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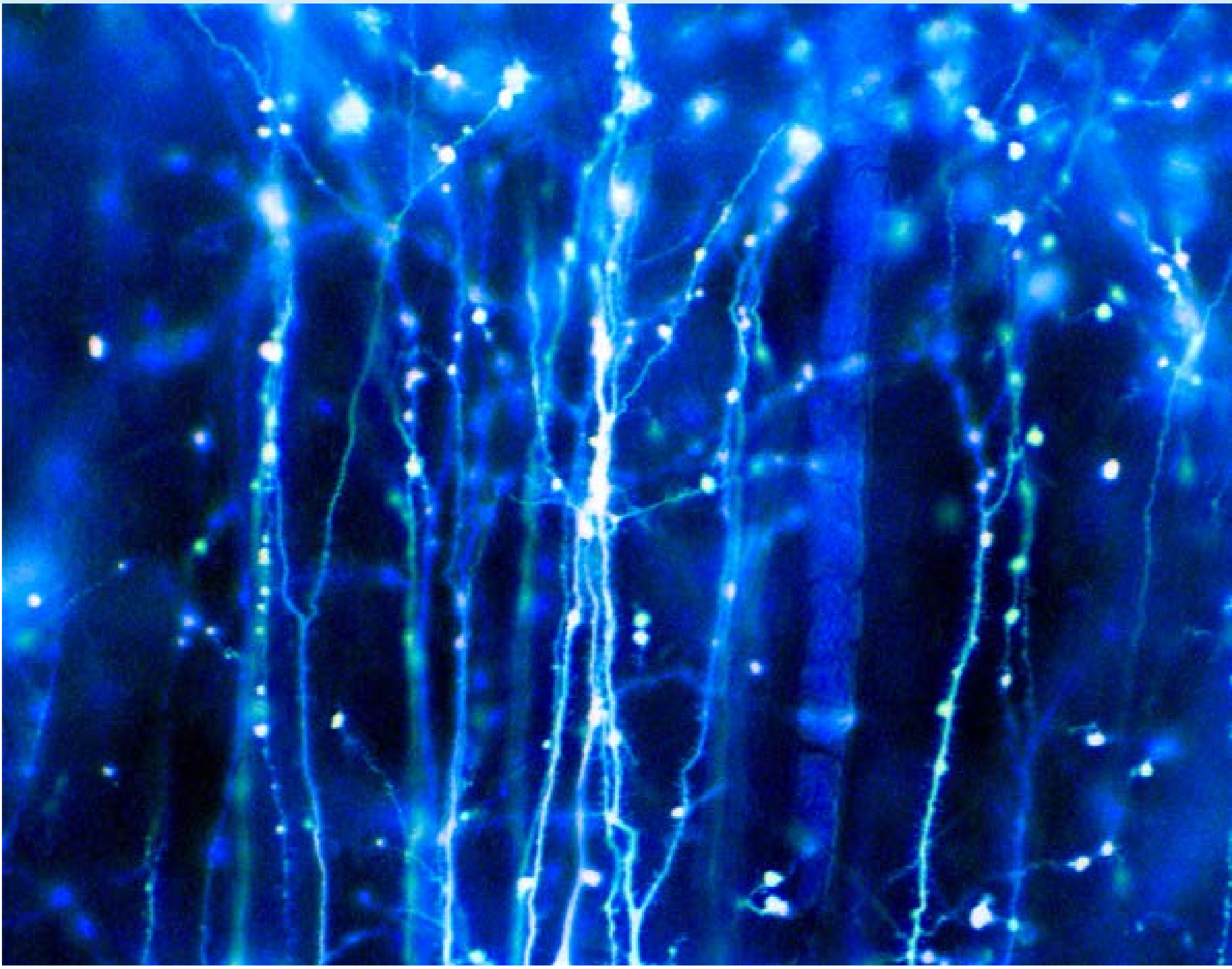

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TRAINING IN WOMEN, FROM PHYSIOLOGY TO PRACTICE

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SUMMARY

One of the main determinants of the physiological differences between men and women are the estrogen levels, predominant in women. Estrogen levels not only influence the characteristics of the distribution of adipose tissue, the predominance of muscle fibers or the use of fat as an energy source, but also impact training in terms of muscle strength, maximum voluntary contraction, and muscle fatigue. These differences between men and women are especially seen in the fact that women have a greater resistance to exercise, which leads us to think that they benefit from exercises with higher frequencies.

