiological stress are some of the syndrome's proposed causal factors (Morgenthal, 2002; Yeager et al, 1993).

Sports in which strenuous training is combined with emphasized leanness may predispose girls to increased risk of skeletal and reproductive health problems (McManus & Armstrong, 2010). Adolescents and young women engaged in intensive athletic activity often experience chronic energy deficiency, caused by restricted calorie intake (as in disordered eating), excessive exercise (as in high intensity training), or the combination of both (Wheatley et al, 2012). This has significant health consequences, such as hypothalamic amenorrhea, infertility, attainment of low peak bone mass and bone loss leading to fracture (Chan & Mantzoros, 2005; Rackoff & Honig, 2006; Wheatley et al, 2012). Evidence has shown that athletes most at-risk for the female athlete triad are those participating in endurance, aesthetic and weight classification sports, where a leaner build favours athletic performance, appearance is judged or low body weight is the norm (Lebrun, 2006; Loucks & Nattiv, 2005; Torstveit & Sundgot-Borgen, 2005a; Torstveit & Sundgot-Borgen, 2005c). In addition, athletes practicing individual sports appear to be at higher risk than those participating in team sports (Morgenthal, 2002). Therefore, sports considered to be more high-risk than others are long distance running, figure skating, rhythmic sportive gymnastics, artistic gymnastics, martial arts, diving, synchronized swimming and dance (Barrack et al, 2010; Barrow & Saha, 1988; Beals & Manore, 2002; Cobb et al, 2003; Herbrich et al, 2011; Hulley et al, 2007; Kerr, Berman & De Souza, 2006; Lebrun, 2006; Rooks & Corwell, 2006; Waldrop, 2005; Weimann, 2002; Wheatley et al, 2012; Williams, 1984).

Research indicates that social, environmental and personal factors may contribute to the development of the female athlete triad. In fact, psychocognitive functions, personality traits (e.g. perfectionism, obsessiveness), conflicts between performance and expectations, disturbed eating attitudes and behaviours, maladaptive coping mechanism with stress and social relationships with coaches and peers are found to be related with the occurrence of the female athlete triad (Bachner-Melman et al., 2006; Korsten-Reck, 2011; Nagel, 2003; Scoffier, Maoano & d'Arripe-Loungeville, 2010; Wheatley et al, 2012). In addition, a misplaced belief regarding body weights and performance has been noted, with the coaches frequently pressuring female athletes to lose weight or maintain a low body weight via restricted eating. Thus, they inadvertently induce eating disorders with their beliefs, coaching styles and attitudes (Martinsen et al, 2010; Muscat & Long, 2008; Nagel, 2003).

Each of the female athlete triad's components alone has detrimental effects in athletes' health, but the presence of all three components can have significant health consequences, including anaemia, damage and inadequate repair of soft tissue, endocrine abnormalities, altered reproductive function, impaired bone formation, stress fractures, inhibition of immune and thyroid function, adverse effects on renal function, endothelial dysfunction and cardiovascular disturbances (Cobb et al, 2003; Lanser et al, 2011; Lebrun, 2006; Matejek et al, 1999; Morgenthal, 2002). However, low energy availability seems to be the key disorder underlying the other components of the syndrome (Nattiv et al, 2007). Gymnastics represents an adjudicated sport with a subjective scoring based both on athletic performance and appearance, where reduced weight is associated with enhanced performance (Engel et al, 2003). Thus, it has been shown that it is associated with increased risk for eating disorders (Engel et al, 2003; Kerr, Berman & De Souza, 2006; Krentz & Warschburger, 2011; Rosen & Hough, 1988). Additionally, the incidence of menstrual dysfunctions in gymnasts is high (Bale, Doust & Dawson, 1996; Baxter-Jones et al, 1994; Erlandson et al, 2007; Otis, 1992; Robinson et al, 1995). The combination of eating disorders and athletic amenorrhea has many adverse consequences with the most serious health risk appearing to be the adverse effects on bone mineral density in girls and young women (Morgenthal, 2002). However, gymnastics is considered as one of the most osteogenic sports that induces benefits in cortical and trabecular bone in the peripheral and axial skeleton (Bareither, Grabiner & Troy, 2008; Courteix et al, 1999; Laing et al, 2002; Nickols-Richardson & O'Connor, 1999; Vicente-Rodriguez et al, 2007).

The aim of this review article was to examine the relationship between the female athlete triad and gymnastics. The bibliographic research was limited in three electronic databases. PubMed, Scopus and ScienceDirect were used to identify relevant articles in English language. The key words used to detect appropriate articles were Athletic triad, Eating disorders, Amenorrhea, Osteoporosis, bone mineral density, Bone mass, Gymnastics, Adolescent. The review of the literature was mainly focused on the co-occurrence of eating disorders, amenorrhea and osteoporosis in female gymnasts.

## EATING DISORDERS IN FEMALE GYMNASTS

Low energy availability in athletes may be either due to increased energy expenditure or reduction in dietary caloric intake. It has been reported that female teenager gymnasts had an energy intake significantly below the estimated energy need (Lindholm et al, 1995). Low energy availability may occur without eating disorders (Nattiv et al, 2007). However, eating disorders is the most frequently recorded component of the female athlete triad among athletes (Barrack et al, 2008a; Hoch et al, 2009; Nichols et al, 2006). In order to achieve a specific sport ideal body weight, female athletes often become overly concerned with it, thus increasing the tendency for disordered eating behaviours. They involve abnormal eating behaviours, anorexia or bulimia nervosa that can result in morbidity, decreased performance, menstrual abnormalities and mortality (Beals & Manore, 2000; Morgenthal, 2002; Thein-Nissenbaum et al, 2011b; Torstveit & Sundgot-Borgen, 2005).

A study on the prevalence of eating disorders in elite athletes found that it was higher in athletes competing in leanness-related and weight-dependent sport disciplines than in other sports. In particular, the prevalence of eating disorders among female athletes competing in aesthetic sports was higher than that observed in endurance, technical, and ball game sports (42%, 24%, 17% and 16% respectively) (Sundgot-Borgen & Torstveit, 2004). Similarly, Smolak, Murnen & Ruble (2000) suggested that female athletes, competing in elite level sports requiring a lean body, were at a higher risk for eating disorders. Gymnastics is an aesthetic "thin-build" sport that requires a strict control of energy consumption combined with a high-energy expenditure, especially in a highest competitive level. A prevalence of 31% of eating disorders in elite female athletes in sports, that emphasise a lean body shape or a low body weight, has been observed by Byrne and McLean (2002). Additionally, significantly greater percentages of eating disorders have been reported by athletes competing in aesthetic sports as compared to those in endurance and team sports (Beals & Manore, 2002; Krentz & Warschburger, 2011; Thein-Nissenbaum et al, 2011b). In gymnastics, a prevalence of 62% of disordered eating behaviours in collegiate gymnasts was recorded by Rosen & Hough (1988). Torstveit, Rosenvinge & Sundgot-Borgen, (2008) also reported that there are more cases of eating disorders among elite female gymnasts (32.4%) than in non-athletes (1-6%) (Torstveit, Rosenvinge &

Sundgot-Borgen, 2008). Moreover, Petrie (1993) found that, despite reporting moderate body satisfaction and having a BMI in the low-to-healthy range, 61% of the study's female collegiate gymnasts exhibited some sort of eating disorders. Another study suggested that the disordered weight control behaviours collegiate gymnasts mostly practiced were binge eating, excessive exercise and fasting or strict dieting (Petrie & Stoever, 1993). Likewise, Engel and coworkers (2003) found that gymnastics and wrestling were associated with heightened food restriction and athletes in these sports demonstrated elevated levels of purging and vomiting behaviour compared to other athletes.

In female athletes, the initiation of dieting and/or excessive exercising is either voluntary (when they compare their degree of fatness with that of other more successful athletes) or based on coaches' and trainers' recommendations (Sudi et al, 2004). Factors considered to be associated with eating disorders include early start of training, frequent weight fluctuations, prolonged dieting periods, the belief about the need for low body weight for good athletic performance, a sudden increase in training volume, pressure from important others to reduce weight (parents, coaches), lack of weight loss guidance, low self-esteem, fear of puberty in female athletes, injury and overtraining, fear of failing and causal comments (Morgenthal, 2002; Rome et al, 2003; Sundgot-Borgen, 1994). As reported by Krentz & Warschburger (2011), athletes more at risk for eating disorders believe they could improve their athletic performance by weight reduction. In elite female artistic gymnasts, performance scores are negatively correlated with the degree of fatness or endomorphy of the athlete (Claessens et al, 1999). Therefore, trainers usually encourage gymnasts to lose weight, often by making inappropriate comments. In a study by Rosen and Hough (1988), 75% of the athletes, who were told to lose weight by coaches, began to use unhealthy weight control methods. Previous research showed that weight-related teasing and body disparagement might have a significant negative impact on body image and eating behaviours in adolescent females (Van den Berg et al, 2002). Similarly, Kerr, Berman and De Souza (2006) found that gymnasts receiving from coaches disparaging comments concerning their bodies were significantly more likely to engage in unhealthy weight control practices and to report eating disorders. The authors concluded that, disordered eating behaviours occur in gymnastics and they are often endorsed, either implicitly or explicitly, by coaches and the sport context.

It seems that the combination of reduced dietary energy intake and increased exercise energy expenditure results in low energy availability and contributes to the development of eating disorders. Despite adequate training levels, disordered eating in athletes may lead to overtraining syndrome, chronic fatigue, impaired athletic performance and increased risk of injury. In addition, the occurrence of low energy availability affects the secretion of hormones, such as insulin, cortisol, growth hormone, insulin-like growth factor-I, leptin and substrates, such as glucose, fatty acids and ketones (Misra et al, 2005; Nattiv et al, 2007; Smith et al, 1987). Therefore, insufficient energy intake in addition to physical stress may be associated with negative health impacts such as menstrual dysfunction, potentially irreversible bone loss (Sundgot-Borgen & Torstveit, 2003), psychological complications, including depression and low self-esteem, fluid and electrolyte imbalance and impairments in renal, cardiovascular, endocrine, gastrointestinal, immune and thermoregulatory systems (Barrack et al, 2010; Beals & Manore, 1999; Bedford, Prior & Barr, 2010; De Souza & Williams, 2006; Misra et al, 2005; Morgenthal, 2002; Steinman et al, 2003; Vescovi et al, 2008; Wheatley et al, 2012).

## MENSTRUAL DISORDERS IN GYMNASTS

In female athletes, low body weight with low dietary energy intake and intense exercise may lead to the development of reproductive abnormalities, such as luteal phase deficiency, primary amenorrhea (delay in the age of menarche), secondary amenorrhea (absence of menstrual cycles lasting more than three months in postmenarchal women) and oligomenorrhea (menstrual cycles occurring at intervals more than 35 days) (Morgenthal, 2002; Nattiv et al, 2007; Otis, 1992).

In bibliography, the prevalence of menstrual disorders estimated in high school athletes in different sports ranges from 18% to 54% (Hoch et al, 2009; Nichols et al, 2006; Thein-Nissenbaum et al, 2011b). In addition, the prevalence of amenorrhea in the athletic population (5%-46%) was above the prevalence found in the general population (2%-5%) (Morgenthal, 2002). Furthermore, it has been noted that the prevalence of menstrual dysfunctions in female athletes engaged in aesthetic sports, such as figure skating, rhythmic sportive gymnastics, artistic gymnastics, diving, synchronized swimming and dance, was higher than in endurance and team/anaerobic athletes (Beals & Manore, 2002). In gymnastics, it has been shown that by the age of 14, only 20% of gymnasts had reached menarche, compared with 40% of distance runners and 95% of the normal population (Bale et al, 1996). A delay in age of menarche (ranging from 14.3 to 16.2 years) is also documented in gymnasts relative to non-athletic females (12 to 13 years) (Baxter-Jones et al, 1994; Beunen, Malina & Thomis, 1999; Claessens, Malina & Lefevre, 1992; Lindholm, Hagenfeldt & Ringertz, 1994; Malina, Bouchard & Bar-Or, 2004; Robinson et al, 1995; Thomis et al, 2005). Besides, it has been suggested that women's participation in intensive physical training since an early age may lead to delayed age of menarche (Baxter-Jones et al, 1994; Broso & Subrizi, 1996). In the study by Robinson and coworkers (1995), gymnasts exhibited significantly higher prevalence of oligomenorrhea and amenorrhea compared with controls (47% and 0% respectively). Furthermore, it has been estimated that the prevalence of primary amenorrhea is less than 1% in the general population and more than 22% in cheerleading, diving and gymnastics (Beals & Manore, 2002; Chumlea et al, 2003; Nattiv et al, 2007). Similarly, Georgopoulos and coworkers (2002) reported that 35% of the female gymnasts participating in a European championship were amenorrheic although aged over 15 years. All of the above are in line with the observation that participating and competing in sports that emphasize leanness are associated with menstrual dysfunction (Korsten-Reck, 2011; Torstveit & Sundgot-Borgen, 2005c).

The major factors associated with menstrual cycle disturbances in female athletes include energy and nutrient balance, sport modality, performance level, body weight and composition, eating disorders and mental stress. In particular, low energy intake seems to be the most important factor for the induction of menstrual cycle irregularities in athletes (Loucks, Verdu & Heath, 1998). Loucks and coworkers (1998) determined that menstrual disturbances are present only when high stress levels of exercise are combined with low energy availability. Similarly, De Souza and coworkers (2007) noted that menstrual disturbances in exercising women are energy-related and their severity increases in proportion to the magnitude of negative energy balance. In addition, it has been asserted that sports requiring thin bodies, such as gymnastics, tend to have a much higher prevalence of menstrual cycle irregularities and a later age of menarche (Sundgot-Borgen, 1994). Concerning the performance level, it has been found that the better performing athletes tend to have higher prevalence of menstrual irregularities (Schwartz et al, 1981). It has also been suggested that, as adipose tissue serves as an important endocrine organ for the conversion of androgens to oestrogens (Mohamed-Ali, Pinkney & Coppack, 1998), low body fat and eating disorders may play an important causal role in the development of menstrual cycle irregularities in athletes (Frisch, 1984; Sundgot-Borgen, 1998). Besides, research on menstrual disorders indicates that they are usually induced in athletes with low body mass (Trivelli et al, 1995) and low body fat (Theodoropoulou et al, 2005). Finally, it has been said previously that oestrogen production is sensitive to stress (Birch, 2005). Some exercise related stressors are rapid loss of body weight, sudden onset of strenuous exercise, inadequate nutrition to meet energy requirements, psychological and physical stress (Morgenthal, 2002).

Artistic gymnastics is a major sport that requires intensive physical training in combination with a strict control of energy input and a high energy output during childhood and adolescence. Gymnasts are subject to a significant energy drain, occurring early in prepubertal age, and are constantly pressured to achieve low body weight consistent with their sport requirements for a thin somatotype (Georgopoulos et al, 2010). In these weight and body image conscious athletes, reduced energy intake and increased exercise energy expenditure with concomitant low body fat may lead to reduced oestrogen production and primary amenorrhea ((Robinson et al, 1995; Theodoropoulou et al, 2005). Thus, gymnasts tend to develop primary amenorrhea due to training demands (prolonged intensive training, chronic undernutrition, emphasis on leanness) (Yabuuchi et al, 1984). Besides, Weimann (2002) found that young elite female gymnasts displayed low estrogen levels, hypoleptinemia, reduced body fat mass, insufficient caloric intake and retarded menarche.

Female gymnasts, beginning an intense athletic activity at a prepubertal age, being strenuously trained and competing at a high level, are exposed to high levels of physical and psychological stress. Excessive exercise is a stress situation that leads to increased levels of growth hormone, prolactin, glucocorticoids and cathecholamines, together with an elevation of cortisol levels and the Corticotropin Releasing Hormone (CRH) (Mastorakos et al, 2005). These increased hormone levels combined with the chronic stimulation of the hypothalamic-pituitary-adrenal axis under physical and mental stress, in addition to endogenous opioids, melatonin and dopamine can have an inhibitory action on gonadotropin-releasing hormone (GnRH) pulsatility (Keizer & Rogol, 1990). In the female athlete triad, menstrual disorders result from the suppression of the spontaneous pulsatile hypothalamic GnRH secretion, which leads to a decreased pulsatile secretion of luteinizing hormone (LH) and follicle stimulating hormone (FSH) and the prevention of the ovarian stimulation (Gordon, 2010; Williams et al, 1995). LH pulsatility reflects the pulsatile secretion of GnRH from the hypothalamus (Filicori et al, 1998). Dueck & Manore (1996) maintained that high energy expenditure, low energy intake and high psychological and physical stress are the main variables related to negative energy balance (energy drain), which is the primary factor effecting GnRH suppression in female athletes. However, it has been asserted that exercise training has no suppressive effect on LH pulsatility, when dietary energy intake is increased to compensate for exercise energy expenditure (Loucks, Verdu & Heath, 1998). Likewise, Williams and coworkers (1995) suggested that strenuous training may not be a sufficient stimulus to disrupt reproductive hormone secretion unless accompanied by inadequate caloric intake.

As the ovarian hormones are suppressed in amenorrheic athletes, the levels of oestrogen and progesterone fall. Consequences of oestrogen deficiency recorded in athletes include premature loss of bone mineral density (Drinkwater et al, 1984; Morgenthal, 2002; Nichols et al, 2007; Soleimany et al, 2012; Wheatly et al, 2012), impaired endothelial cell function with resultant impaired arterial dilation (Hoch et al, 2003; Lanser et al, 2011; Rickenlund et al, 2005), impaired skeletal muscle oxidative metabolism (Harber, Petersen & Chilibeck, 1998), elevated low-density lipoprotein cholesterol levels (O'Donnell & DeSouza, 2004; Soleimany et al, 2012).

## BONE MINERAL DENSITY IN FEMALE GYMNASTS

Although regular weight-bearing exercise has beneficial effects on bone mass, there is evidence that athletes who experience amenorrhea or oligomenorrhea have lower bone mineral density than eumenorrheic athletes (Drinkwater et al, 1984; Drinkwater, Bruemner & Chesnut, 1990; Morgenthal, 2002). Low energy availability may suppress bone formation via effects on hormones that regulate bone formation and facilitate calcium uptake into bone, including oestrogen, insulin, T3, insulin-like growth factor-I, cortisol and leptin (Nattiv et al, 2007). Additionally, since the reproductive hormones affect bone formation and remodelling, any factor that contributes to lower oestrogen levels could influence bone density and predispose female athletes to osteopenia and premature osteoporosis (Morgenthal, 2002; Wheatly et al, 2012). Low oestrogen and progesterone levels in combination with low body weight have been linked to reduced bone mineral density in female athletes (Rencken, Chestnut & Drinkwater, 1996). From the literature, it is clear that eating disorders and low calcium intake combined with menstrual dysfunction and the resultant oestrogens withdrawal are related to loss of bone mineral density, which in turn leads to osteoporosis, increased susceptibility to stress fractures and other musculoskeletal injuries during the competitive years (Drinkwater et al, 1984; Lloyd et al, 1986; Wheatly et al, 2012). In premenopausal women and children, osteoporosis is diagnosed when low bone mineral density is present with other factors, including chronic malnutrition, eating disorders, hypogonadism, glucocorticoid exposure and previous fractures (International Society for Clinical Densitometry, 2004). Amenorrheic athletic women have been found to be strong candidates for bone loss (Snow-Harter, 1994). Recently, another research has showed that female athletes with eating and menstrual disorders may be at greater risk for bone loss, changes in bone mineral density and stress fracture occurrence (Thein-Nissenbaum et al, 2011b). In addition, it has been reported that bone mineral density is inversely related to the age of menarche and it declines as the number of missing menstrual cycles accumulates (Drinkwater, Bruemner & Chesnut, 1990; Morgenthal, 2002). Decreased bone mineral density appears to be generalized throughout the skeleton, in both appendicular and axial skeletal sites (Lebrun, 2006; Morgenthal, 2002; Otis et al, 1997; Rencken, Chestnut & Drinkwater, 1996).

In the literature, it has been observed that college athletes at risk for eating disorders reported menstrual irregularity and suffer from bone injuries more often (Beals & Manore, 2002). Several studies have reported that amenorrheic athletes are at increased risk for stress fractures. Amenorrheic athletes have been found to be two to four times likely to sustain stress factures than eumenorrheic athletes (Bennell et al, 1999). In the study by Thein-Nissenbaum and coworkers (2011b), the cumulative seasonal incidence of musculoskeletal injuries in female high school athletes was reported as 65.6%, but 78.0% in aesthetic athletes aside. Additionally, athletes with eating disorders were twice as likely to sustain a sports-related injury during a sports season (Thein-Nissenbaum et al, 2011b). In a subsequent study, Thein-Nissenbaum and coworkers (2012) estimated a higher prevalence of 71.4% of musculoskeletal injuries in aesthetic female athletes compared with endurance and team/anaerobic athletes (67.5% and 59.6% respectively). Similarly, Beals and Manore (2002) determined that 65.9% of female collegiate athletes reported a muscle injury during their collegiate career, with athletes participating in aesthetic sports exhibiting the highest percentage of self-reported injuries (78.0%), when compared to endurance and team/anaerobic athletes. They concluded that a greater percentage of athletes with irregular menses reported muscle injury (67.4%), as compared to those with eumenorrhea (60.8%). Rauh, Nichols and Barrack (2010) have also observed that female high school athletes who reported menstrual dysfunction were 3 times more likely to incur a musculoskeletal injury than athletes with normal menses.

Nevertheless, it has been established that exercise during growth is associated with site-specific bone mineral accrual (Laing et al, 2005). Furthermore, it has been demonstrated that gymnastics training is associated with greater site-specific bone mass and bone size in retired elite female gymnasts (Eser et al, 2009). Similarly, several studies found that former female gymnasts have greater bone density than sedentary controls at the upper limbs, lower limbs and spine (Bass et al, 1998; Kirchner, Lewis & O'Connor, 1996; Pollock et al, 2006; Scerpella, Dowthwaite & Rosenbaum, 2011; Zanker et al, 2004). In addition, it has been reported that young female oligomenorrheic or amenorrheic athletes in high impact sports may have site-specific beneficial effects on bone mineral density (Slemenda & Johnson, 1993). In gymnastics, female athletes have been shown to exhibit higher bone mineral density than normally active females (Bareither, Grabiner & Troy, 2008; Corujeira et al, 2012; Courteix et al, 1999; Dowthwaite, Rosenbaum & Scerpella, 2012; Helge & Kanstrup, 2002; Laing et al, 2002; Nickols-Richardson & O'Connor, 1999; Vicente-Rodriguez et al, 2007) or female runners at the lumbar spine, hip and whole body, despite a similar prevalence of amenorrhea and oligomenorrhea in athletes (Robinson et al, 1995). It has been suggested that there is a possible protective effect of loading at specific bone sites in athletes with deficient reproductive hormone profile (Eser et al, 2009; Robinson et al, 1995). Specifically, the mechanical forces resulting from increased mechanical loading and strong muscular contraction associated with gymnastics training may have powerful osteogenic effects, which appear to partly compensate for the resorptive effects of low circulating levels of oestrogen. Indeed, gymnasts perform exercises, such as single and double somersaults and dismounts from the uneven bars and balance beam, with a high dynamic impact on the bones, in addition to exercises with a variety of strain (shear, compression, and rotation), which represent important factors in osteogenesis (Helge & Kanstrup, 2002). Thus, the high lean body mass per unit of body surface area in the gymnasts in combination with the production of ground reaction forces of a large magnitude may contribute to enhance bone mineral density (Robinson et al, 1995). Therefore, it may be suggested that bone mineral density is unrelated to menstrual status in female gymnasts.

