

See discussions, stats, and author profiles for this publication at: <https://www.researchgate.net/publication/344563424>

Critical-thoughts-and-insights-on-the-female-athlete-triad-precedents-existing-challenges-and-prospects

Article *in* International Journal of Information and Decision Sciences · October 2020

CITATIONS

0

READS

284

2 authors:



Meltem Ince Yenilmez

Tohoku University

51 PUBLICATIONS 152 CITATIONS

SEE PROFILE



Merve Ince Palamutoğlu

Afyonkarahisar Health Sciences University

16 PUBLICATIONS 0 CITATIONS

SEE PROFILE

Some of the authors of this publication are also working on these related projects:



gender responsiveness budgeting [View project](#)

CRITICAL THOUGHTS AND INSIGHTS ON THE FEMALE ATHLETE TRIAD: PRECEDENTS, EXISTING CHALLENGES AND PROSPECTS

Meltem Ince Yenilmez, Yasar University
Merve Ince Palamutoglu, Afyonkarahisar Health Sciences University

ABSTRACT

The female athlete triad (FAT) is a serious health-related problem that threatens women who exercise. This condition is an interrelated multifactorial syndrome that includes low energy availability, menstrual cycle disturbances and decreased bone mineral density. The study was aimed to outline the biological import of exercise in female athletes, in addition to the vital elements of the "Female Athlete Triad Syndrome" Articles from 1977 to present are reviewed the major components of the FAT and their relationships, as well as strategies for diagnosis and treatment. A qualitative review of the literature are performed and analyzed. The main goal in treatment of female athletes with the triad is a natural return of menses as well as enhancement of bone mineral density. Interrelationship between components of the FAT may result in clinical manifestations, including eating disorders, amenorrhea and osteoporosis. Clinical conditions are not exhibited simultaneously. Prevention is important to minimize complications. Female athlete triad is an interrelated, multifactorial syndrome comprised of disordered eating, amenorrhea, and osteoporosis. It is a common entity among female athletes. Prevention, early detection, and early treatment are essential to maintain the athletes' health into maturity and to prevent the serious consequences of this triad. Therefore, this additional research will aid in the development of educational curricula and protocols to address screening, prevention, and treatment of the triad. These resources and tools are necessary to protect the present and future health of the adolescent female athlete.

Keywords: Eating Disorders, Amenorrhea, Decreased Bone Mineral Density, Energy Availability.

INTRODUCTION

According to available records, women's first participation in the Olympics games happened in 1900. The Games took place in Paris, and the women folks had a measly representation figure of two percent only (Curry et al., 2015). A law known as "Title IX", brought about a significant increase in the participation of women in the Olympics, especially women coming from the United States. This law instituted that all educational institutions in the USA will receive funding from the federal government. This was to ensure that the government's investment in sports for both genders was balanced (Following this intervention, the percentage of women athletes participating in the Olympics increased from a poorly 2% in 1900 to about 40% in the year 2000 (Pfister, 2003).

It is a known fact that constant physical training has an observable connection with good health (Mallinson et al., 2013) Starting our count from the year 1972, there has been a steady

increase in the participation of women in sports which has made it possible to establish the burgeoning figure of women athletes that are impacted by health challenges, which can be placed on the doorstep of the adverse result of excessive and misplaced training routines, which was identified by the American College of Sports Medicine (ACSM) as Female Athlete Triad Syndrome (FAT), comprising three interconnected factors which include eating dysfunctions, amenorrhea and osteoporosis (Otis et al., 1997). In 2007, the American College of Sports Medicine updated this term to include athletes categorized as "at risk", who may not necessarily satisfy all requirements of the earlier 1992 clinical evaluation of Female Athlete Triad. On the other hand, Female Athlete Triad can pose as an impediment to an excellent performance from the athlete (Vanheest et al., 2012). The beginning of a high-level competition for a young female in any type of sport is often the start of a novel body experience, whereby their body often demands exercises and physical conditions that can sometimes be beyond their reach. While there are positives to be taken from routine sports trainings, the Female Athlete Triad Syndrome has marked up when it comes to sports requiring high performance.