Keywords: Women, Estrogens, Physical Fitness, Resistance Training, Endurance Training

RESUMEN

Uno de los principales determinantes de las diferencias fisiológicas entre el hombre y la mujer son los niveles de estrógenos, hormona predominante en la mujer. Los niveles de estrógeno no sólo influencian las características de la distribución del tejido adiposo, predominancia de tipos específicos de fibras musculares o el uso de grasa como fuente energética, adicionalmente tienen impacto en el entrenamiento en cuanto a fuerza muscular, contracción voluntaria máxima y tiempo de fatiga muscular. Estas diferencias entre hombre y mujer se destacan principalmente en que la mujer tiene mayor resistencia al ejercicio lo que lleva a pensar que pueden beneficiarse de ejercicios con mayores frecuencias.

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Introduction

The term sex refers to biological attributes in humans or animals. Unlike gender, sex focuses on physical or physiological characteristics. In this sense, it is important to consider that the differences are based on chromosomal differences (23XX in women and 23XY in men) and they condition responses at all levels of organization [1].
Due to the obvious differences in the development of their physical capacities, the vast majority of sports competitions separate men from women. This is evident when reviewing the world records for each event (for example, in athletic events). Many of these differences focus on the hormonal variations such as the concentration of androgens and estrogens, and result in functional characteristics such as body composition, muscle power, maximum strength, and anaerobic power, which together lead to differences in sports results [2].
This review aims to highlight the hormonal differences between men and women and to trace the way they influence different responses and adaptations to physical exercise in women. In the end, a proposal based in the consideration of these differences is made to optimize training, whether in search of improvement in sports performance, modification of aesthetics or physical exercise for health.

Effects of estrogens on the physiology of adipose tissue, muscle and bone

Estrogens are a group of sex hormones that mainly include estrone and estradiol. They are produced in premenopausal women in a percentage of 95% by the ovaries and are responsible for a very broad set of cellular responses through intracellular receptors (ERα and Erβ) and a G-protein-coupled membrane receptor (GPER1). The complex estrogen–intracellular receptor modules the transcription of genes, nevertheless, a full comprehension is not easy, the response has pleiotropic tissue-specific effects. Besides, the estrogen action is influenced by a lot of extracellular factors and different cell signaling cascade, a complete survey of the cellular effect of the estrogens is beyond the scope of this review [3].
Estrogen concentrations vary throughout the female menstrual cycle, being lower at the beginning of the follicular phase, increasing to the highest values during the pre-ovulatory phase and decreasing slightly during the luteal phase. After menopause there is a rapid fall of estrogen production that is related to a reduction in bone mass and a decrease in muscle mass, among many other effects [3].
Estrogens are responsible for a different distribution of body fat, making adipose tissue more abundant at the subcutaneous level and less profuse at the visceral level in women [4].
In addition to the difference in distribution, female adipose tissue also has a greater sensitivity to insulin, greater mitochondrial biogenesis, higher anti-inflammatory response (given by a population of M2 macrophages higher than its inflammatory form M1), higher sensitivity to catecholamines and higher production of hormones such as adiponectin and leptin [4]. Together these characteristics lead the female subcutaneous adipose tissue, in the presence of estrogens, to being considered healthy.
The presence of estrogens in women generates a slight predominance of slow-twitch fibers (type I) over fast-twitch fibers (type IIa and IIx). More than 3,000 genes that differentiate skeletal muscle between men and women have been identified. The expression of many of these genes is linked to the presence of hormones such as estrogens, which, in general, bring about lower speed of contraction, higher oxidative activity and lower tendency to hypertrophy in women muscle [5].
In skeletal muscle, estrogens also favor the predominance of fat as an energy source in a higher proportion than carbohydrates, which means that during exercise glycogen is preserved. By using fewer glycolytic pathways, less lactate, less acidosis and therefore less fatigue are