However, it seems that mechanical loading on the female athlete's skeleton has a beneficial effect on bone mineral density only after resumption of normal menses (Morgenthal, 2002). Notwithstanding there is evidence that weight-bearing exercise in high impact sports, like gymnastics, may selectively protect parts of the skeleton, it cannot offset the detrimental effect of hormonal deficiency (Lebrun, 2006). Besides, the duration of secondary amenorrhoea has been shown to affect the exercise-induced skeletal benefits (Pearce et al, 1996). Furthermore, it has been found that retired gymnasts with a history of either primary or secondary amenorrhoea did not show any benefits in bone density and bone strength in the peripheral skeleton over sedentary controls, in contrast with retired gymnasts without a history of menstrual dysfunction (Ducher et al, 2009). Therefore, adolescent amenorrhoea, which has been associated with a higher incidence of osteoporosis in postmenopausal women (Csermely et al, 2007), may compromise some of the high impact training-induced benefits in cortical and trabecular bone in the peripheral and axial skeleton, hence predisposing the athletes to skeletal fragility later in life (Ducher et al, 2009).

## RECOMMENDATIONS FOR PREVENTION AND TREATMENT OF THE GYMNASTS' FEMALE ATHLETE TRIAD

Female athlete triad is a severe health issue concerning especially athletes competing in aesthetic sports, like gymnastics. Prevention and treatment of this syndrome's clinical manifestations are required, in order to maintain athletes' good health and prevent adverse long-term side effects. A collaborative effort among coaches, athletic trainers, parents, health-care providers, a sports nutritionist, a psychologist/psychiatrist and athletes has been recommended to recognize, prevent and treat the female athlete triad (Lanser et al, 2011; Nattiv et al, 2007; Otis et al, 1997; Rooks & Corwell, 2006; Yeager et al, 1993). Social, environmental and personal factors may assist in preventing and reducing the occurrence of the female athlete triad among gymnasts (Nagel, 2003).

Prevention is always preferred over intervention or treatment options and it can be accomplished by thorough risk-factor assessment and screening questions. Prevention usually includes education of athletes, athletic trainers, physical therapists, coaches, other support personnel and parents to raise awareness and effective risk management of the problem and promote healthy nutritional habits and training regimens (Buschman, 2002; Currie & Morse, 2005; Rooks & Corwell, 2006; Tietjen-Smith & Mercer, 2008; Waldrop, 2005). The athletic staff should be informed on signs, symptoms and potential adverse consequences of the condition, in order to assist early recognition and facilitate a healthier approach to athletic performance and competition (Cover, Hanna, Ross & Barnes, 2012; Nagel, 2003; Thein-Nissenbaum et al, 2011b). Since female gymnasts are at risk for developing the female athlete triad showing amenorrhoea, restrained eating behaviour and an increased rate of stress fractures, it has been advised to estimate individual training volume and training capacity at short intervals, in order to avoid negative consequences of high-intensity training (Weimann, 2002). Besides, Corujeira and coworkers (2012) found that, in contrast to high-intense training that reaches 60 hours per week, a moderate weekly training load up to 18 hours is not associated with a compromise of nutritional status, pubertal development and genetically defined height. In their study, competitive gymnastics was associated with an increase in bone mineral density and none of the athletes showed female athlete triad. However, the sample was small and not representative of the gymnasts' population.

The influential role of parents and coaches is also crucial in the treatment of the female athlete triad. In gymnastics, coaches have reported more monitoring/management behaviours towards their athletes, differing from other coaches on their attitudes toward eating and weight in the sport (Heffner et al, 2003). It has been suggested that some of their coaching attitudes and behaviours may inadvertently increase the risk for eating disturbances, if they hold the belief that gymnast's low body weight is beneficial to athletic performance (Heffner et al, 2003; Kerr, Berman & De Souza, 2006). However, coaches are the more suitable persons that could recognize symptoms of chronic energy deficiency, influence athletes' eating behaviour and adopt effective coaching styles and techniques (Wheatly et al, 2012). Therefore, educating them about enhancing the well-being of young gymnasts and developing their athletic talent is very important. Furthermore, the evaluative role of judges concerning technical performance and physicality may be influential on the issues of weight control (Kerr, Berman & De Souza, 2006). It has also been suggested that changes to the competition regulations may stop favoring thinness and reduce the phenomenon of the female athlete triad (Sudi et al, 2004).

It has been established that higher oestrogen levels increase calcium levels, leading to elevated calcium storage in the bone (Drinkwater et al, 1986) and that irregular menses are associated with decreased bone mineral density (Nichols et al, 2007). Thus, early identification and treatment is necessary to protect young amenorrheic athletes from premature osteopenia-osteoporosis. Referral to a physician for examination of the athletes with menstrual irregularity is required (Thein-Nissenbaum et al, 2012), in order to recognize athletes with premature bone loss as early as possible after the onset of amenorrhea, prevent insufficient bone density gain and possibly replace some bone already lost (Morgenthal, 2002).

Negative changes in bone mineral density and cardiovascular biomarkers of female athletes with functional hypothalamic menstrual dysfunction could occur, if proper therapeutic intervention is not considered (Soleimany et al, 2012). Since energy deficiency leads to oestrogen deficiency and consequently insufficient bone density gain, therapeutic intervention of the female athlete triad includes hormone replacement and low energy availability and potential eating disorders treatment, by modifying diet and exercise load in order to improve energy availability and restore normal menstrual cycles (Lanser et al, 2011; Soleimany et al, 2012). However, in treating the female athlete triad, hormone replacement and/or calcium supplementation do not appear to reverse the bone loss in the young athlete (Morgenthal, 2002). In the contrary, increase in body weight and resumption of normal menses with proper nutrition and attention to the physical and psychological pressures are required for bone density recovery (Rackoff & Honig, 2006; Rencken, Chestnut & Drinkwater, 1996). Therefore, it has been suggested that educational efforts encouraging adolescent female athletes improve their caloric intake, to better balance their energy availability and consequently prevent or correct menstrual dysfunction, may help them avoid major musculoskeletal injuries (Thein-Nissenbaum et al, 2012). Although, treatment for eating disorders was found to be insufficient, interrupted or not attempted among athletes (Markser, 2011), it has been reported that when energy availability is restored, menstrual cycles return in approximately 11 months (Casper et al, 2006). Nevertheless, the disruption of the reproductive hormones secretion caused by low energy availability can be restored by refeeding at a very slow rate (Loucks & Verdu, 1998), with the amenorrhoeic females not fully regaining lost bone mineral density, despite returning to a normal reproductive status (Wheatly et al, 2012).

Furthermore, treatment of the female athlete triad includes motivation, communication with the athletes, setting common goals that emphasize the athletes' health and anticipate and prepare them for potential relapse, and development of the necessary skills to maintain behavioural change and a healthy long-term lifestyle (Rooks & Corwell, 2006). Wheatly and co-workers (2012) suggested that along with the education of parents, coaches, educators and health care professionals in identifying and treating females with chronic low energy deficiency, other intervention strategies are also indispensable, such as changing the social milieu, building self-esteem, maintaining a healthy energy balance. Similarly, Lanser and co-workers (2011) maintained that female athletes with eating disorders should receive counselling from a certified sports psychologist to address issues, such as body image issues and self-esteem that may be underlying their problem (Lanser et al, 2011). In addition, a sports dietician should be consulted to evaluate athletes' specific energy requirements (Lanser et al, 2011). An adequate energy intake is crucial to maintain growth and development of tissues and to support energy requirements of young gymnasts. After a relevant assessment and determination of body weight and composition, the athletic personnel should recommend safe weight control strategies (avoiding daily weightings) with a positive health and performance impact (Sudi et al, 2004). Besides, it has been suggested that improved nutrition and weight gain, but not hormone replacement, may reverse large bone density deficits caused in adolescence (Fredericson & Kent, 2005).

## CONCLUSION

The female athlete triad is a concerning health condition with adverse long-term side effects. This review article examined the occurrence of the female athlete triad in gymnastics. Gymnastics is a physical activity with high-impact loading activity involving acceleration, deceleration, pushing and pulling movements, acrobatic elements and aesthetically pleasing movements. In addition, it is a sport requiring a strict control of energy consumption and characterized by regular exposure to high-impact prolonged intensive physical training at an early age. Although the mechanical loading on the female gymnast's skeleton has a site- specific beneficial effect on bone mineral density, it cannot offset the detrimental effect of hormonal deficiency on the skeleton caused by low energy availability (increased exercise energy expenditure and/or reduced dietary energy intake). Chronic energy deficiency leads to oestrogen deficiency and consequently loss of bone mineral density.

Low energy availability (with or without eating disorders), menstrual disorders and premature osteoporosis may lead to decreased athletic performance and adverse long-term health consequences. Early diagnosis of the condition in gymnasts is vital for successful intervention and timely treatment to preserve their health and reduce the prevalence of the condition. Adequate screening and development of targeted educational intervention programs have been recommended, in order to facilitate a healthier approach to athletic performance and competition in athletes. A concerted effort among coaches, athletic trainers, parents, athletes, and healthcare personnel is optimal for the recognition, prevention and treatment of the female athlete triad in gymnasts.

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# PRECOMPETITIVE ANXIETY EFFECT ON CONCENTRATION AND PERFORMANCE ON ELITE RHYTHMIC GYMNASTS

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*Research article*

***Abstract***

*The multidimensional conceptualization of competitive anxiety incorporating cognitive and somatic components has provided a clearer understanding of how athletes respond to competitive stressors (see Jones, 1995; Woodman and Hardy, 2001 for a review). Thus, in competition, some athletes anxiety tend to dissipate their attention resources and to identify threats to stimuli that disrupt the running of the race. In addition, each athlete has suffered a break in concentration followed by a decline in performance and loss of confidence. So, the purpose of the present study was to examine the relationship between competitive anxiety, concentration and performance of gymnastics athletes at different time of assessment.. Data for this study were collected from 6 competitive female rhythmic gymnasts in the highest national team (age 14.8 ± 1.3 years, weight 77.5 ± 7.1 kg, height 180.8 ± 5.6 cm). Descriptive statistics revealed that the scores of cognitive anxiety increased from 15.83 ± 1.835 in the training condition to 19.67 ± 2.160 for the competition condition. Regarding somatic anxiety has increased from 15.50 ± 1.517 to 19.67 ±, 816 during the competition condition. In contrast, the average self-confidence has diminished from 21.00 ± 1.414 to 17.50 ± 1.871 during the competition .Accordingly, the importance of collecting information on how anxiety changes during the course of a competition appears fundamental to improving the predictive value of theories that seek to explain how such anxiety may influence athletic performance.*

***Keywords****: anxiety, competition, concentration, rhythmic gymnastics.*

## INTRODUCTION

Anxiety, particularly pre competition anxiety, has been an important focus of research in sport and performance psychology (e.g. Jones & Hardy, 1990; Martens, Burton, Vealey, Bump & Smith, 1990). The influence of emotional states on the activity of the athlete and the performance, as competitive emotions emerge as one of the main factors likely to influence performance. The stressful nature of elite sport, and the competitive environment surrounding it, places many demands on participating athletes (Jones & Swain, 1995).

An athlete's emotional state may affect the outcome of the competition by influencing performance both during training and while competing (Bulter, 1996). The examination of athlete's behavioral and emotional responses to such stressors has developed into a focal area of sport psychology with many researchers interested in assessing anxiety responses of athletes to competitive events (Woodman & Hardy, 2001). Accordingly, the multidimensional conceptualization of competitive anxiety and the development of the competitive state anxiety inventory-2 (CSAI-2); Martens et al. (1990) have been identified as major developments within the field. Research in clinical and training condition anxiety literature has separated the state anxiety into cognitive and somatic components (Borkovec, 1976; Davidson & Schwartz, 1976; Liebert & Morris, 1967). Cognitive anxiety refers to negative expectations and cognitive concern about performance, the consequences of failure, negative self-evaluation, evaluation of one's ability relative to others, the inability to concentrate, and disrupted attention. Somatic anxiety refers to one's perception of the affective physiological elements of anxiety, generated from an increase of autonomic arousal and unpleasant feelings such as nervousness, tension and upset. The current multidimensional approach to competitive state anxiety has emerged through the work of Martens et al. (1990) and their development of the Competitive State Anxiety Inventory-2 (CSAI-2) which measures cognitive anxiety, somatic anxiety, and self-confidence.

The multidimensional conceptualization of competitive anxiety incorporating cognitive and somatic components has provided a clearer understanding of how athletes respond to competitive stressors (see Jones, 1995; Woodman and Hardy, 2001 for a review). However, scales designed to assess the construct, such as the Competitive State Anxiety Inventory-2 (CSAI-2) (Martens et al., 1990) and Sport Anxiety Scale (SAS) (Martens et al., 1990), like many other traditional anxiety instruments, measure the "intensity" of cognitive and perceived physiological symptoms that are purported to signify the presence of anxiety. The subsequent adoption of modified directional versions of the CSAI-2 (Jones & Swain, 1992) and SAS (Hanton & Connaughton, 2002) to investigate symptom interpretation has lead to considerable attention in the sport psychology literature.

Concentration is the mental quality to focus on the task at hand while ignoring distractions. The capacity to concentrate is widely regarded by athletes, coaches and sports psychologists as one of the keys to successful performance in sport. Coaches have long been concerned with how concentration or attention levels among athletes can be improved and maintained and how distractions can be avoided. Common distractions appear to be anxiety, skill errors and mistakes, fatigue, weather, public announcements, opposition players, 'sledging' and negative thoughts. However, sometimes in competition, some athletes anxiety tend to dissipate their attention resources and to identify threats to stimuli that disrupt the running of the race. In addition, each athlete has suffered a break in concentration followed by a decline in performance and loss of confidence. Peper, E. & Schmid, A.B (1993) define the concentration as "the ability to focus attention on the task at hand, and, therefore, not be distracted or affected by internal or external stimuli not appropriate. From these definitions concentration appears as a process by which the attention athlete needs to use all the necessary information leading to the achievement of its better performance while focusing his attention on the task he is expected to achieve without submitted under the disruptive effect of external factors that can prevent achieving adequate performance. The purpose of the present study was to examine the relationship between pre competitive anxiety, concentration and performance in rhythmic gymnastics athletes at different time of assessment.

## METHODS

*Participants*

Six female rhythmic gymnasts in the highest national team (age 14.8 ± 1.3 years, body mass 77.5 ± 7.1 kg, height 180.8 ± 5.6 cm) voluntarily participated in this study. All subjects had been competing for at least 10 years and had previous experience in the execution of the maces' exercise. Before starting the experiment, we took parental consent's gymnasts. They were therefore given detailed instructions to perform maces' exercise accurately and efficiently. All were in training for competition at the time of data collection. Participants noted their current performance and their ranking during the international tournaments. Gymnasts were informed that data were to be collected at two stages during which the gymnasts were evaluated during a training condition and a simulated competition condition. No information about the purposes of the study was given to the participants until after they completed the experiment.

*Procedures*

The experiment included two conditions followed by a final debriefing. Information was obtained from the same group of gymnasts by comparing two different situations:

a) Baseline Training Condition (TC);

b) Competition condition (CC).

In each condition, the data from the psychological and physical variables were obtained 30 min. before the gymnastic trial.

*Familiarization phase:* This phase consisted to familiarize participants with the experimental material and inform them about the experiment. This condition was treated as a control day in which the participants performed a maces' exercise. Since anxiety quickly escalated immediately prior to the competition (Gould, Petlichkoff & Weinberg, 1984) and pre-experimental interview indicated that the gymnasts prepare themselves psychologically just few days prior the competition , the two conditions were separated each other by one week ,and the first assessment of anxiety was used as control measure of the stress level. They were also asked to avoid high-intensity physical training for 24 h before simulated competition condition. This aimed to prevent the influence of residual fatigue from interfering with the test performance. Then, psychological items used in the study were presented and explained to participants. After receiving these instructions, the participants were assured that both their answers to the psychological items and their data would remain confidential.

*Experimental phase:* The athletes completed the Competitive State Anxiety Inventory-2 just prior to the warm-up phase, approximately half hour before the competition. Then, participants started a standardized warming-up. Then, participants completed the general and specific warm-up conditions. Before the technical assessment, subjects performed a concentration test .Next, participants received a specific instruction-delivered according the assigned condition, and they were asked to achieve as best they can maces' exercise.

During each phase, the same researchers were present throughout the tests. The two conditions were conducted at the same time of the day for each subject to ensure that there are no diurnal variations, and under standardized environmental conditions (24 ± 1°C and 43 ± 2% relative humidity). Sport doctors were available to intervene in case of problems. No medical problem appeared during the study.

*Final debriefing:* Participants were debriefed about the goal of the study once all experimental conditions were finished. Moreover, participants received their own performance of each test performed during the study.

*Measures*

*The Competitive State Anxiety Inventory-2* (CSAI-2) (Martens et al., 1990) was used as the measure of competitive anxiety. Participants rated their anxiety responses over the multidimensional constructs of cognitive anxiety (CA), somatic anxiety (SA) and self-confidence (SC) through a total of 27 items 9 for each subscale (cognitive anxiety, somatic anxiety and self-confidence). Symptom intensity levels were rated on a scale ranging from 1 (‘not at all’) to 4 (‘very much so’). Each item was rated on a 4-point type scale, producing a score ranging from a low 9 to a high 36 for each subscale. Internal consistency scores (Cronbach’s alpha coefficients) for the intensity scales have been reported to be acceptable range 0.79 to 0.90 (Martens et al., 1990). A value of 0.85 was reported for the current study.

Concentration test (CR): The concentration was measured using the "Grid training condition concentration" of Harris and Harris (1984). The exercise is performed by checking of consecutive numbers in a grid. The grid has 10 rows and 10 columns, with each box in -the grid containing a number from 0 to 99. The greater the number of consecutive numbers marked within a one-minute period, the greater the concentration level of the subject. Harris and Harris (1894), report that athletes with high concentration skill score in the high twenties and even the low thirties. Typical scores are in the range of half those numbers. A number of training conditioning variations can be performed with this exercise.

Performance evaluation (PERF): Two international judges were asked to evaluate the gymnasts’ performance by referring to the Code of Points FIG (2009). Video analysis was established with a Sony video camera (DCR PC 105E, 1 megapixel CCD, 50 fps).

*Heart rate* (HR): During the training and competition condition participants were asked to wear the elastic electrode belt (placed with conductive gel), attached by the researcher. The participants were asked to remain quiet, without speaking or making any movements for 10 minutes in a supine position. The HR data were obtained by using Polar Team System (PE3000 Polar Electro Oy, Kompella) on the resting position and during the exercise which was placed and set to start by the researcher.

*Statistical analysis*

Data are reported as mean ± standard deviation (SD). The distributions’ normalities, estimated by the Kolmogorov-Smirnov test, varied between variables. Therefore, we used the non-parametric Wilcoxon Rank-sum test was applied to compare pair-wise the two phases of the study. Spearman correlation analysis was performed to check any relations between the training conditions and variables. The results were considered significantly different when the probability was less than or equal to 0.05 ($P \leq 0.05$). Statistical analyses were performed using the software package SPSS version 13.0 (SPSS Inc., Chicago, IL, USA).

## RESULTS

Table 1 shows all the descriptive kinetics and kinematic variables. These were compared between the two conditions and presented in table 2.

Table 1. *Descriptive statistics for training and competition.*

| Training condition | Mean | SD |
|---|---|---|
| CA | 18.83 | 1.60 |
| SA | 19.50 | 1.22 |
| SC | 20.33 | 2.33 |
| CR | 7.50 | 2.51 |
| HR | 178.83 | 5.77 |
| PERF | 7.45 | 0.54 |
| TE | 89.59 | 0.85 |
| Competition Condition | | |
| CA | 23.50 | 2.58 |
| SA | 24.17 | 1.60 |
| SC | 16.17 | 1.72 |
| CR | 3.00 | 2.75 |
| HR | 184.00 | 3.22 |
| PERF | 7.11 | 0.52 |
| TE | 91.34 | 1.95 |

- (CA) cognitive anxiety; (SA) somatic anxiety; (SC) self-confidence; (CR) concentration; (PERF) performance; (HR) heart rate; (TE) time of exercise.

Table 2. *Comparative statistics training versus competition conditions.*

| Variables | *Wilcoxon Rank-sum Test* | |
|---|---|---|
| | Z | Sig. |
| CA | -2.226 | 0.026* |
| SA | -2.226 | 0.026* |
| SC | -2.264 | 0.024* |
| CR | -2.251 | 0.024* |
| HR | -2.207 | 0.027* |
| PERF | -2.232 | 0.026* |
| TE | -2.201 | 0.028* |

* Significant at $P < 0.05$.
- (CA) cognitive anxiety; (SA) somatic anxiety; (SC) self-confidence; (CR) concentration; (PERF) performance; (HR) heart rate; (TE) time of exercise.

Wilcoxon Rank-sum Test demonstrated that the two conditions had different effect on the psychological and physical variables. The scores of cognitive anxiety (CA) are increased in the competition condition: (CCΔCT = 19.87% with $P < 0.05$). Similarly, the somatic anxiety (SA) has increased during the competition condition: (CCΔCT = 19.32% with $P < 0.05$). Moreover, the self-confidence (SC) was decreased in competition with respect to training condition: (CCΔCT = -20.46% with $P < 0.05$) and the same was observed for the concentration (CR): (CCΔCT = -60.00% with $P < 0.05$), (figure 1).

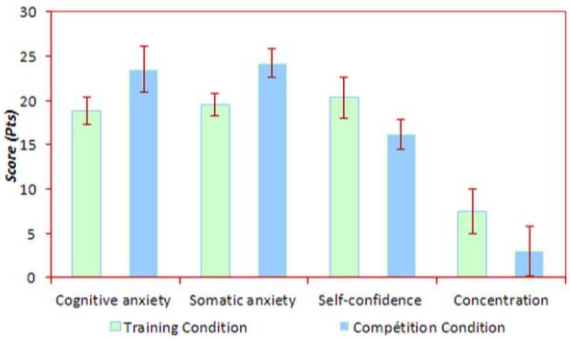


Figure 1.

With regards of the physical data, the heart rate (HR) was increased in the competition with respect to training condition: (CCΔCT = 2.81% with $P < 0.05$). Also, the time of exercise (TE) was increased in the competition condition: (CCΔCT = 1.92% with $P < 0.05$). Moreover, the performance (PERF) was decreased in competition with respect to training condition: (CCΔCT = -4.47% with $P < 0.05$).

Table 3 present the correlation of the psychological and physical data and performance of gymnast's in training and competition condition.