The female athlete triad syndrome is a relatively new issue to the literature. It is not clear what coaches know about the syndrome (low energy availability, menstrual dysfunction, and low bone mineral density), its effects to the athlete, risk factors and their roles as coaches in the prevention of this syndrome. Therefore, with this article, it is tried to analyze the biological import of exercise in female athletes, in addition to the vital elements of the Female Athlete Triad Syndrome. In other words, this paper will answer the question "Who is at risk for female athlete triad?" To answer this question, articles from 1977 to present were selected for review of major components of the female athlete triad as well as strategies for diagnosis and treatment of the conditions. In addition to answering the research question set out above, it is expected to discuss the finding of the current study along with how they relate to past research performed on the female athlete triad in athletes.

FEMALE ATHLETE TRIAD

Studies (Clark et al., 2018) has shown that the female athlete triad occurs frequently amongst athletes who engage in sporting events whereby the physiological and/or athletic requirement for an excellent performance is hinged on maintaining a low percentage of body fat. Besides, athletes, especially the female athletes, are faced with an additional pressure known as sports pressure, in which they are judged based on the esthetics of their body as well as by their performance on the tracks/field. There are important health concerns for women athletes who are deficient in vital nutritional needs, which can affect their sports performance. Some of the health concerns, which may develop, include menstrual disorders, low bone mineral density, cardiovascular dysfunction, musculoskeletal injuries, depression, social apathy and low quality of life.

In this sense, female athlete triad refers to three interconnected health conditions, which are irregular nutrition, amenorrhea and osteoporosis (Pentyala et al., 2013). This concept was highlighted by the American College of Sports Medicine in 1992 when experts noticed glaring differences between female non-athletes and adolescent or young adult females who engaged in sports that emphasized esthetics or low intensity, such as ballet or running (Nazem & Ackerman, 2012). For some females, achieving or maintaining the ideal body shape through exercise or training alone is not sufficient (Sundgot-Borgen & Torstveit, 2003). Therefore, they are wont to follow a strict low-calorie diet to achieve or maintain this unrealistic low body weight within a very

short time. In that case, they involve themselves in low weight programs that will later cause health problems for them. Irregular dietary pattern is common practice amongst female athletes, including other irregular eating behaviors that may not meet the prerequisite to be added to the range of serious eating disorders, such as anorexia nervosa and bulimia nervosa (Sundgot-Borgen & Torstveit, 2010). When malnutrition occurs in these athletes due to irregular nutrition, menstrual disorders and other skeletal problems can spring up. With each triad comes the likelihood of morbidity and mortality, both the dangers becomes very pronounced when they occur in synergy (Sundgot-Borgen & Torstveit, 2003).

In the study carried out by Martinsen et al. (2010) to examine the prevalence of irregular eating and the differences between athletes competing in weak and non-leanness sports in the 15-16 age group living in Norway, the elite sports group representing 50 different sports were chosen randomly from elite sports schools. Leanness sports such as dance, decathlon, judo, karate, swimming, and gymnastics are defined as sports where weakness and/or low weight are important, while sports such as golf, basketball, volleyball, and tennis are less important. Compared to those competing in non-leanness sports, athletes in skim sports have a higher prevalence of irregular eating only in girls compared to boys in the same sports groups. Again, in Norway, a study on female elite athletes aged 13-39 and non-athletic subjects of the same age group investigated the prevalence of eating disorders in elite athletes. Study; menstrual, bodyweight, training, injury and diet history, oral contraceptive use and pregnancy, physical activity patterns, nutritional habits, use of pathogenic weight control methods, and self-reported eating disorders. Eating disorder prevalence was higher in triad compared to elite athletes with risk (28.1%) and non-risk control group (20.8%) (Torstveit et al., 2007). Bone mineral density in elite rowing athletes and its relation with female athlete triad was investigated among 21 female rowers, who were over 18 years old, active rowing, and retired. As a rule of rowing sport, it suggests that athletes can start training at an early age and require low weight, long lengthiness, high eating disorder levels, high oligomenorrhea/amenorrhea rates, bone mineral density deficiencies associated with the number of lifetimes and tendency to have post-retirement eating disorders (Meng et al., 2020). Low energy availability and eating disorders of female elite athletes (ELA) (trampolining, rhythmic gymnastics, aerobics) and university recreational athletes (REA) (rhythmic gymnastics, aerobics, dance sports, cheerleading, and dancing) in Chinese national teams were evaluated. Annual training duration and frequency for training and the total number of hours per week in ELA were found to be significantly higher compared to REA. Prevalence of menstrual disorder and primary amenorrhea were significant between ELA and not expected to be higher than REA. As a result, it shows that Chinese female athletes in aesthetic sports have a low risk of energy availability, and the increased risk prevalence observed in ELA is significantly higher than REA.