produced. This makes recovery speed higher in women, especially in isometric strength exercises, where this resistance is also considerably higher in women compared to men [5,6].
In addition to the differences in the proportion of fiber types and the effect of estrogens on muscle metabolism, sex hormones, such as estrogens, seem to modify the activity of the sympathetic nervous system, favoring vasodilation processes. This increases muscle perfusion and metabolite elimination which contributes significantly to less muscle fatigue [7].
In skeletal muscle, the presence of estrogens also has antiapoptotic effects, as well as positive effects in terms of muscle growth and regeneration. For this reason, the decrease in estrogen levels has been associated with loss of muscle mass, increasing of the risk of muscular injuries and reduction of the muscular regenerative capacity. Consequently, it is considered that the estrogens contribute to the maintenance of muscular strength and to mass preservation [8].
On the other hand, estrogens are a fundamental hormone for the maintenance of bone mass in women, by regulating their metabolism and remodeling, besides influencing calcium homeostasis, increasing its absorption and decreasing its excretion [9]. Among the various mechanisms to improve bone health, estrogens seem to decrease osteoclastic activity and bone resorption due to its effect as regulator of apoptosis [10]. This is a response mediated by an interaction of the ERα receptor with an intermediate protein p130Cas that leads to a decrease in differentiation and osteoclastic activity. Additionally, estrogens play an important role in increasing the osteogenic response to loading [11].
Given that estrogens contribute to the increase in bone mass and women reach their estrogen peak between the ages of 30 and 40, this is also the time when women reach their maximum bone mass. After menopause, an accelerated decrease in estrogens is evidenced, associated with loss of bone mass and an increased risk of osteoporosis and bone metastases in case of cancer [12]. For this reason, estrogen hormone replacement therapy has been suggested to increase bone mineral density, reduce in the incidence of fractures and improve muscle mass [11], something that is still controversial and possibly risky, a summary of the effect of estrogens in the adipose tissue, muscle and bone is in figure 1

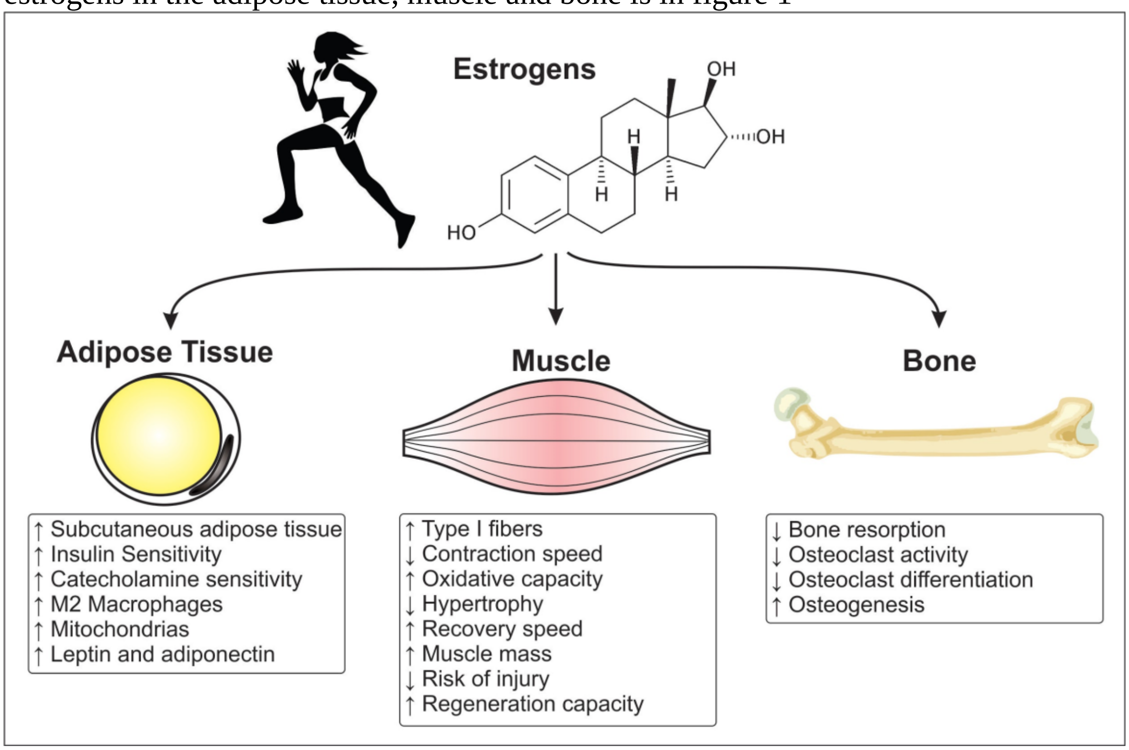

Figure 1: Estrogens effects in the adipose tissue, muscle and bone.