Table 3. *Correlation in the training and competition conditions.*

| | | CA | SA | SC | CR |
|---|---|---|---|---|---|
| Training condition | HR | 0.716 | 0.501 | -0.866* | -0.896* |
| | PERF | -0.970** | -0.461 | 0.742 | 0.955** |
| | TE | -0.559 | -0.926** | 0.853* | 0.618 |
| Competition Condition | HR | 0.897* | 0.893* | -0.676 | -0.794 |
| | PERF | -0.794 | -0.739 | 0.75 | 0.956** |
| | TE | 0.232 | -0.213 | 0.348 | -0.029 |

* Significant at $P < 0.05$; ** Significant at $P < 0.01$
- (CA) cognitive anxiety; (SA) somatic anxiety; (SC) self-confidence; (CR) concentration; (PERF) performance; (HR) heart rate; (TE) time of exercise.

Correlation between the psychological and physical variables in all condition showed a significant relation at (*P*<0.01), between the performance (PERF) and concentration.

## DISCUSSION

The purpose of the present study was to examine the relationship between precompetitive anxiety, concentration and gymnast' performance at two times of assessment. The interest findings of this study were that gymnasts showed greater precompetitive somatic and cognitive anxiety levels in CC than in TC, whereas self-confidence and concentration scores were decreased.

Comparing the scores of cognitive and somatic anxiety according to previous study, our finding was in line with what Esfahani and Gheze Soflu (2010) reported. So, they found that female volleyball players had higher mean scores in cognitive anxiety 21.86 and somatic anxiety 19.38 subscales. As well, Pineda-Espejel, López-Walle, Rodríguez, Villanueva and Gurrola (2013) showed that Women exhibited significantly higher somatic anxiety levels than men. Furthermore, we noted that gymnast reveal higher cognitive anxiety and lower self-confidence in CC. Accordingly, the results obtained by Vosloo, Ostrow and Watson (2009), were similar to our findings. They reported that the swimmers women exhibited higher levels of somatic anxiety and lower levels of self-confidence than the men. This negative relationship has been empirically demonstrated by the findings of Craft, Magyar, Becker, and Feltz (2003) and Besharat and Pourbohlool (2011). Whereas, Pineda-Espejel et al. (2013) showed that gymnasts exhibited higher self-confidence and lower cognitive anxiety in the competitive situation.

As for the effect the type of sport has on anxiety, Martens, Vealey, and Burton (1990) propose that athletes in individual sports who are subjectively judged in competition exhibit more intense symptoms of cognitive anxiety and lower self-confidence. Peares (2007) reported that activity level (professional or amateur); type of sport (individual or group-based) as well as activity history and experience are of important and effective factors influencing pre-competition anxiety (Peares, 2007). Gualberto and Wiggins (2008) believes that those athletes who experience higher levels of competitive anxiety would experience early burnout in their sport field and this factor causes stress due to expressing bad performance by the athlete.

The results showed as well that there is a significant correlation between concentration and performance in both conditions. Hence, the higher levels of anxiety were associated with less of concentration and performance during the CC. The effect of anxiety on concentration supported previous research conducted by Hatfield and Hillman (2001), quality performance associated with elite competition is typified by efficient attentional functioning**.** Shinke and Costa (2001) who investigated the causes of failure in athletes and reasons of weak performance in important competitions reported that lack of experience in these competitions and lack of concentration and sufficient self- confidence are of the most important factors which decrease performance and create unusual behaviors and states in athletes (Shinke & Costa, 2001). When athletes, even elite ones, experience increased anxiety, they often perform less than optimally. Processing efficiency theory (PET) provides an explanation of how heightened levels of anxiety may affect attention and subsequent motor performance. Sport psychology researchers have postulated that excessive anxiety disrupts attentional functioning, and numerous investigations of this hypothesis have offered unequivocal support for their contention (Janelle, 2002). However, others researches contend that the influence of difference effect of anxiety and performance has been proposed to describe how cognitive anxiety, self-confidence and somatic anxiety interact to influence performance (Gould & Krane, 1992; Fazey

& Hardy, 1988; Hardy, 1990). The results of various researches indicate that different factors are involved in pre-competition anxiety. Miyamoto, Morya, Bertolassi, and Ranvaud (2007). and McNally (2002) believe that competitive anxiety and stress in important competitions as well as delicate performances performed with numerous audiences weaken the performance (Hanton, & Connaughton, 2002 : McNally, 2002). The results of findings of Pigozzi, Spataro, Alabiso, Parisi, and Rizzo (2004) confirmed that an athlete's skill level is an important factor in controlling his/her competitive stresses and he believes that elite athletes who are able to control their competitive anxiety through mental skills (such as imagination, feeling control), have good motivation and self-confidence, but amateur athletes with high anxiety experience weak performance in competitions (Pigozzi et al. 2004). One possible alternate explanation for our results is that our gymnasts did not follow any mental and psychological preparation by a specialist or coach before the competition.

Once the difference of stress level was confirmed, the next step was to analyze the change in the physical variables between two conditions. Then, exercise's time and heart rate were increased while performance was decreased on CC compared to TC. Therefore, the findings indicated that anxiety influenced on HR and time's control of the exercise .This timeout requires gymnasts to end their sequence without music which influenced accordingly on their performance. This decrease is due to negative effect of anxiety which disrupts gymnast in the control of maces and result in gymnast's penalty. Accordingly, several studies focused on abnormalities of HR and anxiety disorders (Friedman, 2007) while this study assessed the relationship of HR to precompetitive state anxiety. From a psychophysiological point of view, authors like Lane, Adock & Burnett (1992) and Berntson et al. (1997) agrees that heart rate is sensitive to changes in emotional state. Accordingly, the significant decrease of the HR in the competition condition is related to the inhibition of the parasympathetic activity in stress situations, in our case, under the impact of the competitive situation. In agreement with other authors, a predominance of sympathetic activity over parasympathetic activity is expected to be found in stress situations like sports competitions (Iellamo, Pigozzi, Spataro, Lucini, & Pagani, 2004; Kamath et al., 1991).

## CONCLUSION

In summary, this study emphasizes the importance of examining the effect of competitive anxiety on the concentration and the performance evidenced through two different time of assessment. So, the interest findings of this study was that somatic and cognitive anxiety increase during the CC compared to TC However the self-confidence and concentration were decreased. Concerning the physical data, the heart rate (HR) and time exercise were increased while the performance was decreased in the competition compared to training condition. Accordingly, the importance of collecting information on how anxiety changes during the competition appears fundamental to explain how such anxiety may influence athletic performance. As well, it seems that the lack of mental preparation would have negative effects on athletes' performance and also would modify and increase their anxiety before competition. As a result, we recommend that the coaches should keep up related strategies in training sessions in order to control and modify the tension and anxiety before competition in a planned and regular method.

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# COMPARISON BETWEEN PHYSICAL CONDITIONING STATUS AND IMPROVEMENT IN ARTISTIC GYMNASTS AND NON-ATHLETES PEERS

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*Research article*

***Abstract***

*The aim of the present study was to evaluate the status and improvement of physical conditioning in male gymnasts, aged 9-12 years, and to compare these results with non-athletes. Fifty seven gymnasts, with an experience of 4-5 years in training and competition and 74 non-athletes of the same age were enrolled in the study. All participants were tested twice, in a 12 month interval, on 9 depended variables selected from the Euro Fit Test Battery. Results showed that gymnasts had better results than non-athletes in overall the tests (p<0.01). Except the improvement in the throwing tests, which seems to be mostly age related, the significant improvement in the jumping tests, was more evident in the gymnasts (p<0.01), whereas the improvement in the flexed arm hang and balance tests were observed in the athlete group only. The 30m running speed improvement was observed only in the non- athlete group. Neither group displayed any improvement in the push-ups and the sit-and-reach tests. In conclusion, the status and improvement of physical conditioning in pre-adolescence is significantly related to the kind and extend of physical activity performed and the scholastic motor activity curriculum should be implemented with arm strength conditioning, balance and flexibility programs.*

***Keywords****: motor abilities, Euro Fit Test, boys, normal population, gymnasts.*

## INTRODUCTION

Physical conditioning is important in artistic gymnastics to structure the technical requirements of exercises on various apparatus. The increase of exercise difficulty demands, required by the International Code of Points from the early age level, constrains the development of high level static strength e.g. example in static strength elements (cross, blanche, etc.) as well in dynamic conditions, as an impact velocity of 8.5m/sec generate ground reaction forces which have been measured from 8 to 18 times the body weight (McNitt-Gray, 1991). The optimal combination of muscle strength, speed, and flexibility consents to the neuromuscular system to produce maximal power output, maximizing the gymnastics performance (Bassa et al, 2002; Debu & Woolacott, 1998; Gleim & McHugh, 1997). Gymnasts, in order to reach these requirements might tolerate high level of loading on different parts of the body, as well must keep high level of flexibility to perform the technical elements of this sport (Bencke et al, 2002).

In order to improve their strength, gymnasts use resistance training, involving free weights or training machines. Several studies have shown that weight training is a safe and effective method of conditioning for children and young athletes, for its controlled and progressive increase of loads; provided that the appropriate exercise guidelines are followed (Faigenbaum et al, 2003). The current position of the National Strength and Conditioning Association (NSCA) of America indicated that weight training is safe for youth. Recent evidence dispels the myth that weightlifting in children is dangerous as a result of growth plate injury risk and ineffective because children are unable to increase strength or muscle mass (Meyer & Wall, 2006). Hamill (1994) showed a very low injury rate of weight training and weight lifting (0.0017%). Weight training increases muscular strength enhances the motor skill performance, increases athlete’s resistance to sports-related injuries, can help to improve psychosocial well-being of youth, and to promote and develop exercise habits during childhood and adolescence (Faigenbaum et al, 2009). Some studies have also reported the positive personality effects in children (Faigenbaum, 2000) and athletes (Poiss et al, 2004). Moreover, it would seem that resistance training and weight training could have an influence on the neuromuscular system, with significant increase muscle strength without a concomitant augmentation in muscle size (Ramsay et al, 1990). Furthermore, other factors, such as balance (Debu & Woolacott, 1998) and flexibility (Gleim & McHugh, 1997) are necessary for technical performance in gymnastics. Gymnasts must learn to keep their balance when performing leaping and tumbling maneuvers, as well as in static poses, barefoot on surfaces that vary in stiffness, or to balance to their hands, e.g. on still rings routines that require extraordinary balance ability by gymnasts. For this reason athletes improve balance significantly more than non athletes, as it has been verified by previous data (Balter et al, 2004; Bressel et al, 2007), and this improvement can be observed through practice (Tsigilis & Theodosiou, 2008). Flexibility demands are the most significant and unique aspect that characterized gymnastics from the other sports. Although there is a number of studies that refer to the effect of training programs (Bassa et al, 2002; Pfeiffer & Francis, 1986), neither about the fitness status of gymnasts during competitive session nor the rate of this improvement in relation to the previous annual season. Gymnastics training, in early age, develops strength indexes, comparing to non-athletes and even to athletes of other sports. It has been observed that gymnasts over 11 years old were stronger than untrained boys (Maffulli et al, 2004). Thus, the purpose of this study was to assess the physical conditioning level of young gymnasts aged 9-12 years between two annual competition seasons with a set of field tests. The knowledge of gymnast fitness status provides trainers with the ability to guide correctly the training procedures, and to reach the highest level of this status at the moment of the competition. Second aim of the study was to compare these findings with those of a group of non athletes for a need assessment of scholastic motor activity curriculum. We hypothesized that the physical conditioning of gymnasts could be a reference model of a health status for youth.

## METHODS

*Participants*

A total of 131 health boys (54 gymnasts and 74 non-athletes) volunteered to participate in this study. Fifty-seven were gymnasts (athletes) with a 4.5±1.0 years training experience and they were from different clubs from Northern Greece. Seventy-four were children which participated only in school physical education classes. The study was designed according to the Declaration of Helsinki and was approved by the local Ethics Committee. Both the children and their parents were informed about this research project and parental written consent was obtained.

*Procedure*

Participants had followed training programs of their clubs during their five years training with a frequency of 3 hours per day, for six days per week. Two measurements were performed, each one after the end of the annual training competition period, in order to evaluate the effectiveness of the current training program. Subjects were instructed, orally and in writing prior to first testing. All subjects participated in familiarization practice, organized before the testing procedures. During this time, they were taught the proper technique on each testing exercise, and any questions they had were answered. The general physical fitness parameters that are stressed during an annual competition were in accordance with EUROFIT (1988) protocol and included muscle strength, muscle endurance, aerobic capacity, speed in upper and lower extremities, flexibility and balance test. The most commonly used field tests of upper body muscular strength-endurance are the pull-up and flexed arm hang test, meanwhile other tests such as push-ups and modified pull-ups have been included in some batteries (Ross & Pate, 1987). Prior to testing, the subjects performed a warm up of 10 minutes, consisting in low intensity running, stretching exercises for the lower limbs and the familiarization with testing apparatus. Minutes of rest was allowed between trials of different muscular group. One test leader, positioned at the side of the subject, controlled the correct technique of each test. The specific methods for administration of each of these tests are presented below.

*Push-ups:* Prone position, elbows bent, hands flat on floor, thumbs pointing inward and next to chest; participant pushes body up until elbows are straightened, while heels, hips, shoulders, and head remain in the same straight line; repeat as many times as possible; record total number performed.

*Flexed arm hang:* Overhand grip; spotter raises participant to position with chin clearing bar, elbows flexed, chest close to bar; spotter releases support; extraneous body movements prohibited; record total time (s).

*Strength of upper extremities:* Throwing with two hands up of the head medicine ball 1 kg (m) and throwing with two hands under the head shot put 4 kg (m).

*Sit and reach:* Using a flexometer, trunk flexion was performed in the seated position. The better of two trials was recorded to the nearest 0.5cm (cm).

*Vertical jump:* Performed from a standing position facing parallel to a wall on which a measuring tape had been attached. Initial reach height was measured with the participant reaching as high as possible on the measuring tape with the arm and fingers of his dominant arm fully extended and the palm toward the wall (cm).

*Strength of lower extremities:* Standing long jump (cm).

*Running speed:* Running speed 30 m (s).

*Balance test:* Flamingo balance**:** Stand on the beam with shoes removed. Keep balance by holding the instructor's hand. While balancing on the preferred leg, the free leg is flexed at the knee and the foot of this leg held close to the buttocks. Start the watch as the instructor lets go. Stop the stopwatch each time the person loses balance (either by falling off the beam or letting go of the foot being held). Start over, again timing until they lose balance. Count the number of falls in 60 seconds of balancing. If there are more than 15 falls in the first 30 seconds, the test is terminated and a score of zero is given. Scoring: The total number of falls or loss of balance in 60 seconds is recorded.

*Statistical analysis*

All data were presented as mean and standard deviation in pre and post tests, for the gymnasts and control group. Preliminary analysis revealed that the within subjects effect of the two measurements repeated at the one-year interval is commensurable with the between subjects effect of adjacent years on the dependent variables. Also there was no significant interaction of the measurement with the age factor. This was corroborated by the equality of the means, as proven with the independent samples t-test, of the second measurement of 9-year old athletes and novices (i.e. when they became 10-year olds) with the first measurement of 10-year olds, and likewise of the second measurement of 10-year old athletes and novices (i.e. when they became 11-year olds) with the first measurement of 11-year olds.

The above results provide evidence for the validity of the measurements and allow for the application of simpler multifactor MANOVA models, where the only factors that have to be examined are the boys' athletic level and age together with their interaction. Furthermore the age groups that can be examined are increased to four, spanning from 9 to 12 years, since the second measurement of boys who were initially 11 years old when they are 12 years of age can be considered autonomously. Boys were included in the model only once (either in their first or second measurement), through randomization, ensuring that the age subgroups, both for athletes and novices, remain roughly equal in size. For each dependent variable, the F-values with their degrees of freedom, the corresponding p-values and the effect sizes of each factor and interaction are reported through the corresponding eta-square values in their percentage form. These values roughly represent the proportion of variance in each variable attributed to the effects of each factor. The MANOVA models were followed by post-hoc pairwise comparisons with Bonferroni corrections of age groups within each athletic level and of athletic levels within each age group. The level of significance was set at the 0.05 level.

## RESULTS

Figure 1 shows the Mean values for the weight, height and BMI for athletes and non-athletes. The athletes had lower values than non-athletes in all three variables, at all ages.

The MANOVA procedure showed that in all the nine tests there was a significant level effect and a significant age effect (except in the push-ups test). In two tests there was also a significant Level X Age interaction (Flexed arm hang and running speed 30m) (table 1).

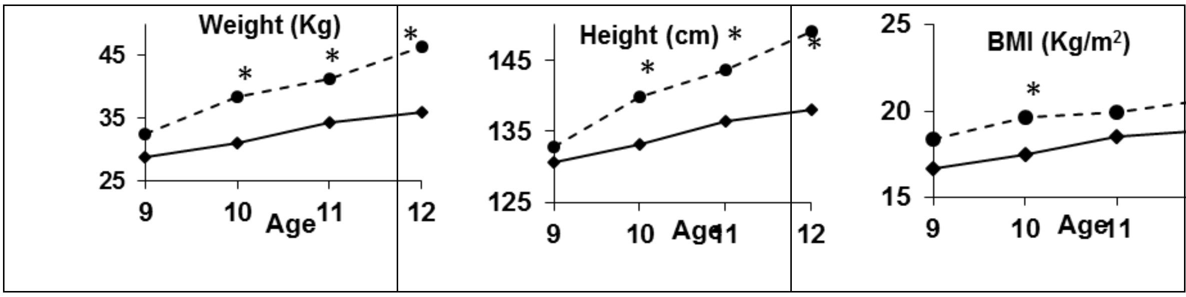


Figure 1. *Mean values for the weight, height and BMI for athletes (continuous line) and non-athletes (dotted line). Asterisks denote statistically significant differences between athletes and non-athletes at the 0.05 level. *p<0.05*

Table 1. *F-values (degrees of freedom), p-values and effect size expressed through the eta-square values in their percentage form of the effect of level, age and their interaction on each of the nine parameters.*

| | Level | | | Age | | | Level X Age | | |
|---|---|---|---|---|---|---|---|---|---|
| | **F(1,123)** | **p** | **$\eta^2$** | **F(1,123)** | **p** | **$\eta^2$** | **F(1,123)** | **p** | **$\eta^2$** |
| Flexed arm hang | 379 | <0.01 | 75.5% | 7.2 | <0.01 | 14.9% | 3.7 | <0.05 | 8.3% |
| Balance test | 25.7 | <0.01 | 17.3% | 5.0 | <0.01 | 10.9% | 1.2 | NS | 2.8% |
| Standing long jump | 81.7 | <0.01 | 39.9% | 11.2 | <0.01 | 21.4% | 0.7 | NS | 1.7% |
| Vertical jump | 39.5 | <0.01 | 24.3% | 7.9 | <0.01 | 16.1% | 0.9 | NS | 2.2% |
| Throwing shot put 4 Kg | 9.5 | <0.01 | 7.1% | 30.1 | <0.01 | 42.4% | 0.6 | NS | 1.3% |
| Throwing medicine ball 1 Kg | 31.3 | <0.01 | 20.3% | 16.6 | <0.01 | 28.9% | 2.2 | NS | 5.0% |
| Push ups | 923 | <0.01 | 88.2% | 2.3 | NS | 5.4% | 1.4 | NS | 3.2% |
| Sit and reach | 385 | <0.01 | 75.8% | 3.1 | <0.05 | 7.0% | 1.8 | NS | 4.2% |
| Running speed 30m | 40.3 | <0.01 | 28.6% | 3.5 | <0.05 | 7.9% | 3.1 | NS | 6.9% |

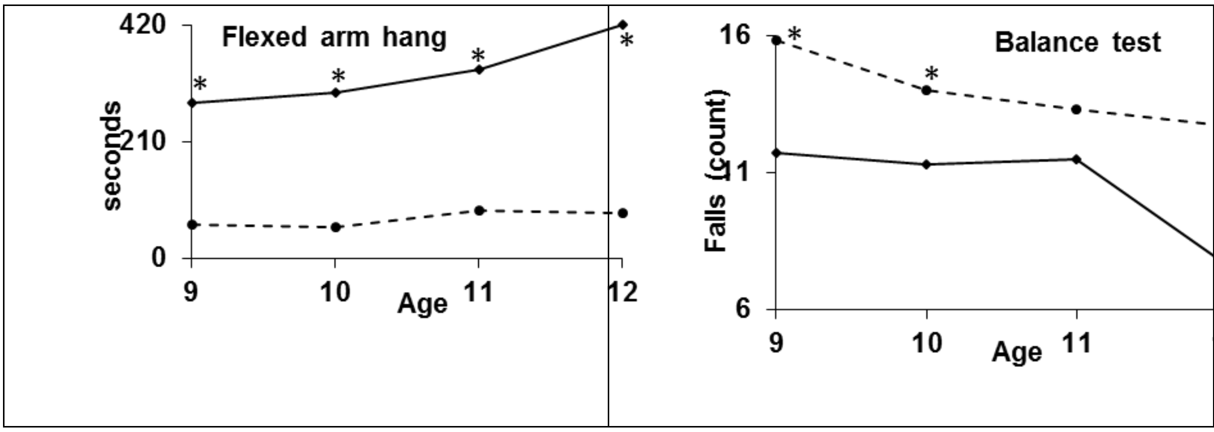


Figure 2. *Mean values for the flexed arm hang and balance tests for athletes (continuous line) and non-athletes (dotted line). Asterisks denote statistically significant differences between athletes and non-athletes at the 0.05 level. *p<0.05.*

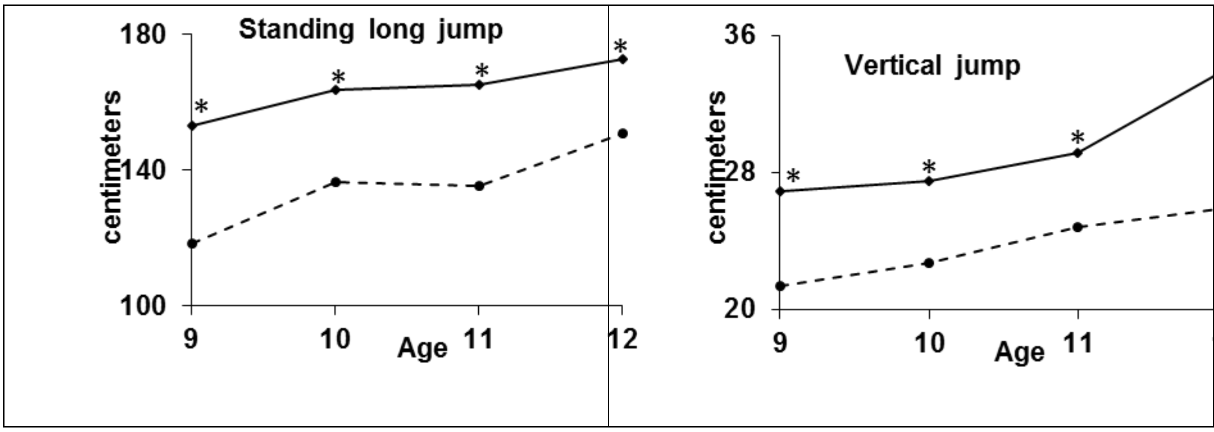


Figure 3. *Mean values for standing long jump and vertical jump for athletes (continuous line) and non-athletes (dotted line). Asterisks denote statistically significant differences between athletes and non-athletes at the 0.05 level. *p<0.05.*