In the triad, low energy availability can occur, with or without an eating disorder. Energy availability is calculated by subtracting the energy (in kilocalories) depleted in the course of exercise from the dietary energy intake (in kilocalories) (Nattiv et al., 2007). The equation is given as:

$$\text{Energy Availability (EA)} = \text{Energy Intake} + \frac{\text{Exercise Energy Expenditure}}{\text{Fat free mass (kg)}}$$

The result, which is known as energy availability, EA, is the amount of energy left for other body functions. Low energy availability arises from eating disorders or eating practices such as

fasting or abstaining from food, which reduces the body's energy intake. On the other hand, an athlete can develop low EA either on purpose or unintentionally without an eating disorder in the picture if their energy demands exceeds their calorie intake. When this happens, such athlete is at risk of having their health impaired (Manore et al., 2007; Stickler et al., 2015).

Eating Disorders

Eating disorders can be described as psychological disorders whereby diet, body weight/shape concerns have become an unhealthy focus of an individual's life, which oftentimes, is a way by which such individual deals with an unexpressed psychological problem. If left unattended to, the psychological or social implications can be devastating on the long run. Once established in an individual, the resultant effect is subtle but poisonous, tending to affect every vital aspect of an individual's life, and for some people it can be death dealing. Eating disorders and body image concerns cut through a wide range of acuteness, from a normal healthy eating habit through extreme dietary patterns and a range of other dysfunctional eating behaviors to the clinically determined eating disorders.

Anorexia nervosa and bulimia nervosa are eating disorders, which consists of abnormal dietary behavior and weight management, contorted attitude and suppositions towards body weight and shape. Anorexia nervosa comes in the form of small amount of food intake, refusing to eat and a resultant weight loss. Even when faced with an increased weight and muscle wasting against obesity, a compulsive state is still present. This type of patients usually present with a high mortality rate which has been observed for some period now, and which exceeds those with clinical and psychological morbidity and other psychiatric disorders. Anorexia athleticism gives experts a way of recognizing athletes with eating disorders that do not meet all the standard diagnostic requirements for anorexia nervosa or bulimia nervosa. Although athlete with anorexia athleticism weigh normal, they experience a fear of weight gain that is uncalled for. Most complications that arise from anorexia nervosa are due to the result of direct or indirect starvation. Irregular menstruation and amenorrhea suppresses estrogen level in women and can affect bone health and fertility. Complications arising from bulimia nervosa occur due to binge eating and followed up by the removal of ingested food, which can lead to fluid and electrolyte loss during such removal. Athletes with eating disorders rake up the mortality rate by up to six times; this is when compared to the general population (Sundgot-Borgen & Torstveit, 2003).

Amenorrhea

For women, their monthly menstrual cycle is usually a complicated interaction of the endocrine and reproductive systems. When athletes present with menstrual disorders, a significant drop in their reproductive hormones, most especially the estrogen and an interference of the normal menstrual cycle, characterizes it. Several factors can bring about athletic menstrual dysfunction (amenorrhea, oligo menorrhea, anovulation, luteal phase deficiency, and delayed menarche) in female athletes, affecting largely their sports performance (Nazem & Ackerman, 2012). Amenorrhea is amongst the most talked about menstrual dysfunction. It can be defined as the absence of menstruation for a period of about 3 months and more. There are two types of amenorrhea - the primary and secondary amenorrhea. Primary amenorrhea occurs when menarche is delayed until the age of 16.5 years or two years after the development of secondary sexual characteristics. In secondary amenorrhea, there is an absence of menstruation for more than 6

months for women with normal menstrual cycles (Julie & Smucker, 2000). Although athletic amenorrhea is considered an extreme form of menstrual dysfunction, there are other forms that could cause significant suppression of estrogen levels, thereby affecting bone health and fertility. Loss of bone density is usually a subtle process, and most times, athletes are oblivious to the problem until a detectable problem such as stress fracture occurs (Loucks & Thuma, 2003). And complications, which can arise because of amenorrhea in female athletes, include osteoporosis, infertility, lipid metabolism, and cardiovascular diseases (Constantini & Warren, 1994).