Testosterone in women, an adjunct in female hormonal function

Although testosterone is a predominant hormone in men, women have small amounts of testosterone produced mainly by the adrenal glands and to a lesser extent by the ovary. These concentrations vary throughout the menstrual cycle and behave in a similar way to the activity of estrogens [3].

Testosterone is an androgen hormone that, like estrogens, acts mainly by binding to intracellular receptors that regulate gene expression [5]. These androgen receptors are found in multiple organs and tissues, such as the heart, breast, lung, brain, and spinal cord, peripheral nerves, bladder, uterus, ovaries, bone tissue, adipose tissue [8]; and are especially found in myoblasts, myofibers and motor neurons [5].

In women, testosterone is essential for physical and mental health. Postmenopausal women present symptoms of androgen deficiency such as depression, anxiety, fatigue, loss of bone and muscle mass, cognitive changes, memory loss and sexual dysfunction [13]. Testosterone is associated with an increase in the synthesis of proteins that favor muscle hypertrophy [5,14], and only in the case of men an increase in the number of satellite cells. Given its effect on protein synthesis, in postmenopausal women, the administration of testosterone could be indicated in the prevention or treatment of sarcopenia [8].

Regarding adipose tissue, testosterone in women is related to visceral fat growth and a lower amount of subcutaneous fat, which partly explains the sex differences in the distribution of adipose tissue. In the bones, the effects of testosterone are similar to those described for estrogens [15].

Prolonged and intense exercise increases total testosterone, free testosterone and androstenedione levels in women, which return to normal hours after training stops [14]. This increase seems to be related to a decrease in the metabolic clearance of androgens during exercise and even greater stimulation of the hypothalamic - pituitary - adrenal axis [16].

Polycystic ovary syndrome (PCOS), which is a disorder characterized by chronic ovulatory dysfunction and hyperandrogenism [17], has been used to understand the effect of excessive testosterone in women. It is well known that PCOS is associated with the development of hyperinsulinemia and the increase in the inflammatory effect of visceral fat. Physical exercise is currently seen as a treatment for PCOS, as it is associated with the regulation of free testosterone levels [17,18].

In summary, testosterone in women contributes to improve sports performance and physical capacities such as strength. However, it is clear that its increase, either in pathological conditions (such as PCOS) or due to the use of anabolic androgenic steroids, leads to multiple adverse effects, such as increased facial and body hair, hair loss, menstrual irregularities and an increase in the size of the clitoris [18], in addition to a greater tendency to heart and liver disease. For this reason, its use is not indicated except in very specific conditions.

Other differences between the sexes associated with training

Although hormonal differences between men and women are evident, probably from puberty these hormones contribute to differences in other organs and systems.

Regarding the respiratory system, women present a smaller size of the rib cage, which leads to the description of a thoracic pyramidal shape in men and more prismatic in women. These morphological differences result in functional differences, such as lower air flow, a smaller surface area for gas exchange and a greater activation of respiratory muscles (diaphragm and accessory muscles) [19].

It is well known that physical exercise improves cardiovascular functionality and reduces the risk of developing pathologies, in part due to cardiac adaptations [20]. However, there appear to be differences in the mechanisms for regulating blood pressure between men and women, especially after menopause, associated with the activity of the sympathetic nervous system (it generates higher heart rates in women when facing similar stimuli), but especially differences in the size of the heart and the volume of blood ejected per beat, which is lower in women [21]. This results in differences in cardiac output that bring out a lower oxygen supply under conditions of intense effort.