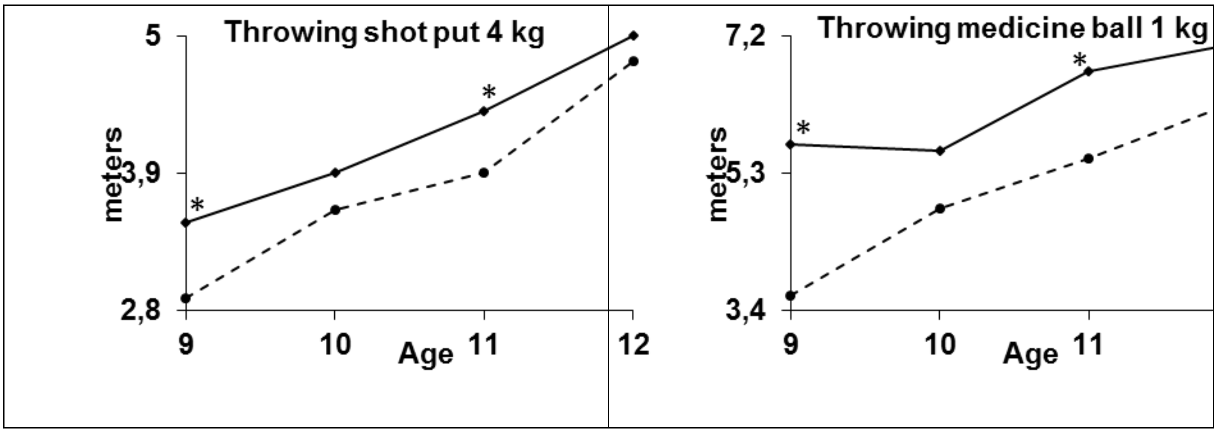


Figure 4. *Mean values for the throwing shot put 4 Kg and throwing medicine ball 1 Kg tests for athletes (continuous line) and non-athletes (dotted line). Asterisks denote statistically significant differences between athletes and non-athletes at the 0.05 level. *p<0.05.*

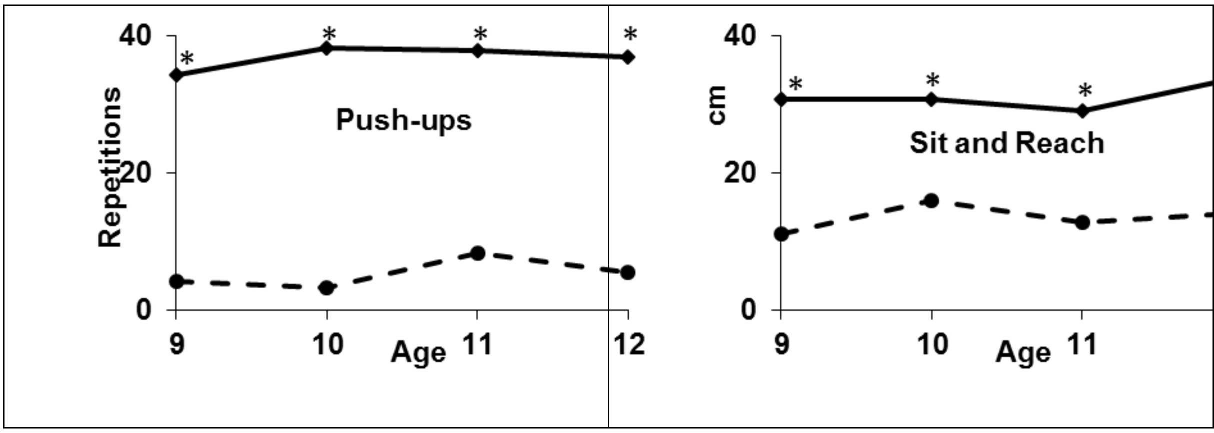


Figure 5. *Mean values for the push-ups and sit and reach tests for athletes (continuous line) and non-athletes (dotted line). Asterisks denote statistically significant differences between athletes and non-athletes at the 0.05 level. *p<0.05.*

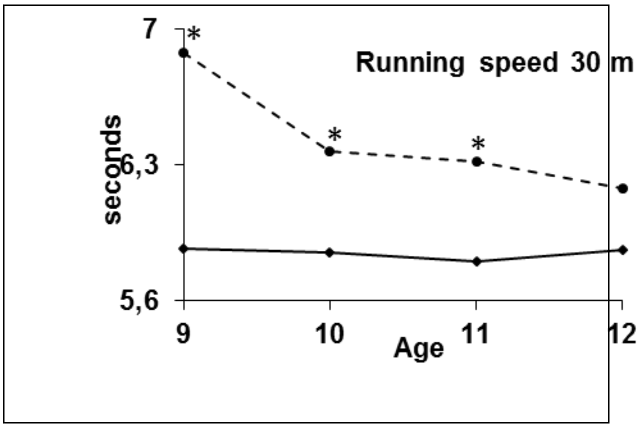


Figure 6. *Mean values for the running speed tests for athletes (continuous line) and non-athletes (dotted line). Asterisks denote statistically significant differences between athletes and non-athletes at the 0.05 level. *p<0.05.*

As the corresponding effect size values showed, for three parameters (push-ups (88.2%), sit and reach (75.8%) and flexed arm hang (75.5%) the athletic level is responsible for more than three quarters of their variability. The effect size of age becomes more important than the effect size of level for the two throwing tests (throwing shot put 4 Kg (42.2% vs. 7.1%) and throwing medicine ball 1 Kg (28.9% vs. 20.3%)).

The results of the post-hoc pairwise comparisons revealed that the nine tests could be grouped into five different types, depending on the nature of the effect of group (athletes vs. non-athletes), age and their interaction on performance.

The first type of tests have been characterized by a significant improvement of athlete performance, especially after the age of ten years, while non-athletes did not show any significant improvement and performed, at all ages, significantly worse than athletes. In this type belong two tests – flexed arm hang and balance test (figure 2).

The second type of tests has been characterized by a significant improvement of both groups, with the athletes always performing significantly better than non-athletes. In this type belong two tests – standing long jump and vertical jump (figure 3).

The third type of tests has been characterized by a significant improvement of both groups, with the non-athletes performing almost as well as the athletes at all ages. In this type belong two tests – throwing shot put 4 Kg and throwing medicine ball 1 Kg tests (figure 4).

The fourth type of tests has been characterized by significant differences between athletes and non-athletes at all ages, with the athletes performing significantly better than non-athletes. However, neither the athletes, nor the non-athletes displayed any improvement with age. In this type belong two tests – the push-ups and sit and reach tests (figure 5).

In the fifth type belongs only one test – the running speed 30 m test. This test showed a significant improvement with age of non-athletes, while athletes remained stationary. As a result at the age of twelve, there were no significant differences between the two groups (figure 6).

## DISCUSSION

The main result of the study was that significant improvements of the athlete group in the arm strength test and balance test were found, while non-athletes did not show any improvement in these two tests, over the years from 9 to 12.

This result could be attributed to the daily training of gymnasts in general and to the special drills for muscle strengthening of the upper extremities. Moreover, artistic gymnastics promotes the improvement of the upper extremities, due to their predominant role in four of the six competition performances. Conversely non-athletes, especially in primary schools, take part in activities that are governed, as a rule, by the participation of the lower limbs (Alwis et al, 2008). Physiologically, the benefits of consistent strength training include an improvement in muscular strength, in tendon, bone, and ligament strength of the upper limbs also. For this reason it should be better to include the arm strength training for future health of non-athlete adolescents also (Harris & Eng, 2010).

Similarly the gymnasts had better balance performances than untrained adolescents, due to the technical training that could enhance postural control and balance (Vuillerme & Nougier, 2004). Balance constitutes a basic skill of performance in—gymnastics, since the athletes have to be “stabilized-immobilized” in the majority of the gymnastics exercises, during their landing from the apparatus, or indirectly executing specialized balance elements. Moreover balance requires achieving the most mechanically efficient position of the body, reducing the abnormal wearing of joint surfaces and reducing stress on the ligaments holding the joints of the spine together, becoming a useful skill for the daily life. In fact this training could prevent the low back from becoming fixed in abnormal positions, low back pain, and lessens fatigue because muscles are being used more efficiently, allowing the body to use less energy (Harringe et al, 2007). The significant difference between gymnasts and non-athletes of the present study can be explained by the fact that superior balance among athletes is the result of repetitive training experiences that influence motor responses (Tsigilis & Theodosiou, 2008). To our knowledge although gymnasts did not dedicate a great part of their training to improve balance ability, especially in these particular ages, it is evident that this ability is enhanced during training (Hoffman et al, 1995). This aspect verifies the finding of Ashton-Miller, Wojtys, Huston & Fry-Welch (2001)**,** which support that gymnasts often practice motionless balance skills on rings, so gymnasts may develop superior attention focus on cues that alter balance performance, such as small changes in joint position and acceleration (Bressel et al, 2007; Tsigilis & Theodosiou, 2008). This finding reinforces data of Balter and his colleagues (2004). The improvement in muscular strength, balance and flexibility can be achieved from gymnasts through gymnastics training during the annual training season. This ability to control the position and movement of the central portion of the body, referred as Core stability, assist in the maintenance of good posture and provide the foundation for all arm and leg movements. Also, good balance due to a good core stability can help maximize running performance and prevent injury, whereas, well-conditioned core muscles help to reduce the risk of injury resulting from bad posture. The ability to maintain good posture while running helps to protect the spine and skeletal structure from extreme ranges of movement and from the excessive or abnormal forces acting on the body.

A significant improvement of the standing long jump and vertical jump in both the athletes and non-athletes groups was found. In particular lower limb power is a decisive factor for a good performance in the floor exercise and vault, and therefore it is exercised on a daily basis (Bosco & Komi, 1980). The significant difference in muscular strength of low extremities between gymnasts and non athletes, verified previous data who examined knee extensors strength (Bassa et al, 2002; Maffulli et al, 2004). In Vertical jump height, as Squat jump and Counter Movement Jump, which are expression of explosive muscle strength of lower limbs (Bosco et al, 2002), the gymnast mean value was the same value (28cm) to that published by Bencke, et al (2002). Non-athletes improved leg strength in their daily motor activity and leisure time, consisting and in running and jumping, even if the intensity of these exercises cannot match the corresponding of athletes (Sheerin et al, 2012).

The levels of the non-athlete group are very near the levels of the athletes in the two throwing tests. This result can be attributed to the fact that throwing is not a gymnast specific skill and not related to movements executed in their training programs. Further, the importance of upper arm strength is related to specialized gymnastics elements (Sands, 1994; Watanabe, 1997). Conversely in non-athletes these movements are executed in several school sport activities (e.g. volleyball, basketball) as well as in many activities during their leisure.

Push-ups constitute a basic exercise in strength training, even though the specific exercise has no great affinity with the specific tasks required in artistic gymnastics (Watanabe, 1997). No strengthening in the school curriculum of non- athletes was included, and they had a very low performance levels in this task.

Better results were found in gymnast sit and reach task, than non-athletes, who are not engage in any stretching exercises. The gymnasts stretched the knee flexors and low back extensors at the beginning and high flexibility levels have been maintained up to their twelfth year. Further, flexibility is an important component of fitness, which means that sport as artistic gymnastics rely heavily on the gymnast’s ability to achieve great range of limb position. Flexibility has an important role in sport performance and generally in health. It is well known that a safe and effective flexibility training program increases physical performance, which means that a flexible joint greatly decreases risk of injury and improves muscular balance and posture (Gleim & McHugh, 1997).

Similar results between the two groups were found in running exercises, either in their pure forms (sprints, relay races etc) or trained in team sports (basketball, football etc). Running constitutes the basic form of exercise for practically all non-athletes (Gorely et al, 2009). Therefore it is not surprising that non-athletes displayed a significant improvement in the specific years in the specific task. This improvement was similar to the athletes' level because they did not usually train for sprints up to 20 meters.

## CONCLUSION

The status and improvement of physical conditioning in pre-adolescence is significantly related to the kind and duration of exercise, as in previous studies was highlighted (Debu & Woolacott, 1998; Gleim & McHugh, 1997; Bencke et al, 2002; Faigenbaum et al, 2009; Faigenbaum, 2000; Poiss et al, 2004). Moreover the present results are in accordance with previous findings (Pfeiffer & Francis, 1986; Haywood et al, 1986; Blimkie, 1993; Servedio et al, 1985), which stated that systematic sport specific training has a positive effect on muscular strength, balance and flexibility, in pre-pubertal children. Additionally, improvement of flexibility and balance plays an important role in the achievement of the technical aspects in artistic gymnastics and must improve through training procedure. The novelty of this study was significant differences were found in arm strength and balance and flexibility tests, between groups. Balance, as result of postural control, during standing and walking and of the ability to recover a stable posture rapidly is important not only in sport but also in everyday life (Gautier & Thouvarecq, 2008). These findings highlighted that the scholastic motor activity curriculum should be implemented with arm strength conditioning, balance and flexibility programs. Certain limitations do not allow generalization of the present findings without caution. The research team was unaware of the physical activities after school involved for the members of both groups. No intermediate measures of physical conditioning were conducted and no reliability indexes were reported therefore.

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# COMPARATIVE STUDY OF GIANT SWINGS BACKWARD ON THE PARALLEL BARS

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*Research article*

***Abstract***

*Comparative data between skilled and unskilled performances in order to examine mechanical determinants affecting the level of technical execution can arguably be beneficial to coaches and sport specialists. Therefore, the purpose of this study was to provide descriptive and comparative kinematic data on giant swings backward on the parallel bars judged by internationally qualified judges as been more or less skillful. Video data was collected utilizing a 60 Hz video camera. Fourteen giant swings were studied. Results showed no significant differences between motion patterns of parallel bars giant swings backwards receiving—on a scale from 0 to 1.0—more than 0.2 (unskilled) and less than 0.2 (skilled) deductions by internationally qualified judges. However, overall data trends and comparison of the two giants receiving the most and least deductions showed that different joint motion patterns might exist.*

***Keywords****: giant swings, parallel bars, kinematics.*

## INTRODUCTION

A contemporary parallel bar exercise consists predominantly of swing and flight elements selected from all available Element Groups in the Men's Code of Points (M.A.G, Code of Points, 2013-16) and performed with continuous transitions through various hang and support positions. Many swinging elements lead to or begin from a handstand position on/from one or two bars/rails. Giant swing backward to handstand (depicted in Figure 1) in the parallel bars is only a difficulty value C element, however it is considered a "profile" element in the process of technical preparation. "Profile" elements are considered the ones that, if correctly executed, form the technical basis for learning more difficult and complex elements from the same Element Group (Smolefski & Gaverdofski, 1999). Indeed, though the first performance of a giant swing backward from Eizo Kenmotsu in 1979 was highly appraised, this element at present is executed even by novice athletes—albeit not with the same technique as by skilled performers—and is a skill that positions one for more technically difficult elements (Fujiwara & Mizuguchi, 2001).

Biomechanical research in artistic gymnastics has grown substantially over the years; however, as reported by Prassas, Kwon & Sands (2006), the lion's share of the research focused on vaults (Lee 1998; Sands, 2000; Sands & Mc Neal, 2002; Springings and Yeadon, 1997; Takei, 1989; 1990; 1991a; 1991b; 1992; 1998), take off and landings on floor exercises (Burgess & Noffal, 2002; Geiblinger, Morrison &

McLaughlin, 1995a; 1995b; Hwang, Seo & Liu, 1990; Mc Nitt-Gray Yokoi, and Millward,1993;1994; McNitt-Gray, Hester, Mathiyakom, & Munkasy, 2001) and dismounts, flight elements and the mechanics of giant swings on high bar and uneven bars (Arampatzis & Brüggeman, 1998, 1999; 2001; Brüggeman, Cheetam, Alp & Arampatzis, 1994; Hiley & Yeadon, 2003; Kerwin, Yeadon & Harwood, 1993; Prassas, Papadopoulos & Krug, 1998; Prassas & Terauds, 1986; Yeadon, 1997). Research on the parallel bars is generally limited (Boone, 1977; Gervais & Dunn, 2003; Liu & Liu, 1989; Prassas, 1988; 1991; 1994; Prassas, Kelley & Pike, 1987; Prassas & Papadopoulos, 2001; Takei, Dunn, Nohara & Kamimura, 1995). Interestingly and although giants performed on the parallel bars are considered as “basic” skills for further technical evolution, there is scarcity of scientific data on the skill including a case study by Prassas, Ostarello and Inouye (2004) and a skilled-unskilled comparative abstract by Prassas (2011). In addition, kinetic and kinematic data comparing giants on the parallel bars and high bar has also been presented (Tsuchiya, Murata & Fukunaga, 2004).

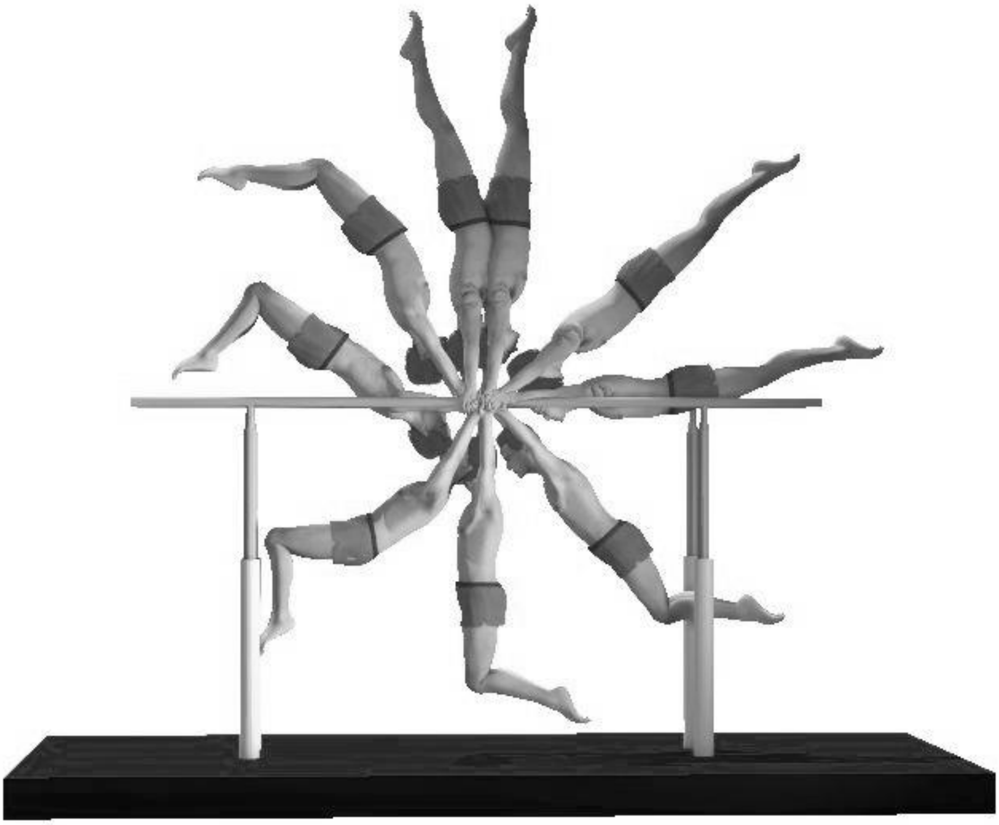

Figure 1. *Representative giant swing backwards on the parallel bars at selective positions. Motion is in the clockwise direction.*

Comparative data between skilled and unskilled performances, in order to examine mechanical determinants affecting the level of technical execution, can be beneficial to coaches and sport specialists. According to Gervais & Dunn (2003), much can be discovered about performance from studying different levels of execution of an element. Therefore, the purpose of this study was to provide descriptive and comparative kinematic data on giant swings backward on the parallel bars judged by internationally qualified judges as been more or less skillful.

## METHODS

Six gymnasts (Age: 19.7±1.63yrs; Mass: 60.7±6.34Kg; Height: 1.6±0.02m) participated in the study. Four were collegiate level gymnasts (USA, Division I University) and two were members of the Greek national gymnastics team. The subjects signed a consent form prior to data collection. All gymnasts performed a series of giants and their performance was captured utilized a 60 Hz video camera. The videotaped performances were viewed by two internationally qualified gymnastics judges and scored (deductions according to FIG Code of points, with 1.00 being a perfect score). Skilled giants were deemed the ones with less than 0.2 points deductions. Fourteen (2 of each of the collegiate gymnasts and 3 of each member of the Greek national team) giants were chosen for analysis utilizing the Ariel Performance Analysis System (APAS). Six body points (the left ankle, knee, hip, shoulder and elbow joints and the left hand), resulting in a 5-segment model, were digitized. In order to measure the hand displacement during the release/re-grasp phase, an additional point on the bar~~,~~ where the gymnast held it initially, was also digitized. All digitizing was done by a single and experienced individual. Dempster's (1955) data as presented by Plagenhoef (1971) was utilized to predict the segmental and total body anthropometric parameters necessary to solve the mechanical equations. Body angular velocity (**ω**) was defined as the angular velocity of the line connecting the CM with the bars. It was calculated utilizing the equation $v_{cm} = \omega r$, where $v_{cm}$ was the linear velocity of the CM and r was the length of the aforementioned line. The raw data was digitally smoothed with a cut-off frequency of 7 Hz before being submitted to further analysis. Mann-Whitney rank sum tests (SigmaStat 3.5) were conducted to compare performance variables for giants receiving more (Unskilled) and less (Skilled) deductions.

## RESULTS

Since the time during the first and the last few degrees of rotation varied considerably among the giants, results are presented commencing with the gymnast's center of mass (CM) 10 degrees past the vertical position in the downswing and ending with the gymnast's CM 10 degrees prior to reaching the vertical position in the upswing. Therefore, the data for the first and fourth quadrants have 80 degrees of rotation instead of 90 degrees.

Table 1 presents temporal and linear kinematic results. In addition, the Table presents deductions given to the giants by qualified judges. No significant differences between skilled/unskilled giants were found for any of the variables.

Table 2 presents joint range of motion and body angular velocity. As with the linear results, no significant differences between the two groups of giants were also found in the angular variables.

## DISCUSSION

The purpose of this study was to provide descriptive and comparative kinematic data on giant swings backward on the parallel bars judged by qualified judges as being more or less skillful. Results showed that, overall, the motion pattern of giants on the parallel bars was similar to patterns on other apparatuses like the high bar and uneven bars. As expected, due to apparatus' constrains, exception to this was seen with the knee joint motion. To clear the floor, gymnasts must flex the knee joint as they pass through the bottom of the swing. Interestingly, however, data showed that the greatest knee joint flexion angle wasn't at the bottom of the swing, but past that about mid-way into the third quadrant. A plausible explanation to this may be that this action is necessary to minimize the loss of angular momentum resulting from the “negative” effect of the gymnast’s weight.