Leptin, which is the product of an obesity gene, is produced in several organs. This is in addition to the production of white adipose tissue, brown fat, placenta, fetal tissues, and serum levels. These are all proteins that reflect the number of energy stores, as well as short-term variance. Leptin stimulates the release of gonadotropins from the hypothalamus (Pentyala et al., 2013). Leptin plasma level is directly related to total body fat stores, increases after a few days of overfeeding in humans, and begins to decrease within hours with the onset of hunger. These changes in leptin concentration appear to be primarily regulated by insulin, cortisol, and reproductive hormones. Since leptin levels do not increase in response to a particular meal, we cannot expect the hormone to function as a meal-related "toughness factor". Instead, it mainly acts in hypothalamic centers to modulate longer-term responses to the body's energy state, including reproduction. Leptin levels are lower in female athletes than inactive women and even lower in athletes with exercise-induced amenorrhea (Welt et al., 2004). Women suffering from anorexia nervosa or who engage in physically demanding exercise experience a reduction in leptin levels in reaction to starvation. In response to this, there is a reduction in estradiol levels and amenorrhea can follow. Women having anorexia nervosa experience low levels of leptin, which is usually associated with body mass index. However, with female athletes comes a further decrease in leptin level following low fat storage amounts. This deficiency results in menstrual dysfunction because of the effect leptin has on gonadotropin-releasing hormone. For athletes with amenorrhea, there is an increased sensitivity of gonadotropin-releasing hormones to pituitary gland, and this causes amenorrhea, which has a hypothalamic origin (Nazem & Ackerman, 2012).

Osteoporosis

Osteoporosis is one condition that results in skeletal frailty and increases the risk of having fractures, as well as low bone mass and micro composition of bone tissues (Ferdous et al., 2015). Osteoporosis is a disease that affects about 10% of the worldwide population of females and is commonly associated with female athletes. The disease features a decrease in bone mass and density, and the proliferation of bone cavities resulting in weakness of the skeletal system. There are huge benefits that accrue from exercise. Yet, in spite of these benefits, engaging in excessive exercise and strenuous physical activities can result in osteoporosis (Pentyala et al. 2013). Therefore, morbidity associated with osteoporosis is vital and lost bone density may not be replaced (Institute of Medicine, 1992).

Bone mineral density varies depending on factors such as age, gender and race. Peak mass bone is described as the total amount of bone acquired at skeletal maturity. Individuals with high peak bone mass are usually at risk of developing osteoporosis at later stages of their life. A range of factors may be responsible for bone mineral, and they include soft tissue composition (lean mass, fat mass), lifestyle (smoking, alcohol intake), medications, hormones, physical activity, and diet. These factors can interrelate with each other, the degree of their influence varying, depending on the different stages of life of the individual concerned and the skeletal regions in question (Sundgot-

Borgen, 2002).

Puberty is the stage when individuals have a maximum accumulation of bone mass. Engaging in exercise during pre-puberty can contribute significantly to the prevention of osteoporosis, by increasing bone mineral density. Engaging in exercise during adolescence stage is affiliated with primary amenorrhea and low peak bone mineral density. Post-adolescent exercise training is connected to secondary amenorrhea and bone loss. Seen from another angle, physically demanding activities increases bone density in women but causes menstrual conditions in young female athletes, eroding the beneficial effects of physical activity on the bone (Nazem & Ackerman, 2012).