One way to assess cardiac repolarization is to measure the QT interval on the electrocardiogram, which is slightly longer in women. This could be related to higher parasympathetic activity and lower sympathetic activity for women, but also to changes during the menstrual cycle where (in the luteal phase) the interval is usually slightly shorter in relation to the other phases, which suggests a possible hormonal influence on the expression of channels [22]. In the same way, women who train regularly tend to have a shorter QTc interval compared to sedentary women, which, added to a lower heart rate variability, is associated with adaptive changes in sympathetic tone secondary to training, something that was not observed in men [20].

On the other hand, in response to hormones it is also possible to find a lower amount of red blood cells, hematocrit and hemoglobin concentrations in women, something that could be explained by the lower presence of androgens and even by genetic variations. This lower capacity to Oxygen transport, added to a lower cardiac output lead to lower oxygen consumption in women, which would explain at least a good part of their higher aerobic capacity and endurance [23].

There are also remarkable differences between the sexes regarding the effect of exercise on energy and appetite regulation as effect of hormonal response. It has been observed that women respond to the beginning of training with a higher level of ghrelin and a lower level of insulin, which is expected to stimulate energy consumption, despite the fact that estrogens contribute to regulating appetite [22,24].

Regarding the energy substrate, it has been shown that free fatty acids provide a greater energy source in women than in men during training, with estrogens being responsible for greater lipolysis and greater fat oxidation at the muscular level [24].

In response to physical exercise, women have a lower response to bone formation, which means that they require more physical activity when pathologies such as osteoporosis are already established. The mechanical forces generated with exercise produce microfractures that stimulate bone remodeling and bone mineral density [25]. This added to humoral factors such as prostaglandins and growth factors released during training [11] and hormones produced more recently by the muscle (myokines) [25], lead to osteoblast activation and osteoclast inhibition.

Application of the physiological differences to the prescription of exercise in women

Women training (whether sports training or physical exercise for health) has some particular characteristics compared to men's training, this is due to the morphophysiological differences described above.

Regarding training, it is important to establish the components of the load. In a simple way, the FITT protocol (Frequency, Intensity, Time and Type of exercise) has been proposed. It is useful for the prescription of exercise but applicable to other training fields [26], which can be complemented by calculating training volume (V) and training progression (P) (FITT - VP).

Training frequency: There is a dose-response relationship in training, where training volume is given by the number of weekly sessions (Training frequency) and the total number of repetitions. Women, given their greater amount of slow-twitch fibers, associated with greater resistance, faster muscle recovery and greater oxidative capacity, would benefit from a greater frequency of training [7], with 4 sessions of strength training apparently being optimal per week, both for upper limbs and lower limbs, even if the goal is muscle hypertrophy [27]. Higher training frequency also contributes to optimizing resistance work. This is explained by adaptations from the genomic and epigenomic point of view. Training frequency has been proposed as the first variable to modify in the training progression [28].

Training intensity: Training intensity assesses the degree of effort required to carry out an activity. It is usually evaluated by percentages, based on values such as maximum oxygen consumption, heart rate or maximum force; or in qualitative terms such as the perception of effort. Women have the ability to sustain physical efforts at higher intensities compared to men with the same perception of effort. This is due in part to the greater oxidative capacity of fats that provide a higher amount of energy [6]. In the case of strength training, previous studies have shown that effects such as hypertrophy can be achieved with the use of high or low intensities [29]. In the case of women, intensities above 70% of the Repetition maximum (RM) did not show superior results than those of lower intensity training sessions. The reason for this is the higher proportion of slow-twitch fibers (Type I), which responses are higher at moderate intensities than at high ones [27].

Training time: it is useful for resistance exercises and is used especially in exercise prescription to promote adaptation. Apparently, there are no concrete differences between men and women in this regard.

Type of training: Although there are multiple physical capacities, classically we mention strength training and resistance training to refer to its extremes. Each one independently generates specific adaptations to it [30].

Hormonal variability secondary to the menstrual cycle is considered to have effects on multiple systems including cardiovascular, respiratory, metabolic and neuromuscular; which may have training implications [31]. Planning training according to the menstrual cycle phase in eumenoreic women has been controversial. Some studies have shown that during the follicular phase (first two weeks after menstruation) the increase in estrogen and testosterone favor strength training, with the ovulatory phase being the moment of greatest benefit not only in terms of increased muscle strength, but also in terms of maximum voluntary contraction. In the early follicular phase where estrogens are low, there are women who experience more muscle pain, however, other studies have not shown the same effect [32].