Temporal results (Table 1) showed that the gymnasts spent more time in the first and last quadrant. This was expected as the gymnasts progressively gain angular momentum in the downswing and (progressively) loose some in the upswing. For giants seen performed clockwise, this gain/loss in angular momentum is, to the greatest extent, the result of the effect of the athlete’s weight, which acts clockwise in the downswing and counterclockwise in the upswing. CM maximum velocity was similar between the two groups of giants. It should be noted that direct comparisons between CM velocities in this study and previous ones on high bar and uneven bars may not be appropriate since this study reports CM maximum velocity while in most previous studies, CM “release” velocity for flight elements, or dismounts was presented (Arampatzis & Brüggemann, 1999; Cuk, 1995; Gervais & Tally, 1993; Hiley & Yeadon, 2003; Hiley, Yeadon & Buxton, 2007; Holvoet, Lacouture and Duboy, 2002; Prassas et al., 1998). Results for horizontal hand displacement revealed no significantly differences during the release/re-grasp phase between the skilled/unskilled giants.

Table 1. *Descriptive and Comparative Temporal and Linear Results.*

| Variable | All Giants (n=14) | Skilled (n=6) | Unskilled (n=8) | t-score |
|---|---|---|---|---|
| Total time (TT) (s) | 1.90 ± 0.111 | 1.92 ± 0.104 | 1.89 ± 0.121 | -0.548 |
| T Quadrant 1 (%) | 35.90 ± 2.676 | 35.42 ± 2.748 | 36.39 ± 2.728 | 0.657 |
| T Quadrant 2 (%) | 17.40 ±1.173 | 17.13 ± 1.412 | 17.59 ± 1.015 | 0.703 |
| T Quadrant 3 (%) | 17.03 ± 1.474 | 16.23 ± 0.712 | 17.63 ± 1.65 | 1.921 |
| T Quadrant 4 (%) | 29.68 ± 3.611 | 31.22 ± 3.586 | 28.39 ± 3.332 | -1.525 |
| CM max. vel. (m/s) | 5.96 ± 0.697 | 6.08 ± 0.688 | 5.88 ± 0.745 | $20.5^{+}$ |
| Hand horiz. displ, (m) | 0.29 ± 0.150 | 0.24 ± 0.134 | 0.33 ± 0.150 | 1.133 |
| Deductions$^{++}$ | 0.21 ± 0.154 | 0.09 ± 0.049 | 0.29 ± 0.150 | $48.0^{+}$ |

Note: CM, center of mass; $^{+}$ Mann-Whitney U Statistic; $^{++}$ (1=perfect score)

Table 2. *Descriptive and Comparative Angular Results.*

| Variable | All Giants (n=14) | Skilled (n=6) | Unskilled (n=8) | t-score |
|---|---|---|---|---|
| Knee J. ROM (rad) | 1.90 ± 0.122 | 1.94 ± 0.113 | 1.88 ± 0.133 | -0.697 |
| Hip J. ROM (rad) | 1.29 ± 0.324 | 1.32 ± 0.187 | 1.27 ± 0.412 | -0.261 |
| Should. J. ROM (rad) | 1,24 ± 0.429 | 1.03 ± 0.232 | 1.40 ± 0.485 | 1.724 |
| Elbow J. ROM (rad) | 0.87 ± 0.597 | 0.71 ± 0.448 | 1.00 ± 0.694 | 36.0+ |
| AV Quadr. 1 (rad/s) | 2.06 ± 0.056 | 2.10 ± 0.236 | 2.04 ± 0.198 | -0.489 |
| AV Quadr. 2 (rad/s) | 5.00 ± 0.086 | 5.14 ± 0.290 | 4.97 ± 0.341 | -0.971 |
| AV Quadr. 3 (rad/s) | 5.10 ± 0.124 | 5.46 ± 0.371 | 4.89 ± 0.562 | -2.134 |
| AV Quadr. 4 (rad/s) | 2.30 ± 0.124 | 2.50 ± 0.694 | 2.20 ± 0.162 | $22.5^{+}$ |

Note: ROM, range of motion; AV, angular velocity; + Mann-Whitney U Statistic

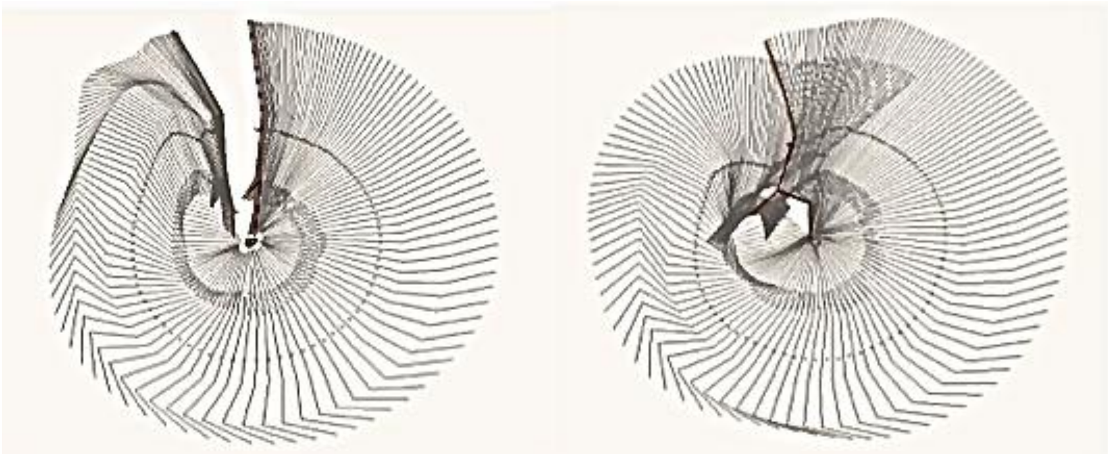

Figure 2. *Stick figures of of the giant swings with the least (Unskilled—left) and most (Skilled—right) deductions. Motion is in the clockwise direction.*

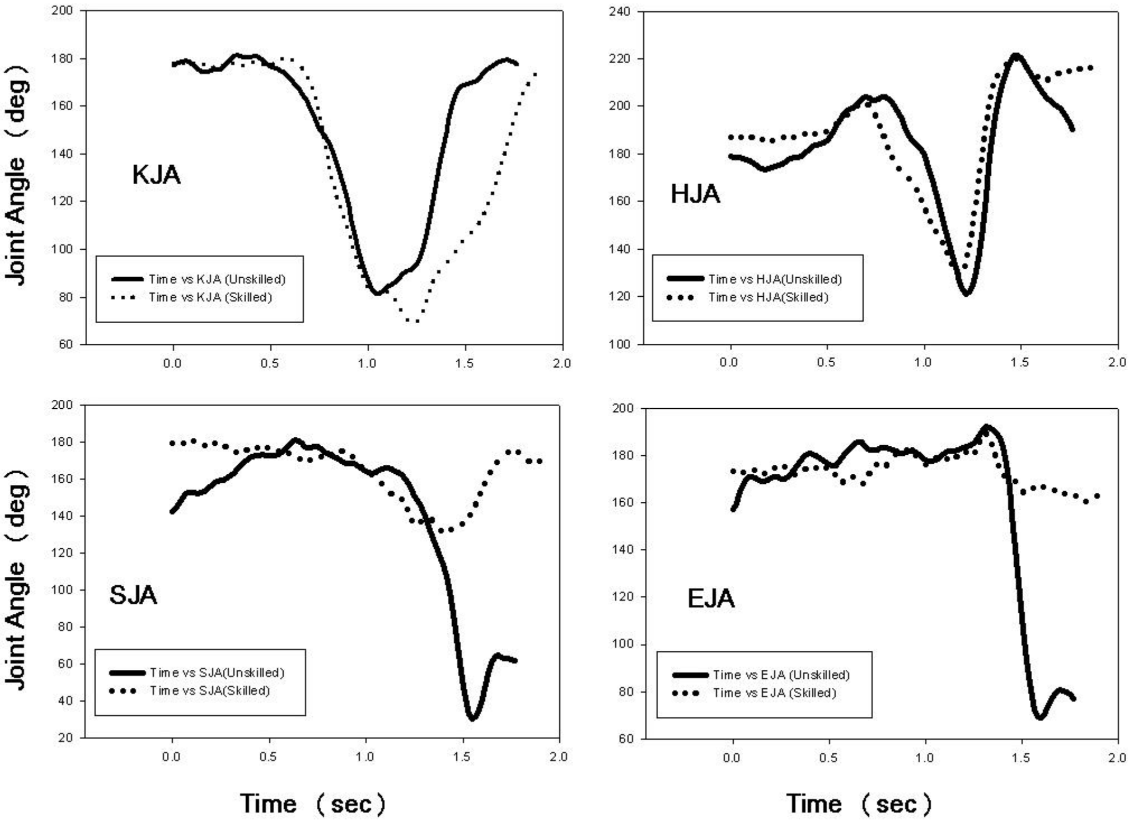


Figure 3. *Knee (posterior), hip (anterior), shoulder (anterior) and elbow (anterior) joint angles (KJA, HJA, SJA, and EJA, respectively) of the giant swings with the smallest (Skilled) and most (Unskilled) deductions.*

The results of this study (Table 2) indicated that joint angles of parallel bars giant swings were similar to results in the literature concerning giants on high bar with the noticeable exception of larger ROM at the knee and shoulder joints (Prassas, 2011). In "traditional" giant swings backward on the high bar the aim is merely to swing from handstand to handstand position using as little flexion and extension as possible

(Cheetam, 1984). However, on parallel bars, constraints in apparatus height, bars orientation and “gripping” force the gymnast to modify shoulder, hip and knee joints range of motion in order to positively influence, through muscular work, the energy exchange between his body and the bars. Brüggeman et al., (1994) and Arampatzis & Brüggemann (1998, 1999) reported that energy exchange between the bars and the gymnast’s body is an important parameter for the quality of giants. The shoulder joint angle is always smaller in the parallel bars compared with high bar while the pattern of hip joint angle is roughly identical for parallel bars and high bar (Tsuchiya et al., 2004). It has been reported previously that hip joint extension in the downswing and hip joint flexion in the upswing are needed more in performing a giant swing backward on the parallel bars than on the high bar (Tsuchiya et al., 2004). The height limitation of the apparatus (180±1 cm above the mat) requires the gymnasts to swing with knees bent at the hang position in contrast with giants on high-bar (placed 260±1cm above the mat) and uneven bars (230±1 cm above mat) that allow execution with extended knee joints.

Joint ROM and angular velocity results showed no significant differences between skilled and unskilled giants (Table 2). A trend, however, was seen with skilled giants showing greater knee joint ROM and unskilled more shoulder joint ROM. Regarding shoulder and especially elbow joint motion, it should be noted that possible out of plane components may exist and those—if present—couldn’t be measured utilizing only one camera. As expected and in accordance with the temporal results, angular velocity increased during downswing and decreased in the upswing.

It is hypothesized that at least some of the non-significant skilled/unskilled comparative results were due to the relatively high skill level of the gymnasts. This is supported by examining data of the two giants receiving the least (0.05 pts) and most (0.6 pts) deductions (referred to as Skilled/Unskilled, respectively in Figures 2 and 3). As seen in the stick figures diagram (Figure 2), the trajectory of the CM is more round and symmetrical on the skilled giant and flatter and asymmetrical on the unskilled one. The diagram also shows the pronounced difference in knee joint motion, especially in the fourth quadrant. Joint angle data in Figure 3 shows that the “skilled” gymnast, by flexing and, perhaps most importantly, maintaining the knee joint flexion for longer time in the upswing, was able to substantially reduce the body’s moment of inertia and thus to complete the giant with less hip, shoulder, and elbow joint action. In contrast, the earlier initiated and faster progressing knee joint extension of the “unskilled” subject increased the moment of inertia to levels beyond his ability to effectively pull and sufficiently elevate his CM.

Thus, in order to complete the giant, he was forced to further decrease the shoulder joint extension angle and to substantially flex the elbow joint. In essence, the “unskilled” subject, unable to elevate the body by pulling it towards the bars, shifted the axis of rotation closer to the body by pulling the handgrips towards the shoulders, re-grasped, and then pushed toward the handstand as he continued the rotation.

## CONCLUSION

Results of this study showed no significant differences between motion patterns of parallel bars giant swings backwards receiving—on a scale from 0 to 1.0—more than 0.2 (Unskilled) and less than 0.2 (Skilled) deductions by internationally qualified judges. However, overall data trends and comparison of the two giants receiving the most and least deductions showed that different joint motion patterns might exist. In particular, it appears that less skilled gymnasts may extend the knee joint prematurely in the upswing, leading to greater elbow joint flexion and shoulder joint extension.

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# COMPARATIVE RESTORATION OF BALANCE AFTER DISTURBING THE VESTIBULAR APARATUS WITH PASSIVE WHOLE-BODY ROTATION: CASE STUDY

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*Research article*

***Abstract***

*The aim of this study was to establish whether the direction of the whole-body rotation influences the restoration of balance after the disturbance of vestibular apparatus with passive whole-body rotation. For this purpose, a chair powered by an electric motor was assembled. It rotates in a chosen direction for 10 seconds until it stops. It makes 11 turns in that time frame. The subject tested on the chair, is an active competitor of baton twirling. For baton twirling it is typical that the turns and pirouettes are performed in a counter clockwise direction (CCW). The results show that the direction of rotation influences the restoration of balance; the subject had better results in CCW rotation. COP (center of pressure) average in CW direction is 18.57% of time deviated to the left and 81.43% of time deviated to the right from center and in CCW direction is 53.83% of time deviated to the left and 46.17% of time deviated to the right from center in whole time of measurements. The differences in measurements depending on the direction of rotation and the deviation of the COP to the left and right of the center are significant.*

***Keywords****: biomechanics, balance, rotation, dominant side, baton twirling.*

## INTRODUCTION

The maintenance of balance is a complex physiological process involving the interactions of numerous body sub-systems regarding the difficulty of the task and the environment. Neuromuscular and musculoskeletal components are important for the control of the body's position and motoric production. Sensory systems consisting of visual, vestibular and somatosensory components coordinate the information about the body's position relative to gravity and the environment and the position of body parts in relation to each other. Central nervous system processes (cognitive and non-cognitive) are also needed for adaptation and preventive aspects of balance control (Sihvonen, 2004).

We distinguish between stable equilibrium, labile equilibrium and indifferent equilibrium. Balance of the body is stable when the body weight returns to the initial position after a small shift from the starting point. Labile position of the body is an unstable state of the body; the body is thrown off balance by the slightest disturbance. Indifferent balance is balance that remains unchanged after a disturbance or returns to its original equilibrium position. Enoka (1994) says that the human body is in the upright and steady position, as long as the force vector of the central center of gravity remains within the boundaries of the base of support and remains stable, as long as it can adapt to interferences with the muscle-skeletal system and return to the state of equilibrium. “Because two-thirds of our body mass is located two-thirds of body height above the ground we are an inherently unstable system unless a control system is continuously acting”, says Winter (1995, p. 193).

Some authors (Tsigilis, Zachopoulou and Mavridis, 2001) do not only face the problem of measuring the balance and test reliability, but also the problem of defining balance. Balance should not be a general motoric ability, but highly specific capability, which depends on the performed tasks or the measurement test. Horak (1987, p. 1881) on the other hand defines balance as "the ability to maintain equilibrium in a gravitational field by keeping or returning the center of body mass over its base of support."

To explore human body and balance in biomechanics, an inverted pendulum model is used. The ability to maintain a balanced position depends on the size of support surface, the center of gravity, height of the central body and its projections on the base of support (Winter, 1995).

In the upright position the base of support is determined by the position of feet including the area under and between the feet. More are the feet apart the greater is the base of support (Hochmuth, 1984).

The main factor in stable position is the strength angle which depends on the size of the support surface and the height of the center of gravity of the body. Strength angle is the angle between the force of gravity and the outer edge of the support surface (Marinšek, 2007).

Disturbances of the vestibular apparatus may be different. Activities such a walking, running, jumping, rotating and changes of the direction present a major challenge for balance system. These are the main movements in a variety of sport disciplines where the soft tissue of lower limbs is exposed to large dynamic forces (Emery, 2003).

*Basic definitions*

*Posture.* It describes the orientation of any body segment relative to the gravitational vector. It is an angular measure from the vertical (Winter, 1995).

*Balance.* Balance is a generic term describing the dynamics of body posture to prevent falling. It is related to the inertial forces acting on the body and the inertial characteristics of individual body segments (Winter, 1995).

*Centre of mass (COM)*. It is a point, equivalent to a total body mass in the global reference system (GRS) and is the weighted average of the COM of all body segments in 3D space. It is a passive variable controlled by the balance control system. The vertical projection of the COM onto the ground is often called the center of gravity (COG). Unit of measurement of the COM is the meter (m) (Winter, 1995).

*Centre of Pressure (COP)*. This is the point location of the vertical ground reaction force vector. It represents a weighted average of all the pressures over the surface of the area in contact with the ground. It is totally independent of the COM. If one foot is on the ground the net COP lies within that foot. If both feet are in contact with the ground the net COP lies somewhere between the two feet, depending on the relative weight taken by each foot. Thus when both feet are in contact there are separate COP-s under each foot. When one force platform is used only the net COP is available. Two force platforms are required to quantify the COP changes within each foot. The location of the COP under each foot is a direct reflection the neural control of the ankle muscles. Increasing plantar flexor activity moves the COP anteriorly, increasing invertor activity moves it laterally. Its units are meters (m). In the literature there is a major misuse of the COP when it is referred to as sway, thereby inferring that it is the same as the COG (Winter, 1995).

When the COM of the body is positioned over the base of support (BOS) and aligned with the COP the equilibrium of vertical posture is achieved (Shumway-Cook and Woolacott, 1995; Winter, 1995). Base of support is the area within the system, which is in contact with the surface; its boundaries are defined by the maximum angle of deflection from the longitudinal axis, without the loss of the equilibrium position (O'Sullivan and Schmitz, 2001). Any body perturbation, either external such as a sudden translation of the support surface or internal such as fast arm or leg movement, shifts the projection of the COM closer to the borders of the BOS and the alignment between the COM and COP is disrupted: this may result in the loss of body equilibrium. To minimize the danger of losing equilibrium, the central nervous system (CNS) utilizes anticipatory postural adjustments (APAs) by activating the trunk and leg muscles prior to the forthcoming body perturbation. As a result of such anticipatory muscle activity, the observed displacements of the COM and COP are small (Belenkiy et al., 1967; Massion, 1992; Aruin & Latash, 1995; Li & Aruin, 2007 in Santos, Kanekar & Aruin, 2010).

When we have an internal or external balance disorder, balance is compensated by different solutions, depending on the degree of the disorder. Responses range from simple monosynaptic reflex to stretch, all the way to the activation of the balance strategies. Balance strategies are sensorimotor solutions which are used for maintenance of control over balance and include muscle synergists, movement patterns, torques in the joints and reaction base forces (Horak, Henry & Shumway-Cook, 1997).

When the projection COP does not cross borders of BOS when standing upright, the body uses two main strategies to compensate the loss of balance. When standing upright the stability can be maintained with ankles positioned front-to-back with the classic reflex of the stretch. The majority of the compensation movements are performed by the hock and foot (O'Sullivan & Schmitz, 2001; Winter, 1995). When the platform moves backwards, the gastrocnemii and hamstrings have the most common response with latencies of l00-120ms after the onset of platform translation. CNS first stabilizes the joint closer to the disturbance, in this case, the ankle, and then follows the stabilization of more distant joints - the knee, hip, and spine. Because the overall response begins in the ankle, such maintenance of the balanced position is called the "ankle strategy". (Balance is established by the invertors and evertors of the ankle.) (Winter, 1995). When it comes to the balance disturbances in the left-right direction (latero-medial disruption), the body responds with a "hip strategy"; a more complex movement, particularly in hips and torso (Winter, 1995), Thus the body enables the activation of major muscle groups, which are easier to withstand unexpected movements (O'Sullivan & Schmitz, 2001). The hip strategy therefore prevails when the muscles around the ankle cannot provide sufficient corrective torque to keep the COM within the BOS, which is typical of larger and faster disruptions of COM (Winter, 1995; Horak, 1987).

For maintaining balance and body posture we have the so-called control system consisting of a sensory system for detecting movement of the body segments, central nervous system (CNS) for processing data and motor system which performs motor tasks (Horak, Nasher and Diener, 1990; Shumway-Cook & Horak, 1986, in Omejec, 2007). The ability to maintain balanced position is based on very complex connections between vision, sensorimotor system, vestibular apparatus and coordination of movements with muscle activity (Horak, 1987). When subjects change the sensory environment, they need to re-weight their relative dependence on each of the senses. In a well-lit environment with a firm base of support, healthy persons rely on somatosensory (70%), vision (10%) and vestibular (20%) information (Peterka, 2002).

Although vestibular sensation is less prominent than that for the senses, the vestibular apparatus signals are essential for the maintenance of body posture and the generation of movement. Vestibular signals help stabilize the head, which, since it houses all of the spatial sense organs, must be kept focus on objects of interest. In addition, if the head moves, the vestibular signals can move eyes within the head, in order to change the direction of view and aim the retina. Finally, vestibular signals cause the convenient synergistic action of legs and trunk muscles to provide a stable body platform from which the eyes and head movements can be initiated (Fuchs, 1989).

Vestibular organ in bony structure of the inner ear in association with the auditory organ, the cochlea and they form two functional units. The two otolth organs sense linear acceleration and its gravity, and the three semicircular canals sense rotational movement in space and detect angular accelerations. With the two organs oriented at right angles to each other, the direction of linear acceleration is spatially encoded in three dimensions and the magnitude of the acceleration is encoded by the firing rate. As the head rotates, the inertial force of the fluid in the semicircular canals deflects the cilia of hair cells aligned with the canals, modulating the firing of the afferent nerves. With the three semicircular canals aligned at right angles to each other, rotation in any direction can be resolved. (Day and Fitzpatrick, 2005). The vestibular nerve then transmits sensory impulses from the semi-circular canals into the cerebellum, which, together with the information from the eyes and joints take care of the balance (Smith, 1992).

Relatively selective stimulation of the horizontal semicircular canals can be applied to a subject who seated in a rotational chair with their head fixed at a 30° angle below the horizontal plane. At the onset of rotation, the inertia of the endolymph fluid in the horizontal canals bends the hair cells (the canal receptors) in a direction opposite to that of head rotation. When the chair is stopped suddenly, the same inertial force will continue to bend the hair cells, this time in the same direction of head rotation even though there is no longer any head rotation. If subjects are made to stand with eyes closed, then they have to suppress these erroneous vestibular inputs and rely on correct somatosensory inputs to maintain standing balance (Horak, Shupert & Mirka, 1989, in Tsang & Hui-Chan, 2006).

The following research (Tsigilis, Douda, Mertzanidou & Sofiadis, 1998) investigated and compared the difference in balance stability of 12 rhythmic gymnast and 17 basketball players after the vestibular apparatus stimulation. All the subjects were female, aged from 9 to 11. The stimulation of vestibular apparatus (semicircular canals) was achieved by a rotation chair (Barany's chair). The chair was programmed to make 10 rotations in 20 seconds. For measuring the static balance they used the Flamingo test and for measuring the dynamic balance the subjects had to walk in a straight line. The subjects had done the balance tests before and after the rotations with »Barany chair«. The analysis of results had shown that gymnasts had better balance stability than basketball players both before and after rotation. They concluded that the main difference was training. Gymnasts have different motor experience, because their training is composed of various repetitions of rotations and pirouettes in frontal and sagittal plane. That improves the efficiency of their vestibular apparatus. The basketball players lack such training. The authors concluded that specific training influences the adaptation of vestibular apparatus to a large extent. Despite better results of the gymnasts, it does not mean they are better in motor control, (but they certainly have the predisposition in establishing and maintaining balanced position.)