PREVENTION OF THE TRIAD

In treating the young female athlete of triad, the biggest challenge therein may be achieving a correct diagnosis of the problem. During training sessions, their coaches for behavioral changes and physical symptoms should properly monitor athletes. Amongst top and professional athletes, the symptoms of triad may be less obvious or totally ignored by the coaches. Therefore, to reach their goals of peak performance, most of the athletes adopt ineffective weight loss practices such as restrictive nutritional patterns, vomiting, laxatives and diuretics. Most of the athletes who have adopted these strategies do not realize that they have a problem and therefore, do not seek help on time (Most athletes, especially the female athletes are usually encouraged to lose weight before the competition proper, in order to participate in certain weight categories or in order to optimize their performance in certain low intensity sports- such as athletics, gymnastics, freestyle sports dance, ice skating, biathlon, kickbox, wrestling, judo, karate, country running, figure skating and lightweight rowing- that requires being weak. To avert the negative effects of rapid weight loss and/or long-term limited energy intake, a corresponding energy restriction program should be encouraged. To achieve a successful weight loss program, one can begin by reducing energy intake while increasing energy intake, or doing both concurrently. The major goal of treatment modalities is to correct irregular menstrual cycles and increase bone mineral density. The first step towards achieving these goals is overhaul the nutrition and exercise programs to increase overall energy availability that is, reducing energy consumption and maximizing energy intake (Costa, 2003). The corresponding increase in body weight, which is as a result in change of diet and exercise, the resumption of menstrual cycle, an improved bone mineral density, are some of the observed findings in studies carried on amenorrheic athletes. However, it is important to note that these changes are not immediate and cannot fully reverse most of the devastating effects of amenorrhea on bone health. Increases in bone minerals are usually minute and the effects will be short-lived if treatment modalities are not started from a young age. Many athletes are not keen on to changes in their training program or diet; therefore, there must be thorough orientation for these athletes on the need to improve their energy balance, and other treatment modalities that are open to exploration. There are obstacles to achieving treatment of triad in young women, and one of them, the biggest actually, is the need to overcome the psychological element of their condition. Athletes are competitive categories of persons with perfectionist tendencies. Changing their entire thought pattern, diet, and exercise program can prove difficult. For athletes with classic symptoms of clinical eating disorders, there is need to seek help from the relevant psychiatric health professional.

CONCLUSION

The female athlete triad is a potentially serious condition that affects many young women. Many of these athletes have been approved to participate in sports without proper evaluation, management, and treatment. Similarly, after medical illness or injury, athletes with a female athlete triad returned to training and competitions without adequate treatment and follow-up.

The level of training at the highest stage is aimed at achieving maximum performance. In addition, this maximum performance requires the athlete to go beyond her individual limits. However, if it is not followed by the right multidisciplinary team approach, it may promote the formation of elements of the female athlete triad. Maintaining the perfect condition of an athlete's health and achieving success in high-level competitions, requires the constant monitoring of the athlete-training program, especially for athletes who are at risk of developing this syndrome.

Low energy availability is an important factor associated with menstrual dysfunction in athletes. The amount of bone mineral loss appears to be related to the severity and length of menstrual irregularity, nutritional status, and the amount of skeletal load during activity. Low bone density is a dangerous consequence of the triad and low bone mineral density rating in young patients largely depends on the age of amenorrhea onset and duration of amenorrhea. There are different theories about the best approach for the treatment of this complex condition. However, it is universally accepted, triad prevention, early recognition, and a properly focused multidisciplinary treatment plan are important to nurture and restart menstruation, and should be priorities among healthcare professionals, coaches, and other adults in the lives of women athletes.

Female athletes are more at risk of irregular nutrition, body image problems, menstrual dysfunction, low bone mineral density, negative energy balance, and other interrelated challenges that may arise. Some of these health concerns can lead to an increase in cardiovascular risk factors, hormonal imbalances, musculoskeletal problems, and poor performance on the field of play. Again, female athletes are more at risk of developing eating disorders or irregular eating habits than their male counterparts. Furthermore, females participating in aesthetic sports are more at risk of developing triads than females engaged in physically demanding sports. Continuous research that body image concerns and female athletes can help researchers and clinicians had better understand ways athletic athletes are protected against body image anxiety. In addition, for the increased risk for the female athlete triad, it can be determined by calorie intake based on calorie expenditure. This is an area to be studied in the future work of the female athlete triad.

REFERENCES

- Clark, L. R., Dellogono, M. J., Mangano, K. M., & Wilson, T. A. (2018). Clinical menstrual dysfunction is associated with low energy availability but not dyslipidemia in division I female endurance runners. *American Society of Exercise Physiologists*, 21(2), 265-276.
- Constantini, N. W., & Warren, M. P. (1994). Special problems of the female athlete. *Baillieres Clin Rheumatol*. 8(1), 199-219.
- Costa, M. (2003). Social issues in American women's sport. In I. Hartmann-Tew & G. Pfister (Eds., sp. 145-161), *Sport and Women: Social Issues in International Perspective*. CRC Press: London.
- Curry, E. J., Logan, C., Ackerman, K., McInnis, K. C., & Matzkin, E. G. (2015). Female Athlete triad awareness among multispecialty physicians. *Sports Medicine Open*, 1(1), 1-7.
- Ferdous, H., Afsana, F., Qureshi, N., & Rouf, R. (2015). Osteoporosis: A review. *Birdem Medical Journal*, 5(1), 30-36.
- Institute of Medicine (US). (1992). *Division of health promotion and disease prevention*. Berg RL, Cassells JS, editors. The Second Fifty Years: Promoting Health and Preventing Disability. Washington (DC): National Academies Press (US), 6, Osteoporosis. Available at: <https://www.ncbi.nlm.nih.gov/books/NBK235615/>
- Julie, A. H., & Smucker, D. R. (2000). The female athlete triad. *American Family Physician*, 61(11), 3357-3364.