On the other hand, it has been proposed that during the luteal phase the presence of progesterone is related to a greater mobilization and use of fatty acids, consequently favoring resistance training [6], while other studies have related it to a decrease in maximum voluntary contraction secondary to an inhibitory effect of progesterone on the motor cortex. In fact, it is possible to find small differences among the population, but this does not mean that it is possible to extrapolate the response to all women given the methodological differences observed in the studies [3]. It has even been proposed that the intake of nutrients such as carbohydrates modifies responses independently to the hormonal component.

On the other hand, the consumption of oral hormonal contraceptives seems to generate slight differences in the effect of exercise producing a lower performance during training, secondary to lower endogenous concentrations of estrogens and progesterone [33]. Moreover, prolonged use of oral contraceptives (> 12 months) has been associated with a decrease in peak oxygen consumption, which could also affect athletic performance.

Additionally, exercise-induced muscle injury has shown less incidence in women compared to men, which seems to be directly related to the antioxidant effect of estrogens. However, when comparing these findings with women using oral contraceptives, It has been found that they tend to have higher levels of creatine kinase (CK), a marker of muscle injury, but they do not have an increase in other markers of muscle damage. This means that additional studies are required to really determine the estrogenic influence in exercise-induced muscle damage [34].

Volume of strength training with a view to hypertrophy

In women it is suggested a workout three or more times a week with three to four series per exercise. For upper limbs a volume greater than 150 repetitions per week is suggested and for the lower limbs, it is suggested that training volume exceed 250 repetitions [35]. A schematic summary of the differences in training between men and women is in figure 2

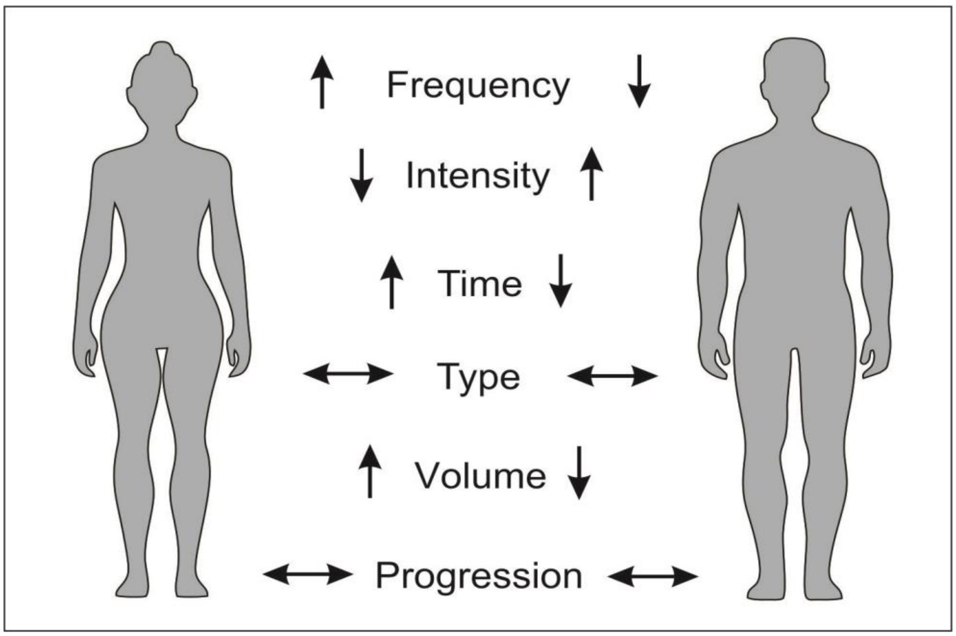

Figure 2. Differences between women and men in the components of load.