Starosta (1986) did an analysis of the direction of rotation on vertical axis. The direction of turns made by 6701 child and adult athletes in 4 sports (figure ice-skating, roller skating, gymnastics, kayaking) was analyzed. The results showed that turn direction varies with type of sport, gender, complexity of exercise, and handedness.

Interestingly, individual preference for the direction of turn might strongly influence on the dancer's skills in performing whole body rotation. For adult classical ballet dancers a rightward turning bias has been described, while the untrained controls predominantly showed a leftward turning bias and a weaker dependence between the direction of rotation and leg preference than dancers (Golomer, Rosey, Dizac, Mertz & Fagard, 2009).

In the research (Čuk and Marinšek, 2013) the aim was to determine which biomechanical characteristics of landing best predict the quality of landing. Twelve male gymnasts performed a stretched forward and backward salto; also with 1/2, 1/1 and 3/2 turns. Stepwise multiple regression extracted five predictors which explained 51.5% of landing quality variance. All predictors were defining asymmetries between legs (velocities, angles). To avoid asymmetric landings, gymnasts need to develop enough height; they need higher angular momentum around the transverse and longitudinal axis and they need to control better the angular velocity in the longitudinal axis.

The aim of the research is to establish whether the direction of rotation has any influence on restoring balance after disturbing the vestibular apparatus with whole-body rotation.

## METHODS

In this study the subject was an active baton twirling competitor. Baton twirling is a poly-structural conventional sport, including aesthetic and choreographically placed acyclic motion structures with a baton. It combines the skillful mastery of baton manipulation, body movement, dance and gymnastics utilizing an array of musical selections (WBTF Coach Manual, 2007). Moreover it has similar movement patterns and prop work as rhythmic gymnastics. For baton twirling it is typical that when the baton is released in the air (aerial) the competitor makes multi successive turns of the body, usually towards the left on the left foot, and then catches the baton. Measurements were made in biomechanics laboratory at the Faculty of Sport in Ljubljana and were made according to Helsinki declaration.

For the constancy of the measurements a rotating chair powered by 100W electric motor was made. The motor was programmed to rotate for 10 sec, and then automatically stop. The chair makes 11 rotations until it stops. The chair has a back rest to ensure the same position of the subject throughout the test. The subject was sitting on the chair during the rotation and when it stopped the subject stood up and stepped to the force platform where she stood still for 30 seconds. The subject was standing narrow astride, heels were approx. 2 cm apart, and hands were akimbo, looking forward (Fig. 1.). We were interested in the foot, with which the subject stepped on the force platform.

Figure 1. *The position of the subject on the force platform.*

With force platform the oscillation of the body was measured for 30 seconds with frequency of 100 Hz, as to acquire value AP (anterior-posterior) (m) and ML (medial-lateral) (m) components of COP (Centre of pressure) and with this also the path of COP.

Measurements have been repeated 12 times in CW direction and 12 times in CCW direction. Between the tests there was 1 min of delay for the subject to rest and to stabilize the vestibular system. 3 measurements in succession have been done for each direction. Between any of series it was 3 min delay for change the direction of electric current and with this also the direction of chair's (motor's) rotations.

The results have been analyzed in Excel 2010. The data of body sway in medio-lateral and anterio-posterior have been arranged increasingly and the time when COP moved in one or other side respectively anterior or posterior have been compared. Statistics have been made in program IBM SPSS Statistics 20.

T tests have been made separate for ML and AP namely between sway medio/lateral respectively antero/posterior for CW in CCW in first 10 sec and in whole time of measurements (30 sec). With T test for independent sample the differences between sways for CW in right and CCW in left for 10 in 30 sec. and also differences between sways CW forward and CCW forward for 10 in 30 sec. have been compared.

## RESULTS

If we rotate in CW direction, it is aspect that when we stand, in time of vestibular stabilization after rotation, we are still sway forward and in right because of disturbance of vestibular apparatus and the felling of rotation, which is still present. Inversely valid for rotation in CCW direction, we should be sway forward and to the left. Because of this in research the time when COP was the sway lateral from center and the sway medial from center have been compared.

The average, standard deviation and standard error for the percent of time deviation COP to the left or right from center after rotation in CW direction and CCW direction, divided by time (10 sec, 30 sec), is presented in Table 1 and Table 2. In first 10 seconds after rotation in CW direction is COP average 27.25% of time deviated to the left and 72.75% of time deviated to the right from center. In whole time of measurements (30 sec) is COP 18.57% of time deviated to the left and 81.43% of time deviated to the right from center. Data presents quite difference in deviation at one or the other side from center.

After rotation in CCW direction in first 10 sec the COP average is 43.40% of time deviated to the left and 56.60% of time deviated to the right from center. In whole time of measurements is COP averagely 53.83% of time deviated to the left and 46.17% of time deviated to the right from center, what indicates a smaller difference than the rotation in CW direction.

T test (paired) between deviation COP to the right and deviation COP to the left from center for first 10 sec after rotation in CW direction presents statistically significant differences between groups, they are also statistically significant differences for the entire measurement time, while the non-significant difference are for the rotation in CCW direction as for 10 seconds, as well as for the entire measurement.

Table 1**.** *Percent of time, while the COP is deviated medial and lateral, after the rotation in CW direction.*

| time (%) Measure | 10 seconds | | 30 seconds | |
|---|---|---|---|---|
| | left dev. | right dev. | left dev. | right dev. |
| average | 27.25 | 72.75 | 18.57 | 81.43 |
| St. dev. | 25.26 | 25.26 | 25.40 | 25.40 |
| St. err. | 7.29 | 7.29 | 7.33 | 7.33 |
| p (t-test) | .000† | | .000 ‡ | |

*Notes: p< .05, two tailed paired; † deviation to the left - deviation to the right, 10 sec; ‡ deviation to the left - deviation to the right, 30 sec*

Table 2. *Percent of time, while the COP is deviated medial and lateral, after the rotation in CCW direction.*

| Measure | time (%) 10 seconds | | | 30 seconds |
|---|---|---|---|---|
| | left dev. | right dev. | left dev. | right dev. |
| Average | 43.40 | 56.60 | 53.83 | 46.17 |
| St. dev. | 25.48 | 25.48 | 32.35 | 32.35 |
| St. err. | 7.36 | 7.36 | 9.34 | 9.34 |
| p (t-test) | .218† | | .568‡ | |

*Notes: p< .05, two tailed paired; † deviation to the left - deviation to the right, 10 sec; ‡ deviation to the left - deviation to the right, 30 sec*

Table 3. *Comparison of the results after rotation in CW and CCW direction.*

| | M | p (t-test) | Df |
|---|---|---|---|
| CW, deviation to the right, 10 sec | 72.75 | .001** | 22 |
| CCW, deviation to the left, 10 sec | 30.99 | | |
| CW, deviation to the right, 30 sec | 81.43 | .030** | 22 |
| CCW, deviation to the left, 30 sec | 53.82 | | |

*Notes:**p< .05, two-sample equal variance*

Table 3 shows that is with the T-test for independent samples (two-sample, equal variance) between the rotation in CW and CCW direction confirmed that both, the first 10 seconds, as well as the whole of the measurement, the difference between the groups are statistically significant (p = .001; p = .030).

It doesn't matter in which direction we are rotating in, we have the feeling like we are always going forward. That's why COP is expected to be deviated a bit anterior from center, whatever way we're rotating in. Averages of both directions (CW and CCW) were made separately. Results are showing that after any rotation (CW and CCW direction) there aren't main differences between deviation anterior or posterior. The most noticeable differences can be noticed in first 10 seconds after rotation in CCW direction, where deviation posterior averagely lasts 31.55% while anterior 68.45%. T test (paired) between deviation of COP anterior and posterior separately for the first 10 seconds and 30 seconds, did not point out any statistical differences. We can also notice, that the T test for independent samples (two-sample equal variance), where we were comparing results after both rotations, did not show any statistically significant differences.

Graphical display shows average path of deviation to medial or lateral after rotation in CW and CCW direction (Fig. 2). The difference between results after rotation in CW and CCW direction is very clearly shown. After rotation in CW direction, deviation starts on left side and goes towards right side, while after rotation in CCW direction deviation starts on right side and goes towards left side. After rotation in CW direction, slightly bigger deviation of COP towards right direction can be seen. After rotation in CCW direction deviation is equally distributed around the center. Balance is sooner and better achieved, when subject is rotating in CCW direction. There aren't any significant differences in anterior and posterior direction, according to rotation before (Fig. 3.). It seems that both average paths of COP are traveling in the same direction. Although, after rotation in CCW direction is COP during 4$^{th}$ and 18$^{th}$ second slightly deviated anterior. That differs from results after rotation in CW direction, when COP is close around center. After 19$^{th}$ second path of COP, after rotation in CCW direction, narrows to the center, while average path COP after rotation in CW direction deviates a bit posterior. As predicted, deviation of COP is irrelevant to the course of rotation and deviated anterior.

After test subject has rotated in CW direction, the biggest deviation has been noted in the medial-lateral to the left side (left = -.036;right = .030). After rotation in CCW direction, the biggest deviation has been noted to the right side (right = .044; left = -.027). In anterior-posterior direction has been at the beginning in both cases the COP path deviated anterior and so was the biggest measurement (CW: anterior = .048,posterior = -.028; CCW: anterior = .045, posterior = -0.033).

On the 4$^{th}$ graph (Fig. 4.) average path COP of all of the measurements, separated for after rotation in CW and CCW direction, has been drawn. The average COP path after rotation in CW direction starts on the left side and travels towards right side. That can be clearly seen on the graph. One can also notice that the average path COP after rotation in CCW direction starts on the right side and goes towards left side. On the 4$^{th}$ graph, there is also noticeable, that the average path COP after rotation in CW direction stabilize a bit further to the right side in comparison to the average path COP after rotation in CCW direction, where COP path in arranged mostly equally around the center, but it is still deviated a bit anterior in comparison to the average COP path after rotation in CW direction.

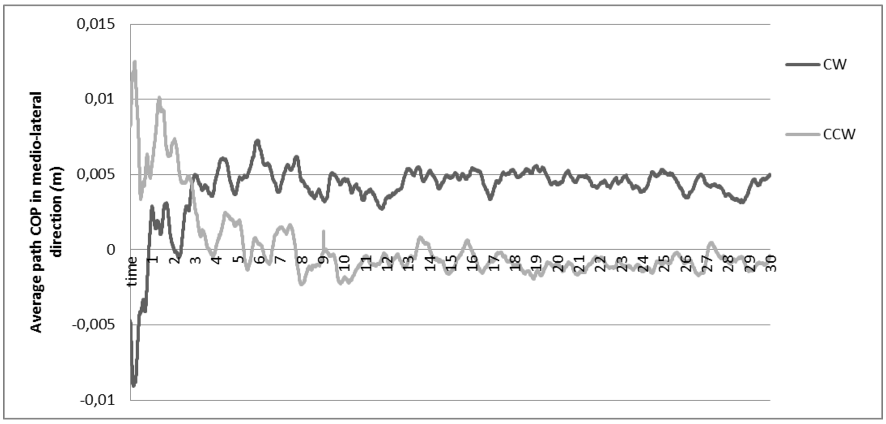


Figure 2. *Average path COP in medio-lateral direction.*

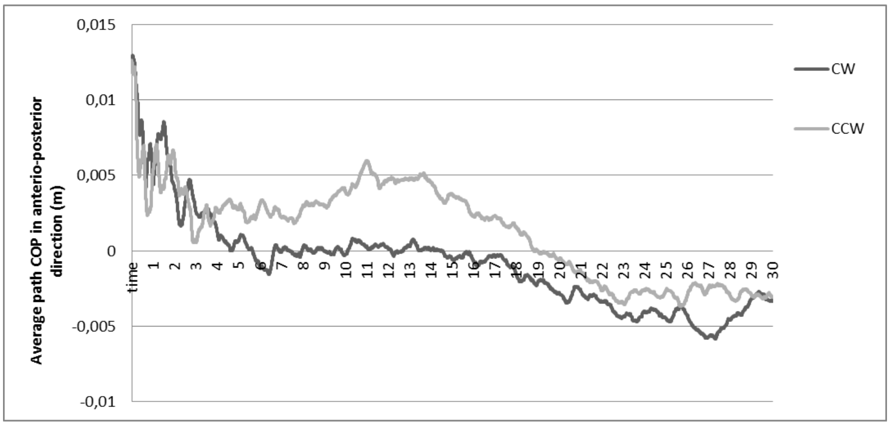


Figure 3. *Average path COP in anterior-posterior direction.*

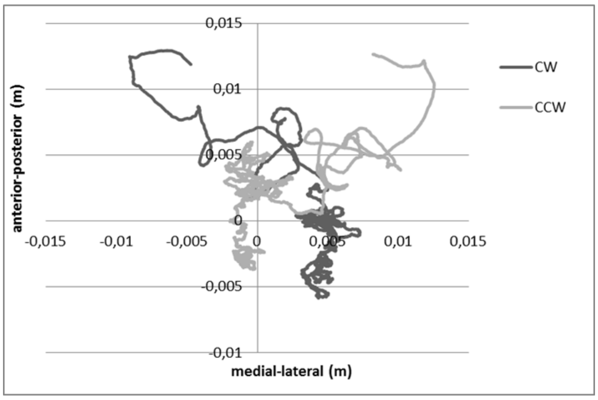


Figure 4. Path *COP after rotation in CW and CCW direction.*

## DISCUSSION

In this study we observed whether human body responds differently to vestibular system disturbance with passive whole-body rotation relative to the direction in which it rotates. From the previous studies, we can conclude that people consciously mostly rotate in a CCW direction, but people who have trained sport where there are rotations to the CW (dance, rhythmic gymnastics) for years, rotate in a CW direction.

In our case, the tested subject was a baton twirling competitor, which mainly rotates to the CCW direction on the left foot. The subject was expected to be able to better maintain balance after the whole-body rotation in a CCW direction, then after the opposite direction.

For the analysis the data of COP deviation from the center in lateral-medial and anterior-posterior direction has been used. The data of COP measurements after rotation in a CW and after rotation in the CCW direction has been compared.

Comparison between the time when the COP is deviated to the left and when it is deviated to the right from center shows that after the rotation in CW direction the average of time when the COP is deviated to the left is 27.25% and the average of time when the COP is deviated to the right is 72.75%, in the overall measurement. During first ten seconds of measurements average of time when the COP is deviated to the left is 18.57%, and when the COP is deviated to the right is 81.43% of time. After rotation in CCW direction the differences were smaller. Namely the average time of the COP being deviated in left direction from the center has been 43.40% and the average time of the COP being deviated in right direction from the center has been 56.60% as noted during all of the measurements. During the first 10 seconds the COP average of time deviated to the left from center was 53.83% and the 46.17% of time deviated to the right. Also, the graph shows that the stabilization of the balance after the rotation in the CCW direction was better than in the CW direction.

T-test (paired) has been made between COP deviation to the right and left from center during the first ten and thirty seconds after rotation in CW and CCW direction. With the 5% certainly we can confirm that there are typical statistical differences after rotation in CW direction in the first 10 seconds of the COP deviation from the center between left and right ($p = .000$). Even in the 30 seconds of measurements there were statistical differences between the COP deviation from the center ($p = .000$). After rotation in CCW direction, there were no statistical differences (10s: $p = .218$; 30s: $p = .568$).

The T-test for independent samples (two-sample equal variance) has also been done, where we were ascertaining the differences between the deviations of the COP from the center after rotation in CW and CCW direction. The results shows that with 5% of certainty there are significant statistical differences between the groups (10s: $p = .001$; 30s: $p = .030$).

An analysis has also been made in the anterior-posterior direction. The average deviation in the anterior direction of the COP during the first 10 seconds after rotation in CW direction was 57.93% of time, and 42.07% of time in posterior direction. In the whole measurement the average of COP deviation from the center was 57.70% of time in the anterior direction and 42.30% of time in the posterior direction. After rotation in CCW direction during the first 10 seconds the deviation in anterior direction from center was 68.45% of time and 31.55% of the time in posterior direction from center. During the whole 30 seconds the average is 54.76% of time when deviation was in anterior direction from center and 45.24% of time when it was in posterior direction from center.

The T-test (paired) between the groups has shown no statistical differences (CW, 10 s: $p = .480$; 30 s: $p = .484$; CCW, 10 s: $p = .094$; 30 s: $p = .625$). Also the T-test for independent samples (two-sample equal variance) between the results after the measurement in the CW direction and after CCW direction the difference is not statistically significant (10 s: $p = .235$; 30 s: $p = .318$).

The graphical presentation of the average path of the COP for measurements after CW direction and after CCW direction shows, that in general path COP of the rotation in the direction of CW starts on the left side and moves to the right. On the contrary, the average path COP of the rotation in the direction CCW starts at the right side and moves to the left, as has also been provided.

The differences can be explained as a consequence of rotation in either direction. During first seconds after the rotation the vestibular system is still disturbed. Inertia of endolymph fluid in horizontal half-circle canals bends their hair in the opposite direction of heads movement, although when one's head stops moving, that fluid doesn't stop spinning at the moment, and that inertia force keeps bending hair inside canals, and that makes one feel like one's still rotating. This could be a reason for the displacement of the COP in direction of whole-body rotation.

The research has also concluded that there are the differences of establishing the balance after the rotation in one or the other side and that the subject better established a balance after rotation in CCW direction than after rotation in CW direction. The differences are particularly noticeable at deviation of COP from the center towards medial or lateral while anterior and posterior, there was no significant difference.

The reason for the difference in measurements is usually reliable of subject's preparedness or training because the subject is actively practicing baton twirling where they mainly rotate in CCW direction.

Finally, the study found that training effects on response of vestibular system and the establishment of equilibrium. However, trainers should have prepared the athletes also for rotation in non-dominant direction of rotation in a particular sport. It can happen that the competitor should have made an element which requires rotation in non-dominant side, but won't be able to make it because of over-trained dominant side.

Probably long-term asymmetric burdening can cause acute (mostly like ankles or knees) or chronic injuries (most likely the back trunk) (Steffen, Baramki, Rubin, Antoniou and Aebi, 1998; Yeadon, 1999 in Čuk and Marinšek, 2013). It is also possible that there would be a deformation of the physical characteristics and thus collapsed posture, which would again lead to injury. In competitive sports have over-trained dominant direction of rotation may also have implications in the implementation of elements. It might happen that the competitor will be forced to perform an element that has a rotation in the opposite direction, as usually done, or will be due to an error in the composition the next element should continue differently (the other way), for which will need a sense of rotation of the both directions.

The results of the pilot study provide us with a good starting point for further research on more people. It would be good to extend research with a focus on dominance and asymmetry of the body.

Beside this it could be very interesting to compare two kinds of athletes. Athletes in significant asymmetric sports like basketball, football, ninepins and the other in significant symmetric sports like track and field (running), swimming, gymnastic, skiing. With this test we can find out if the asymmetry of the body may influence the body stabilization.

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# THERMAL IMAGING OF HANDS DURING SIMPLE GYMNASTICS ELEMENTS ON THE WOODEN BAR WITH AND WITHOUT USE OF MAGNESIUM CARBONATE

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*Research article*

***Abstract***

*The article describes investigation of effectiveness of magnesium carbonate in simple gymnastics. Students at the faculty of sports performed a simple element (one leg circle forward) while temperature of the bar and palms was measured with a thermal imager. In the first attempt they were using magnesium carbonate while in the second attempt they performed the element without magnesium carbonate. It was notable that with use of magnesium palm temperature rose, while during performance without magnesium the palm temperature was practically constant. Palm friction blisters are then expected to be less frequent when magnesium is not used, as the palm temperature does not rise (important effect of friction is warming of the bar surface and skin). As subjects did not report any grip problems, we could say that for easy elements without many repetitions not using of magnesium can be safe.*

***Keywords****: blisters, palm, safety.*

## INTRODUCTION

Magnesium in gymnastics terminology stands for magnesium carbonate ($MgCO_3$) and by Goetze & Uhr (1994, p.43) it is virgin white dust, which can be also produced in blocks. Gymnasts rub their hands with magnesium to make firm and secure grip with apparatus. Namely, magnesium neutralizes fat and sweat. It is not known the exact date when gymnasts started to use it in their training and competition. It is worth to mention that it was not used in parallel with development of gymnastics apparatuses. However, more precise inspection of old photos (Karacsony, 2002, p.14, p.21) show evidence that gymnasts used some white dust before WWI on rings and definitely before WW2 on a high bar. It is also worth to mention that probably gymnasts in the past used powder, which had similar effect as magnesium carbonate.

Nowadays gymnasts use magnesium on all apparatuses, not just to prevent their hands from blisters, but mostly to increase torsion with apparatus. They put magnesium on their feet as well e.g. beam, floor (Langsley, 1996, p.57) and their body parts (e.g. when bending for triple salto on floor, they put magnesium on their hands and calves, where they will have to grip legs).

While on one side grip is better the air because of magnesium dust is worse and dust on a certain floor can make it slippery. For primary and secondary school gymnasiums where in classes are many children it is also hard to control use of magnesium only for gymnastic purpose. Probably most have seen white hand sign on teammate trousers or dress, especially if they are of dark color. Another aspect is economic (school or club have to buy magnesium) as one block of magnesium is not cheap while it can easily be spent in one day.

In primary school curriculum (Ministry of Education, 2011) for physical education there is also gymnastics content. Teachers fulfill only 30 % to 40 % of the curriculum content (Bučar, 2003; Turšič, 2007). One reason why they do not fulfill the whole content from gymnastics is risk of an injury.

On up to shoulders height bar felge (Figure 1) from stand with one leg swing to support is compulsory while one leg circle forward is optional (Figure 2). Risk of injury during felge is rather small, probably a blister is the most serious injury while doing it and even that happens only after several repetitions.

Figure 1. *Felge from stand with one leg swing to support (Čuk et. al. 2006, p.33).*

Figure 2. *One leg circle forward (Čuk et. al. 2006, p.45).*

By Wikipedia (2013) a blister is a small pocket of fluid (with or without blood) within the upper layers of the skin, typically caused by forceful rubbing (friction). Friction blisters, caused by rubbing against the skin, can be prevented by reducing the friction to a level where blisters will not form. This can be accomplished in a variety of ways: taping a protective layer of padding or a friction-reducing interface between the affected area, gloves should be worn when using tools sports equipment, a lubricant, typically talcum powder can be used to reduce friction between skin and apparel in the short term. People put talcum powder inside gloves or shoes for this purpose, although this type of lubricant will increase the friction in the long term, as it absorbs moisture. Increased friction makes blisters more likely. Blisters are treated like wounds. To prevent hands from blisters proper hand care is advised (proper hydration and tenderness of skin). Blister is quite common in everyday life (e.g. feet) and sport (feet, hands).