- Loucks, A. B., & Thuma, J. R. (2003). Luteinizing hormone pulsatility is disrupted at a threshold of energy availability in regularly menstruating women. *The Journal of Clinical Endocrinology Metabolism*, 88(1), 297-311.
- Mallinson, R. J., Williams, N. I., Hill, B. R., & De Souza, M. J. (2013). Body composition and reproductive function exert unique influences on indices of bone health in exercising women. *Bone*, 56(1), 91-100.
- Manore, M., Loucks, A., & Cialdella-Kam, L. (2007). The female athlete triad: Components, nutrition issues, and health consequences. *Journal of Sports Sciences*, 25(1), 61-71.
- Martinsen, M., Bratland-Sanda, S., & Eriksson, A. K. (2010). Dieting to win or to be thin? A study of dieting and disordered eating among adolescent elite athletes and non-athlete controls. *British Journal of Sports Medicine*, 44(1), 70-76.
- Meng, K., Qiu, J., Benardot, D., Carr, A., Yi, L., Wang, J., & Liang, Y. (2020). The risk of low energy availability in Chinese elite and recreational female aesthetic sports athletes. *Journal of the International Society of Sports Nutrition*, 17(1), 1-7.
- Nattiv, A., Loucks, A. B., Manore, M. M., Sanborn, C. F., Sundgot-Borgen, J., & Warren M. P. (2007). American college sports medicine position stand the female athlete triad. *Medicine and Science in Sports and Exercise*, 39(10), 1867-1882.
- Nazem, T. G., & Ackerman, K. E. (2012). The female athlete triad. *Sports Health*, 4(4), 302-311.
- Otis, C. L., Drinkwater, B., Johnson, M., Loucks, A., & Wilmore, J. (1997). American college sports medicine position stand, the female athlete triad. *Medicine and Science in Sports and Exercise*, 29(5), 1-10.
- Pentyala, S., Mysore, P., Pentyala, S., Rahman, A., Urbanczyk, K., Tumillo, T., & Khan, S. A. (2013). Osteoporosis in female athletes. *International Journal of Clinical Therapeutics and Diagnosis*, 1(1), 5-11.
- Pfister, G. (2003). Líderes femininas em organizações esportivas-tendências mundiais. *Movimento*, 9(2), 11-35.
- Stickler, L., Hoogenboom, B. J., Smith, L. (2015). The female athlete triad-what every physical therapist should know. *International journal of sports physical therapy*, 10(4), 563-571.
- Sundgot-Borgen, J. (2002). Weight and eating disorders in elite athletes. *Scandinavian Journal of Science & Medicine in Sport*, 12(5), 259-260.
- Sundgot-Borgen, J., & Torstveit, M. K. (2003). The female athlete triad-the role of nutrition. *Schweizerische Zeitschrift für Sport und Sport*, 51(1), 47-52.
- Sundgot-Borgen, J., & Torstveit, M. K. (2010). Aspects of disordered eating continuum in elite high intensity sports. *Scandinavian Journal of Science & Medicine in Sports*, 20(2), 112-121.
- Torstveit, M. K., Rosenvinge, J. H., Sundgot-Borgen, J. (2007). Prevalence of eating disorders and the predictive power of risk models in female elite athletes: A controlled study. *Scandinavian Journal of Medicine and Science in Sports*, 18(1), 108-118.
- Vanheest, J. L., Rodgers, C. D., Mahoney, C. E., & De Souza, M. J. (2014). Ovarian suppression impairs sport performance in junior elite female swimmers. *Medicine and Science in Sports and Exercise*, 46(1), 156-166.
- Welt, C. K., Chan, J. L., Bullen, J., Murphy, R., Smith, P., DePaoli, A. M., Karalis, A., & Mantzoros, C. S. (2004). Recombinant human leptin in women with hypothalamic amenorrhea. *The New England Journal of Medicine*, 351(10), 987-997.