From a practical point of view it is not a question whether magnesium is important for high performance male gymnasts or not. Logic says it is important, everybody use it, either for real need or just placebo. Perhaps we can notice on asymmetric bars that some elite gymnasts are not using magnesium. There is difference between wooden bars (used on asymmetric bars) and steel bars (high bar) in terms of friction, hygroscopic property and porosity (FIG, 2011). Therefore we were interested how palm temperature is changing, while performing elements on a wooden bar.

While impact on hands during felge is small, we choose for our experiment one leg circle forward where higher forces on grip are expected. The aim of our research was to determine temperature change of palms while performing one leg circle forward without and with use of magnesium carbonate. It seemed that thermal imaging could be a useful tool to conduct the mentioned research.

Thermography or thermal imaging is well used in medicine (Ring 2012, Ring & Ammer 2012) and many researches were done in defining injuries (Sands et. al. 1993, Hildebrandt et. al. 2010, Skala Kavanagh et. al. 2011, Sands et. al. 2011), however we could not find any research regarding skin palm temperature change while performing gymnastics. Otherwise thermal imaging could be performed in various sports (horse riding, rowing, climbing, cycling, weightlifting, etc.) in order to measure temperature remotely and in a non-contact way. In such a way it is possible to measure temperature differences rather than absolute temperatures because thermal imaging has quite a few practical limitations (Miklavec et. al. 2011, Grgić & Pušnik 2011). The most important limitations are small targets, various and changing emissivity values of targets, reduced transmittance of atmosphere at larger distances due to water vapor or other gases.

## METHODS

Seven adults (5 men and 2 women) physical education students, who were attending gymnastics class at the Faculty of Sports were participating in the experiment. Average age was 24,1 years ± 2,2 years, average height was 1,8 m ± 0,1 m, and average weight was 82,8 kg ± 12,3 kg. Temperature in gym hall was comfortable 21 °C.

One leg circle forward is a part of gymnastics curriculum at the Faculty of Sport. Participants were novices, therefore they tried one leg circles to perform one lesson earlier but none had more than 4 attempts. During their performance they were assisted by two assistants to safely conclude the task. They voluntarily participated in the experiment as we respected Helsinki declaration.

Four subjects performed the first three one leg circles without magnesium, then rested for 20 minutes and afterwards did three one leg circles with magnesium, while three subjects did it in the opposite order. After each one leg circle a subject stopped to show its right hand to the thermal imager to measure temperature, after approximately 15 seconds stop a subject continued with the next one leg circle.

For measurement of temperature we used the thermal imager Guide TP 8. The thermal imager has a resolution 384x288 pixels, operating wavelength 8-14 µm, minimum focus distance 50 cm and was calibrated with an expanded uncertainty of 0,6 °C. The maximum temperature of the right palm was measured. The imager was put on a stand at the distance of 2 meters. In the analysis of thermograms the emissivity of skin was set to 0,97 and the emissivity of wooden bar was set to 0,9. The thermal imager sometimes performed the self-calibration routine just when the measurement should have been taken. Such a routine disabled making a measurement for about 5 seconds. In this respect not all measurements were performed immediately after termination of the element. Nevertheless, results did not show a noticeable deviation due to this problem.

## RESULTS

First thermal images were analyzed and maximum values were extracted from the right hand (Figure 3). Before subjects performed one leg circle their average palm temperature was 33,23 °C (without magnesium) to 33,71 °C (with magnesium), pairwise t-test was not significant between temperatures (Table 1), so within the protocol we gave enough time for palms to cool down. Pearson correlations were without use of magnesium significant between one leg circle attempts, while with the use of magnesium were mostly not significant.

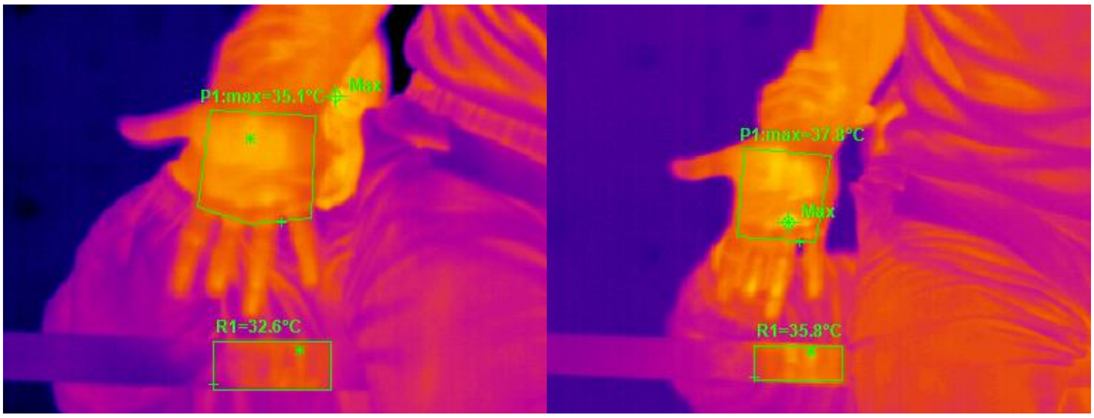


Figure 3. *Thermal image without magnesium and with magnesium.*

Table 1. *Descriptive statistics and Pairwise t-test.*

| | Temperature before one leg circle | Temperature after 1st one leg circle | Temperature after 2nd one leg circle | Temperature after 3rd one leg circle |
|---|---|---|---|---|
| **Without magnesium** | °C | °C | °C | °C |
| person | max. | Max. | Max. | Max. |
| 1 | 33,1 | 32,8 | 33,0 | 33,8 |
| 2 | 32,8 | 32,7 | 33,4 | 33,3 |
| 3 | 34,3 | 34,2 | 34,1 | 35,0 |
| 4 | 34,5 | 34,6 | 34,1 | 34,0 |
| 5 | 33,3 | 33,5 | 33,7 | 33,4 |
| 6 | 34,7 | 34,7 | 34,9 | 35,1 |
| 7 | 29,9 | 30,7 | 31,0 | 30,9 |
| xa | 33,23 | 33,31 | 33,46 | 33,64 |
| sd | 1,64 | 1,41 | 1,24 | 1,40 |
| p t-test previous/next | 0,54 | 0,35 | 0,34 | |
| p t-test 1st/last | | | | 0,07 |
| p t-test withouth/with | 0,34 | 0,00 | 0,00 | 0,00 |
| **With magnesium** | | | | |
| person | max. | max. | max. | max. |
| 1 | 35,3 | 34,8 | 35,5 | 35,5 |
| 2 | 33,2 | 34,8 | 35,6 | 35,3 |
| 3 | 33,6 | 35,7 | 36,6 | 35,8 |
| 4 | 33,8 | 34,4 | 34,3 | 34,8 |
| 5 | 34,2 | 34,7 | 35,5 | 34,7 |
| 6 | 34,1 | 35,6 | 37,2 | 37,8 |
| 7 | 31,8 | 32,8 | 32,4 | 33,1 |
| xa | 33,71 | 34,69 | 35,30 | 35,29 |
| sd | 1,07 | 0,96 | 1,57 | 1,41 |
| p t-test previous/next | 0,02 | 0,05 | 0,95 | |
| p t-test 1st/last | | | | 0,01 |

Table 2. *Pearson correlations (bolded r>0.67 significant at p<0.05).*

| **Without** | Before | After 1st | After 2nd | After 3rd | Height | Weight |
|---|---|---|---|---|---|---|
| Before | 1,00 | **0,99** | **0,97** | **0,96** | **0,70** | **0,72** |
| After 1st | | 1,00 | **0,97** | **0,92** | **0,68** | **0,72** |
| After 2nd | | | 1,00 | **0,94** | 0,60 | 0,58 |
| After 3rd | | | | 1,00 | 0,61 | **0,68** |
| Height | | | | | 1,00 | **0,68** |
| Weight | | | | | | 1,00 |
| **Correlation without/with** | 0,66 | **0,81** | **0,85** | **0,87** | | |

| **With** | Before | After 1st | After 2nd | After 3rd | Height | Weight |
|---|---|---|---|---|---|---|
| Before | 1,00 | 0,64 | 0,63 | 0,56 | **0,86** | 0,48 |
| After 1st | | 1,00 | **0,98** | **0,87** | 0,48 | 0,55 |
| After 2nd | | | 1,00 | **0,91** | 0,42 | 0,38 |
| After 3rd | | | | 1,00 | 0,40 | 0,27 |
| Height | | | | | 1,00 | 0,68 |
| Weight | | | | | | 1,00 |

## DISCUSSION

In general the palm temperature is lower than core body temperature (37 °C), which is normal because distal body parts have lower temperature (Medved, 1980) due to specific thermal regulation of a human body. Without magnesium use the palm temperature did not rise significantly from each one leg circle attempt, t-tests were not significant. Average palm temperature was changing, but after the third one leg circle average temperature was just slightly higher than before starting the first one leg circle and the change was also not significant. Just opposite was with the use of magnesium. Temperature change was significant between the first and after first one leg circle, also between the first and the second attempt, while from the second to the third attempt the palm temperature remained almost the same. Obviously the palms reach thermal equilibrium already after two attempts and temperature does not rise any more. Significant was also temperature change before the first one leg circle and after the third one, as the temperature rose for 1,5 °C. Despite the element is simple, it can be also generator of fear of unknown and therefore participant uses more hand force not to fall down, than it is really required. For maintaining temperature after the second to third repetition it can be already in more conscious control of hand grip strength. Pearson correlations between attempts were high and close to maximum, what means it has been almost linear upgrade of the palm temperature. Almost linear change is characteristic of both situations without and with magnesium (the difference is with use of magnesium for the correlations with before the first attempt and other variables as the first subject had warm palms before the first attempt of one leg circle). Body weight is in medium correlation with the palm temperature when not using magnesium, while when using magnesium it is even not significant. As the correlation is significant already before attempting any element and then is dropping, it is obviously not related to the one leg circle performance but to the body composition.

## CONCLUSION

Despite small subject sample, we gained first data how the palm temperature changed while performing gymnastics elements on a wooden bar. We were testing how the palm temperature changed without or with use of magnesium during simple gymnastics element one leg circle forward. It was notable that with use of magnesium palm temperature rose, while during performance without magnesium the palm temperature was practically constant. Palm friction blisters are then expected to be less frequent when magnesium is not used, as the palm temperature does not rise (important effect of friction is warming of the bar surface and skin). As subjects did not report any grip problems, we could say that for easy elements without many repetitions not using of magnesium can be safe. Without using of magnesium in schools or clubs for simple elements, there can also be some small financial benefit.

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# PARALLEL LINES OF COMMENTARY? THE NBC BROADCAST NETWORK'S PRIMETIME DEPICTION OF MALE GYMNASTS AT THE 2012 OLYMPIC GAMES

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*Research article*

***Abstract***

*This study analyzes how U.S.-based NBC announcers portray male gymnasts in comparison to all other male competitors within the primetime broadcast of the Summer Olympic Games. Contrasts were analyzed regarding attributions of success, failure and personality/physicality. Analysis of NBC's primetime coverage of the 2012 London Olympic Summer Games revealed seven (7) significantly-different dialogue trends between male gymnasts and the aggregate of other male Summer Olympians. Specifically, male gymnasts were more likely to have their success (i) credited to athletic skill/strength and (ii) composure and their failure (iii) attributed to a lack of concentration and a (iv) lack of athletic ability compared to the aggregate of other male Olympians. Male gymnasts were also more likely to receive comments about being (v) modest or introverted and have their (vi) emotional state described. Male athletes competing in all sports except for gymnastics were more likely to have their successes (vii) attributed to their experience.*

***Keywords****: television, commentary, comparision, athletes, gymnasts.*

## INTRODUCTION

"A lot of the guys at school were giving me (flack) and saying, 'Okay, gymnast, so you're going to be a woman in tights?' They can throw all the negativity they want at me. I'm not going to let it break me." -U.S. Olympic Gymnast, John Orozco, *CNN,* 2012[1]

Men's gymnastics has been an integral component of U.S. Olympic television broadcasts for decades. During the past five Summer Olympiads, the sport received over

[1] See video posted on Carroll, J. & Foley, V. (2012, July 26). Bronx native John Orozco an unlikely gymnastics star. *CNN.com*. Retrieved from: http://www.cnn.com/2012/07/26/us/john-orozco-olympic-gold

27 hours of primetime[2] broadcast coverage, more than any other men's event at the Summer Games (Billings, Angelini, & Duke; 2010; Billings, 2008; Billings, Angelini, MacArthur, Bissell, & Smith, 2014). The NBC broadcast network dedicated 3 hours and 40 minutes of its 17-night primetime telecast to men's gymnastics in 2012, making it the third most covered men's sport at the London Olympiad, trailing only swimming and track and field. Yet, men's gymnastics consistently receives less airtime than its female counterpart (which received 6 hours and 57 minutes in 2012) and, outside of the Olympics, is typically an irregular offering on all-sports cable networks in the United States.

Despite the sport's popularity within American Olympic telecasts, men's gymnastics participation in the United States has declined significantly over the past 30 years. Student athlete participation in men's gymnastics decreased by 75 percent between 1981-1982 and 2011-2012 (National Collegiate Athletic Association, 2012). During the 2011-2012 season, female college gymnasts outnumbered their male counterparts by more than a 4 to 1 margin. Similar statistics were reported in a 2007 USA Gymnastics survey (USA Gymnastics, 2008). The decline in men's gymnastics participation is the result of several factors, such as the enactment of Title IX, but one reason may be the perception of gymnastics as a feminine sport (see Csizma, Wittg, & Schurr, 1988; Hardin & Greer, 2009; Koivula, 1995; Matteo, 1988). This perception may negatively impact young males' interest in gymnastics as they could deem it gender-inappropriate to participate in the activity.

[2] Primetime television hours in the United States are defined as Monday through Saturday from 8:00pm – 11:00pm (Eastern Time) and Sunday from 7:00pm – 11:00pm (Eastern Time). NBC's "primetime" Olympic coverage, however, often runs past 11:00pm and sometimes starts before 8:00pm. For the purpose of this and previous Olympic studies, primetime Olympic broadcasts are defined as the network's entire uninterrupted evening Olympic broadcast that runs through the primetime hours.

Though gymnastics has been promoted as a female-appropriate sport in the United States dating back to at least the 19th Century (see Chisolm, 2007), the sport's feminine perception is a relatively recent phenomenon. Gymnastics was part of the Ancient Olympic Games, which were open only to male competitors, and has been used as both a form of military training (see Olivova, 1981; Combeau-Mari, 2011) and nation building (see Kruger, 1996). Cahn (1994) argues that the sport underwent a "sex change" (p. 219) during the 20th century, with factors such as the popularity of women Soviet gymnasts during the 1950s and U.S. media promotion of the aesthetics of female gymnastics contributing to this transformation. A popular 1955 U.S. tour highlighting Swedish women gymnasts noted for having more "elegance" and "grace" than their Russian and German female counterparts (see "Maids on a mission," 1955), may have also facilitated the sport's feminine image.

Subsequently, American gymnasts like Cathy Rigby, Mary Lou Retton, Kerri Strug and, more recently, Gabby Douglas, became household names in the United States. During the Cold War era, Olga Korbut, Nadia Comăneci, and to a much lesser extent, Nellie Kim, were catapulted into détente darling status. The public's fascination with Korbut and Comăneci (both of whom changed how the sport was performed) led to a trend where the sport's most popular figures were petite female teenagers (see Cahn, 1994). With mainstream media narratives focusing on young women, the media's emphasis on the aesthetic/graceful elements of the sport (as opposed to raw power), and male American gymnasts failing to receive media exposure comparable to the Rigbys, Korbuts, and Comănecis of the world, the media helped create and reinforce the sport's feminine image over several decades.

Whether a sport is considered masculine or feminine may have very real consequences. Eagleman (2013) argues that U.S. print media coverage focusing on gymnastics at the 2012 London Games presented both male and female gymnasts "in an ambivalent manner" (p. 12). Alley and Hicks (2005) suggest that sex stereotyping a sport may influence who chooses to participate and that "females may be perceived as more masculine and males as more feminine if they frequently participate in a 'sex-inappropriate' athletic activity" (p. 278). Thus, gymnastics' feminine image could impact how male gymnasts are treated by network announcers and, by extension, the perception of male gymnasts by the general public. As NBC's primetime broadcast of the 2012 Games scored an average audience of 31.1 million viewers per night – 9.5 million viewers more than the average for *NCIS,* the number one primetime program of the 2012-2013 season (International Olympic Committee, 2012; Schneider, 2013) – the commentary deployed during this broadcast could shape the perceptions of men's gymnastics in the U.S. more than any other recent telecast of the sport.

By examining the dialogues of NBC primetime announcers about male athletes during the 2012 Olympic broadcast, this study will determine if male gymnasts are depicted differently than their male Summer Olympian peers on gymnastics' biggest North American platform: NBC's primetime Olympic broadcast.

*Related Theory*

When examining gender in sports media, scholars (e.g., Angelini, MacArthur & Billings, 2012; Billings & Eastman, 2003; Messner, Duncan, & Wachs, 1996) have often used two related theories: agenda setting (McCombs & Shaw, 1972) and framing (Goffman, 1974). Agenda setting is rooted in Lippmann's (1922) notion that the news media influence the "pictures in our heads" (p. 3). Building on Cohen's (1963) assertion that the media "may not be successful much of the time in telling people what to think, but (they are) stunningly successful in telling (their audiences) what to think *about*" (p. 13), McCombs and Shaw proposed that the mass media may influence audience attitudes through the transfer of salience from the media to the audience. Media gatekeepers influence discussion, thinking, and learning by dictating what issues receive attention and this may lead to strengthened attitudes (Kiousis, 2005).

Media framing is often deconstructed into selection, emphasis and exclusion functions (Gitlin, 1980). As any given event may generate several "different stories," communicators become "sponsors" of frames (see Gamson, 1989, p. 158). These sponsors have the power to shape the public's interpretation of events, as issues can be defined and terms of debates set based on the frames used by the media (Tankard, 2001). How a media gatekeeper frames an athlete or an athlete's performance may simply be an attempt to describe an event in a manner that the sponsor considers most meaningful (see Gamson, 1989). That frame, however, provides cues that may have powerful effects as Edelman (1993) asserts: "What we 'know' about the nature of the social world depends on how we frame and interpret cues we receive about that world" (p. 231).

Such postulates connect to cultivation theory (Gerbner, Gross, Morgan, & Signorelli, 1986), suggesting that television exposure can shape perceived social realities. Gerbner (1998) notes, however, that the influence of television involves degrees of repetition that are "subtle, complex and intermingled with other influences" (p. 180). Thus, there is an assumption of "an interaction between the medium and its publics." As such, television does not "create" or "reflect" beliefs, images and opinions, but is part of a larger dynamic process (p. 180). When announcers structure dialogues within a sporting event – at times joining the viewer in the thrill of victory and/or the agony of defeat – the sportscasters may be contributing to much larger societal discourses.

*Gendered Studies of Olympic Television*

Scholars researching gender in U.S. Olympic telecasts have often focused on gender-based differences in sportscaster commentary across entire primetime Olympic broadcasts (e.g., Davis & Tuggle; 2012; Higgs & Weiller, 1994) or the coverage of single Olympic sports (e.g., Angelini, Billings & MacArthur, 2013; Greer, Hardin, & Homan, 2009; Smith & Bissell, 2012). All 10 primetime U.S. Olympic television broadcasts from 1994-2012 have been examined for gendered attributions of athletic success, athletic failure, and athlete personality and physicality at the macro level (see Angelini, MacArthur, & Billings, 2012; Billings & Angelini, 2007; Billings, Angelini, & Duke, 2010, Billings et al, 2014; Billings, Brown, Crout, McKenna, Rice, Timanus, & Ziegler, 2008; Billings & Eastman, 2002; Billings & Eastman, 2003; Eastman & Billings, 1999). Though network announcers have portrayed men and women athletes differently in each of these 10 broadcasts, the taxonomical differences have not been consistent between Olympiads. When viewed longitudinally, these studies have not revealed consistent gender-based dialogic differences on the part of network announcers.

At a more micro level, Billings (2007) analyzed gendered-based differences in commentary within each of the four sports (track & field, gymnastics, diving, and swimming) receiving the most primetime coverage on NBC during the 2004 Games. Specifically, network announcer attributions of success and failure, and depictions of personality/physicality were examined. Angelini and Billings (2010) and Billings, Angelini, MacArthur, Bissell, Smith, & Brown (2014), repeated this approach for the 2008 and 2012 Games respectively, this time focusing on the top five sports that collectively received more than 90 percent of the coverage in primetime, with beach volleyball added to the initial Billings (2007) list. In each of these studies, gymnastics generated gendered differences in commentary across multiple taxonomical categories, with one notable trend: in all three Summer Olympiads, male gymnasts were more likely than female gymnasts to have their success credited to their strength.

Shifting the lens away from male vs. female athletes, Angelini, MacArthur & Billings (2013) examined how male Olympic figure skaters – who, like male gymnasts, compete in a “feminine” sport dominated by female competitors – were portrayed in comparison to their male Winter Olympian counterparts within NBC’s 2010 primetime Vancouver broadcast. The study revealed significantly different network dialogue trends between male figure skaters and the aggregate of other male Winter Olympians in 13 out of the 25 (52%) categories examined. Querying whether similar differences in commentary might exist surrounding athletes competing in “sex inappropriate” sports, the authors suggested it would be useful to study the portrayal of male gymnasts against the aggregate of other male Summer Olympians as both sports (gymnastics and figure skating) seemingly struggle with feminized stereotyping.

Indeed, while there are numerous studies comparing media portrayals of male vs. female athletes (e.g., Angelini, MacArthur & Billings, 2012; Messner, Duncan, & Wachs, 1996; Tuggle, Huffman, & Rosengard, 2007), the question of how male athletes who compete in a “feminine” sport are portrayed in the media compared to male athletes in other sports has received little examination outside of the Angelini, MacArthur & Billings (2013) figure skating study. Gymnastics has not received this treatment as previous studies of network television Olympic gymnastics dialogue have typically focused on either the depiction of male vs. female athletes (e.g., Billings, 2007) or investigated the differences in play-by-play vs. color commentary (see Ličen & Billings, 2012, for Slovenian coverage of Olympic gymnastics).

Yet, this is an area of inquiry that deserves further attention as scholars examining athletes who participate in “sex –

inappropriate" sports have determined the competitors may experience gender-role conflicts (Fallon and Jome, 2007), be subjected to stereotyping (Halbert, 1997), and, in the case of boys who compete in rhythmic gymnastics, "have to negotiate between the often negative identity that others attribute to them and the one they define for themselves" (Chimot & Louveau, 2010. p. 453). Thus, if the media portray athletes in "sex inappropriate" sports differently than their same-sex counterparts in other sports, this may have profound impacts on both the participants and the spectators.

This study answers the call to investigate commentary in such a manner by examining the NBC broadcast network's commentary about male gymnasts. Specifically, it will determine if on-air talk about male gymnasts differs from the dialogues surrounding other male Summer Olympians on the primetime 2012 Summer Olympic broadcast. Hence, the following research questions are posed:

- $RQ_1$: What types of differences in the attributions of success of an athlete are mostlikely to emerge between male gymnasts and all other male Summer Olympians?
- $RQ_2$: What types of differences in the attributions of failure of an athlete are most likely to emerge between male gymnasts and all other male Summer Olympians?
- $RQ_3$: What types of differences in depictions of personality or physicality of an athleteare most likely to emerge between male gymnasts and all other male Summer Olympians?

## METHODS

This analysis examined all 69 hours of the primetime coverage, across 17 nights (July 27-August 12) of the 2012 Summer Olympics as broadcast on NBC. Men's sports accounted for 19 hours and 46 minutes of the broadcast, with men's gymnastics accounting for 3 hours and 40 minutes of that total. Only those descriptive comments spoken by NBC-employed individuals were analyzed because this content can be largely scripted and supervised by network editors and producers (see Billings, 2008). Those network employees included host commentators (Bob Costas), on-site reporters (e.g., Andrea Joyce), special assignment reporters (e.g., Mary Carillo), color commentators (such as Tim Daggett and Elfi Schlegel), and all play-by-play announcers (e.g., Al Troutwig).

The unit of analysis for this study was the descriptor (defined as any adjective, adjectival phrase, adverb, or adverbial phrase) spoken by an NBC-employed individual. Based on the athlete for whom the descriptor was spoken, all were coded for (a) the athlete's sport (b) the gender of the athlete (man or woman), (c) the ethnicity of the athlete (Asian, Black, Hispanic, Middle Eastern, White, or other), (d) the nationality of the athlete (American or non-American), (e) the gender of the announcer (man or woman), and (f) the specific word-for-word descriptive phrase. The descriptors were then classified using the Billings and Eastman (2003) taxonomy (later advanced by Billings, et al., 2008), which divides commentary into three recognizable categories: (a) attributions of success/failure (i.e., descriptions of the immediately viewable athletic performance), (b) depictions of personality/physicality (i.e., descriptions of athletes not directly attributable to the viewed athletic performance), and (c) neutral (i.e., comments that do not describe the athletic performance or depict the personality and/or physicality of the athlete).

In all, 16 classification categories were utilized for the analysis: (a) concentration [i.e. "best at blocking out those extraneous thoughts"]; (b) strength-based athletic skill [i.e. "got a little bit too much power"]; (c) talent/ability based athletic skills [i.e. "he was fantastic on floor"]; (d) composure [i.e. "he had a lot of jitters right there"]; (e) commitment [i.e. "never gives up"]; (f) courage [i.e. "great fight right there"]; (g) experience [i.e. "has won every single international ring competition"]; (h) intelligence [i.e. "bad idea"]; (i) athletic consonance [i.e. "he's got great luck"]; (j) outgoing/extroverted [i.e. "winning personality"]; (k) modest/introverted [i.e. "unassuming"]; (l) emotional [i.e. "smile says it all"]; (m) attractiveness [i.e. "has a beautiful look"]; (n) size/parts of body [i.e. "he's a head taller than all the other Chinese gymnasts"]; (o) background [i.e. "had a tumor out of his leg at age 10"] and (p) other.

Using Cohen's (1960) formula, a second researcher coded 20% of the database and reliabilities were determined for the following variables: (a) the gender of the athlete [$K$ = 1.00], (b) the ethnicity of the athlete [$K$ = .98], (c) the nationality of the athlete [$K$ = 1.00], (d) the gender of the announcer [$K$= 1.00], (e) the word-for-word descriptor or descriptive phrase [$K$ = .83], and (f) the name of the sport being discussed [$K$ = 1.00]. Overall intercoder reliability using Cohen's kappa exceeded 96%.

Once all data were analyzed and tables created, chi-square analysis was employed to determine significant differences between groups by using the percentage of overall comments as expected frequencies. For example, because 14.6% of all attributions for success and failure were about male gymnasts, it was expected that roughly the same proportion (14.6%) of comments about concentration, skill, composure, commitment, attractiveness, and so on should be established as expected frequencies for male gymnasts.

## RESULTS

Research Question 1 queried the differences found in the attributions of athletic success between male gymnasts and all other male Summer Olympians. Table 1 highlights the frequencies in each taxonomical category, with the significant differences noted for both descriptors about successes and descriptors about failures.

Table 1. *Explanations of Success/Failure in All Sports for Male Athletes.*

| | *Success* | | *Failure* | |
|---|---|---|---|---|
| | Gymnastics | All Other Sports | Gymnastics | All Other Sports |
| Concentration | 2 | 11 | 2[d] | 2[d] |
| Athletic Skill – Strength | 17[a] | 28[a] | 1 | 2 |
| Athletic Skill – Ability | 237 | 1413 | 125[e] | 362[e] |
| Composure | 13[b] | 35[b] | 6 | 17 |
| Commitment | 2 | 22 | 1 | 6 |
| Courage | 5 | 13 | 0 | 2 |
| Experience | 52[c] | 769[c] | 13 | 66 |
| Intelligence | 1 | 32 | 1 | 5 |
| Consonance | 22 | 127 | 7 | 36 |
| Total | 351 | 2450 | 156 | 498 |

a: $\chi^2$ = 19.18, $df$ = 1, $p$ < .001; b: $\chi^2$ = 5.90, $df$ = 1, $p$ < .03; c: $\chi^2$ = 45.61, $df$ = 1, $p$ < .001;
d: $\chi^2$ = 3.99, $df$ = 1, $p$ < .05; e: $\chi^2$ = 47.00, $df$ = 1, $p$ < .001

Table 2. *Personality/Physicality Descriptors in All Sports for Male Athletes.*

| | *Sports* | |
|---|---|---|
| | Gymnastics | All Other Sports |
| Outgoing/Extroverted | 2 | 25 |
| Modest/Introverted | 2[a] | 2[a] |
| Emotional | 20[b] | 62[b] |
| Attractiveness | 0 | 2 |
| Size/Parts of Body | 4 | 64 |
| Background | 193 | 1971 |
| Other/Neutral | 121 | 1274 |
| Total | 342 | 3400 |

a: $\chi^2 = 8.04$, $df = 1$, $p < .005$; b: $\chi^2 = 22.97$, $df = 1$, $p < .001$

When examining descriptors about successes, three significant results were found. First, (a) male gymnasts were more likely to be depicted as succeeding because of athletic skill/strength ($\chi^2 = 19.18$, $df = 1$, $p < .001$) and (b) their composure during competition ($\chi^2 = 5.90$, $df = 1$, $p < .03$) as compared to male Olympians competing in all other disciplines. By contrast, (c) male athletes competing in all sports except for gymnastics were more likely to have their successes attributed to their experience ($\chi^2 = 45.61$, $df = 1$, $p < .001$).

Research Question 2 asked what types of differences would be found in the attributions of failure. Regarding athletic failures, two statistically significant differences were found. Male gymnasts were (a) more likely to have their failures attributed to a lack of concentration ($\chi^2 = 3.99$, $df = 1$, $p < .05$) and (b) a lack of athletic ability ($\chi^2 = 47.00$, $df = 1$, $p < .001$) as compared to the male athletes in all other sporting disciplines.

Research Question 3 inquired what sorts of differences would be found in the attributions of personality or physicality of an athlete between descriptors for male gymnasts and descriptors for all other male Summer Olympians. Table 2 highlights the frequencies in each taxonomical code, with the significant differences noted.

When examining these descriptors, two significant results were found as (a) male gymnasts were more likely to be described as modest or introverted ($\chi^2 = 8.04$, $df = 1$, $p < .005$) and (b) have their emotional state described ($\chi^2 = 22.97$, $df = 1$, $p < .001$) than their male counterparts.

## DISCUSSION

When Starr (2008) noted that the Olympics medals table creates competition “primarily on an abacus, not in a sports arena” (p. 42), he was overtly acknowledging that while the Olympic Games are often referenced in the singular, they are more aptly described as a mass amalgamation of sports and athletic skills. This study highlights such divisions, noting that male gymnasts were described in demonstrably different manners than other male Summer Olympians in seven categories. While the majority of dialogue categories did not contain significant differences, the study nonetheless illuminates areas where network broadcaster dialogues are most likely to diverge between male gymnasts and their male athletic counterparts in other major sports.

From the standpoint of media framing, tendencies to highlight certain athletic attributes above others are crucial to the overarching stories and conceptions viewers take from a mass-consumption megasport such as the Olympics. As Smith (1997) notes, “choosing the frame for any story is the most powerful decision a journalist makes” (para. 6). Consequently, part of the interrogation surrounding divergent dialogues in sports media commentary percolates around questions of (a) whether such differences are intended or unintentional and (b) whether such divergences are justified by the varying skill sets required to succeed in each Olympic event.

Relatedly, from the standpoint of cultivation theory, if one believes that the theory, at its core, argues that media can set the terms of the debate (Gerbner, Gross, Morgan, Signorielli, & Shanahan, 2002), the parameters for such arguments seemingly do change between male gymnasts and all other main male Olympians. The question then becomes whether such dialogues create a macro-level conception of perceived fit between gender and the sport being enacted. Hardin and Greer (2009) found that media use played a role in gendered perceptions of a given sport as well as participation rates. Given such a relationship, the seven dialogue differences uncovered in this study could jointly provide answers as to why gymnastics tends to be placed strongly within the feminine domain of cognitively-defined sports continuums.

Delving directly into the results, three significant findings were uncovered relating to attributions for why an athlete succeeded, each of which could have at least some ancillary explanation. For instance, the focus on male gymnasts’ strength could be the result of sportscaster comparisons to women’s gymnastics, which seemingly places less emphasis on strength, with the increased focus on balance (such as the beam) and flexibility (on the uneven bars). The contrast of the women’s events to more power-oriented men’s events (such as pommel horse and rings) could result in heightened focus on the need for strength by male gymnasts to succeed. Likewise, composure seems to be more directly observable for male gymnasts compared to other major Olympic sports; it is easier to witness a lapse of composure in gymnastics than, for instance, a swimming final because of the increased focus on facial features during gymnastics competition. Finally, the tendency to de-emphasize experience within men’s gymnastics in comparison to the other major sports could be the aggregate age of the people competing. While men’s gymnastics usually does not feature teenagers to the degree of women’s gymnastics, it does have a lower median age of participant compared to most other Summer Olympics sports (Rogers, 2012). Thus, age could become a surrogate for experience within overall commentary.

Regarding explanations for failure, the focus on a lack of concentration of men gymnasts could again be endemic within the sport itself as a gymnast falling off of the pommel horse is much more pronounced than a diver who may have lost concentration resulting in an under-rotated dive. The second finding regarding athletic ability is seemingly less explainable by sheer direct comparison between gymnastics and the other studied sports in this analysis. Future research should focus upon whether such a trend is hard-wired within the dialogue differences of commentary in multiple Olympic Games.

Finally, there were two areas in which the personality/physicality of male gymnasts was described significantly differently than of other men athletes. The first difference dealt with male gymnasts being more modest and introverted than their Olympic counterparts in other sports. Perhaps this is a result of the judge-based nature of gymnastics, where avoiding large displays of emotion is part and parcel of the judged performance, a problem that an extrovert such as sprinter Usain Bolt need not be concerned about. It is also possible gymnasts' focus on composure could contribute to this finding. Regardless, the number of modesty/introversion comments is too small to make any broad based conclusions.

The second personality/physicality finding, indicating that emotions were more likely to be a topic of commentary for men gymnasts than for other Olympics is also quite interesting. Future research should explore this area more as one of the traits (stereo)typically applied to women is that they are more emotional than men, a finding recently echoed in Olympic media findings (see Angelini, MacArthur & Billings, 2012; Billings, Angelini, MacArthur, Bissell & Smith, 2014). If male gymnasts are perceived as being more emotional than other Olympians, this could play a role in the belief that men's gymnastics is a feminine sport.

*Limitations & Directions for Future Research*

This study is limited in that it solely utilized content analysis, a method that can describe what exists but cannot enact causal linkages for significant differences in content. Nonetheless, the current study yields interesting findings related to *how* male gymnasts are conveyed, which is a far more interesting postulate than *whether* (or not) they receive coverage. The preponderance of studies related to gender and sport focus on the exposure (or lack thereof) of women's athletics, generally finding that in the media, women athletes are "striving to catch up, but never can" (Poniatowski & Hardin, 2012, p. 636). The same could be said regarding men athletes competing in a sport with feminized connotations like gymnastics. Male gymnasts receive significant primetime exposure on U.S. based Olympic broadcasts and they demonstrate heightened strength, agility, and many other positive athletic traits. Yet, similar to their male figure skating cousins (see Angelini, MacArthur & Billings, 2013), it appears they are anomalous when compared to other male Olympians in major sports.

Future research should focus specifically on gymnastics—seeking to identify the athletic qualities a champion must possess. Such results could then be compared to the commentary to determine whether the skill set required to succeed in gymnastics is significantly different than skill sets for other sports or whether the opposite is true: that gymnastics requires much of the same skill, power, and control of other Olympic sports, making differentiated differential dialogues even more peculiar.

## CONCLUSION

Overall, this study revealed many key findings collectively revealing how men gymnasts are viewed and discussed in different manners than other male Olympians. While some differences could be directly attributable to the nature of what is valued and emphasized to be successful in gymnastics, others are not as easily explained. In the coming years, more research should be conducted relating gender perceptions of the sport within the realm of its mediation. It will also be important to study the rendering of male gymnasts beyond the realm of U.S.-based NBC to establish whether such narratives are uniquely American or seemingly universal. Additional studies related to on-air commentary could help solve the puzzle of a highly popular Olympic media offering that nonetheless features fewer male participants than reported in past decades.

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# Slovenski izvlečki / Slovene Abstracts

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## ŽENSKA ŠPORTNA TRIADA V GIMNASTIKI

Ženska športna trieada je sestavljen iz treh med seboj odvisnih delov: nizke razpoložljivosti energije (z ali brez motenj hranjenja), amenoreja in osteoporoza. Značilnost ženske športne gimnastiki je zgodnja specializacija in s tem dolgoletni napor, ki zahteva strog nadzor nad porabo energije . Postavlja se vprašanje ali to lahko vodi do ženskega športnika triade? Iz bibliografskih zbirk člankov PubMed , Scopus in ScienceDirect smo izbrali članke ki so bili zaznamovani z naslednjimi ključnimi besedami: ženska triade, motnje prehranjevanja, amenoreja, osteoporoza , mineralna kostna gostota, kostna masa, gimnastika in mladostniki. Sto šestintrideset člankov je ustrezalo zahtevam. Bibliografija je pokazala, da lahko v gimnastiki pride vsaka telovadka do vsaj enega dela triade ali njihove kombinacije. Mehanske obremenitve okostje imajo pozitiven učinek na mineralno gostoto kosti, vendar pa vsled energetske podhranjenosti in hormonskih sprememb ne more nadomestiti. Nizek energetski vnos (z ali brez motenj hranjenja), menstrualne težave in prezgodnja osteoporoza lahko povzročijo znižanje tekmovalne uspešnosti in dolgoročne posledice za zdravje . Usklajena prizadevanja med trenerji, starši, telovadkami in zdravstvenim osebjem lahko preprečijo nastanek ženske športne triade.

Ključne besede: motnje hranjenja, amenoreja , osteoporoza, telovadba

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Sarra Hammoudi Nassib, Bessem Mkaouer, Sabri Nassib, Sabra Hammoudi Riahi, Yessine Arfa

## VPLIV PREDŠTARTNE TESNOBE NA POZORNOST IN USPEŠNOST V RITMIČNI GIMNASTIKI

Večdimenzionalni okvir tekmovalne tesnobe, ki vključuje razumske in telesne dejavnike zagotavlja jasno razumevanje, kako se športniki odzivajo na tekmovalni stres (glej Jones , 1995; Woodman in Hardy , 2001). Na tekmovanju nekaterim športnikom tesnoba razprši pozornost, kar onemogoča zaznavanje in s tem so tekmovalno manj uspešni. Ob zmanjšanju pozornosti lahko sledi padec zmogljivosti in izguba zaupanja. Namen raziskave je bil preučiti odnos med predštartno tesnobo, pozornostjo in izvedbo sestav v različnih obdobjih priprav. Vzorec so predstavljale ritmičarke (starost 14,8 ± 1,3 let , teža 77,5 ± 7,1 kg , višina 180,8 ± 5,6 cm ). Opisna statistika je pokazala, da so se rezultati razumske tesnobe povečali iz 15,83 ± 1,835 v obdobju vadbe na 19,67 ± 2,160 v obdobju tekmovanj. Telesna tesnoba se je povečal s 15,50 ± 1,517 na 19,67 ± 816 v obdobju tekmovanj. V nasprotju s tem pa se je samozavest zmanjšala iz 21,00 ± 1,414 na 17,50 ± 1,871 med tekmovanjem. S poznavanjem tega mehanizma je možno vplivati na pozitivne spremembe psihične pripravljenosti.

Ključne besede: tesnoba, pozornost, tekmovanje, ritmična gimnastika

Vassilis Mellos, George Dallas, Paschalis Kirialanis, Giovanni Fiorilli, Alessandra Di Cagno

## PRIMERJAVA RAZVOJA GIBALNIH SPOSOBNOSTI MLADIH TELOVADCEV IN NJIHOVIH ŠPORTNO NEDEJAVNIH VRSTNIKOV

Namen raziskave je bil ugotoviti razlike v gibalnih sposobnostih telovadcev in njihovih športno nedejavnih vrstnikov starih od 9-12 let. Sedeminpetdeset telovadcev s trenažnim stažem 4-5 let in štiriinsedemdeset dečkov iste starosti, je bilo vključenih v raziskavo. Vsi udeleženci so bili testirani dvakrat v 12-mesečnem intervalu, z 9 spremenljivkami gibalnih sposobnosti po Euro Fit sklopu testov. Rezultati so pokazali, da imajo telovadci boljše rezultate kot vrstniki v vseh testih ( $p <0,01$) razen pri testih metov, ki se zdi, da so predvsem starostno pogojeni, večji napredek telovadcev je pri skokih ( $p <0,01$) , medtem ko je izboljšanje v vesi v zgibi le pri telovadcih. Izboljšanje hitrosti na 30m teka je bilo v skupini nešportnikov. Nobena skupina ni izboljšala svojih rezultatov v sklecah in dviganju trupa. Izboljšanje gibalnih sposobnosti v predpubertetnem obdobju je povezano z vrsto in intenzivnostjo telesne dejavnosti, šolski učni programi pa bi morali imeti večji poudarek na moč rok, ravnotežje in gibljivost.

Ključne besede: gibalne sposobnosti , Euro Fit, fantje , normalna populacija , telovadci .

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Spiros Prassas in Olyvia Donti

## PRIMERJALNA ŠTUDIJA VELETOČEV NAZAJ NA BRADLJI

Primerjalna analiza med dobrimi in slabimi izvedbami veletoča nazaj na bradlji je želela ugotoviti mehanske zakonitosti, ki določajo stopnjo tehnične izvedbe in ki bi lahko pomagale trenerjem in telovadcem. Narejeni sta bili opisna in primerjalna statistika na osnovi kinematičnih podatkov veletoča nazaj na bradlji in ocenami izvedba mednarodnih sodnikov. Kinematična analiza je bila narejena na osnovi video zajema podatkov s hitrostjo 60 slik na sekundo. Štirinajst veletočev nazaj je bilo analiziranih . Rezultati niso pokazali značilnih razlik v gibalnem vzorcu veletoča med skupinami izvedb (slabe izvedbe odbitek več kot 0.2 točke in dobre manj). Trend razlik je bilo zaznati, vendar ni statistično značilen.

Ključne besede: kinematika, biomehanika, sojenje.

Ana Kašček, Matej Supej

VZPOSTAVLJANJE RAVNOTEŽJA PO MOTENJU VESTIBULARNEGA APARATA S PASIVNIM VRTENJEM CELEGA TELESA

Cilj raziskave je bil ugotoviti, ali smer vrtenja celotnega telesa vpliva na vzpostavljanje ravnotežja po motnji vestibularnega aparata s pasivnim vrtenjem celotnega telesa . V ta namen je bil skonstruiran vrtljivi stol, ki ga poganja električni motor. Stol se vrti v izbrano smer 10 sekund in v tem času naredi 11 obratov. Merjenka je bila ena, je aktivna mažoretka – plesalka s palico. Za mažoretke je značilno, da se obrate izvede v nasprotni smeri urinega kazalca ( v levo). Rezultati kažejo, da smer vrtenja vpliva na obnovo ravnotežja; mažoretka je imeli boljše rezultate po vrtenju v levo. Središče pritiska je bilo odmaknjeno (po obračanju urino smer) 18.57 % časa na levo in 81,43 % časa na desno od centra, pri vrtenju uri nasprotni smeri je 53.83% časa na levo in 46,17 % časa odklonjena desno od centra v celotnem času meritve. Razlike v meritev glede na smer vrtenja in odklon središča pritiska na levo in desno od centra so pomembne.

Ključne besede: biomehanika, ravnotežje , vrtenje , vodilni strani , ples s palico

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Igor Pušnik, Ivan Čuk

TOPLOTNO SLIKANJE DLANI PRI PREPROSTIH PRVINAH NA LESENI ŽRDI Z IN BREZ UPORABE MAGNEZIJEVEGA KARBONATA

Članek opisuje raziskavo učinkovitosti magnezijevega karbonata pri preprostih telovadnih prvinah. Študentje na Fakulteti za šport so izvedli preprosto prvino (toč jezdno naprej), medtem pa so merili temperaturo lesene žrdi in dlani, s pomočjo toplotnega tipala. V prvem poskusu so uporabljali magnezijev karbonat, v drugem poskusu pa so izvedli prvino brez magnezijevega karbonata. Bilo je opazno, da je z uporabo magnezijevega karbonata temperatura dlani narasla, medtem ko je med izvajanjem brez magnezijevega karbonata temperatura dlani bila skoraj nespremenjena. Žulji, kot posledica trenja med žrdjo in dlanjo so manj verjetni pri izvajanju preprostih prvin brez uporabe magnezijevega karbonata, ker se temperatura dlani ne dvigne. Merjenci niso poročale o nobenih težav prijema, zato je za enostavne prvine, brez veliko ponovitev, izvajanje prvin brez uporabe magnezijevega karbonata varno.

Ključne besede: žulji, dlani, varnosti

Paul MacArthur, James Angelini, Andrew Billings, Alexis March

VZPOREDNI KOMENTAR? NBC TELEVIZIJSKO SPREMLJANJE MOŠKIH TELOVADCEV NA OI 2012 V NAJBOLJ GLEDANEM ČASU

Raziskava analizira kako komentatorji televizijske mreže NBC v ZDA opisujejo telovadce v primerjavi z drugimi športniki v času največje gledanosti na poletnih olimpijskih igrah. Iskana so bili nasprotje pri opisovanju uspeha, neuspeha in osebnosti/telesnosti. Izkazanih je bilo sedem razlik med telovadci in ostalimi športniki. Telovadcem se je pripisoval uspeh zaradi športnih znanj/moči in sestave (težavnosti in izvedbe), medtem ko je bil neuspeh telovadcem pripisan zaradi pomanjkanja pozornosti, njihovih slabših gibalnih sposobnosti v primerjavi z ostalimi telovadci. Prav tako so bili večkrat opisani kot skromni ali vase zaprti in večkrat so opisovali njihovo čustveno stanje. Ostalim športnikom so največkrat pripisali uspeh zaradi njihovih izkušenj.

Ključne besede: televizija, komentator, primerjava, športniki, telovgadci.