Conclusion

It is undeniable that there are differences between the two sexes, largely due to the influence of sex hormones. Women are characterized by having a greater amount of type I muscle fibers, greater use of fat as an energy source, and an activity of the sympathetic nervous system that favors vasodilation, perfusion and the elimination of metabolites at the muscular level. This leads woman to have higher endurance, less fatigue, faster muscle recovery and a lower risk of muscle injury. Based on this, women appear to achieve better training results by increasing frequency, using moderate intensity, and achieving high weekly volumes. However, this is still under study, as the results of the influence of estrogens on training are not totally conclusive. Additional studies are necessary to take advantage more specifically of the effects of sex hormones and the morphological and functional characteristics of women in training, whether it may be for sports performance or physical exercise for health. Besides, more research is necessary to understand the possible training changes after menopause, when there are different changes in hormones, body composition, and cardiovascular risk.

REFERENCES

[1] **Hunter SK.** The relevance of sex differences in performance fatigability. *Med Sci Sport Exerc*. 2016; 48: 2247-2256

[2] **Sandbakk O, Solli GS, Noakes TD.** Sex Differences in World-Record Performance: The influence of sport discipline and competition duration. *Int J Sports Physiol Perform* 2018; 13: 2-8

[3] **Sims ST, Heather AK.** Myths and Methodologies: Reducing scientific design ambiguity in studies comparing sexes and / or menstrual cycle phases. *Exp Physiol.* 2018; 103: 1309-1317

[4] **Kautzky-Willer A, Harreiter J, Pacini G.** Sex and Gender Differences in Risk, Pathophysiology and Complications of Type 2 Diabetes Mellitus. *Endocr Rev.* 2016; 37: 278-316

[5] **Haizlip KM, Harrison BC, Leinwand LA.** Sex-Based Differences in Skeletal Muscle Kinetics and Fiber-Type Composition. *Physiology* 2015; 30: 30-39

[6] **Devries MC.** Sex-Based Differences in Endurance Exercise Muscle Metabolism: impact on exercise and nutritional strategies to optimize health and performance in women. *Exp. Physiol.* 2016; 101: 243-249

[7] **Hunter SK**. Sex Differences in Human Fatigability: Mechanisms and Insight to Physiological Responses. *Acta Physiol.* 2014; 210: 768-789

[8] **Glaser R, Dimitrakakis C.** Testosterone Therapy in Women: Myths and misconceptions. *Maturitas*. 2013; 74: 230-234.

[9] **Nie X, Jin H, Wen G, et al.** Estrogen Regulates Duodenal Calcium Absorption Through Differential Role of Estrogen Receptor on Calcium Transport Proteins. *Dig Dis Sci.* 2020.

[10] **Khosla S, Oursler MJ, Monroe DG.** Estrogen and the Skeleton. *Trends Endocrinol Metab.* 2012; 23: 576-581

[11] **Bemben DA, Fetters NL.** The Independent and Additive Effects of Exercise Training and Estrogen on Bone Metabolism. *J. strength Cond. Res* 2000; 14: 114-120

[12] **Salamanna F, Borsari V, et al.** Link Between Estrogen Deficiency Osteoporosis and Susceptibility To Bone Metastases: A way towards precision medicine in cancer patients. *J. Breast.* 2018; 41: 42-50.

[13] Testosterone Therapy for Menopausal Women. *Drug Ther Bull.* 2017; 55: 57-60

[14] **Vingren JL, Kraemer WJ, et al.** Testosterone Physiology in Resistance Exercise And Training: The up-stream regulatory elements. *Sport Med.* 2010; 40: 1037-1053

[15] **Schiffer L, Arlt W, et al.** Understanding the Role of Androgen Action in Female Adipose Tissue. *Front Horm Res.* 2019; 53: 33-49.

[16] **Enea C, Boisseau N, Agnès Fargeas-Gluck M, Diaz V, Dugué B.** Circulating Androgens in Women Exercise-Induced Changes. *Sport Med.* 2011; 1: 1-15

[17] **Ehrmann DA.** Polycystic Ovary Syndrome. *N Engl J Med*. 2005; 352

[18] **Ip EJ, Barnett MJ, et al.** Women and Anabolic Steroids: An Analysis of a Dozen Users. *Clin J Sport Med.* 2010; 20 6:475-481

[19] **Dominelli PB, Molgat-Seon Y, Sheel AW.** Sex Differences in the Pulmonary System Influence the Integrative Response to Exercise. *Exerc Sport Sci Rev.* 2019; 47: 142-150

[20] Genovesi S, Zaccaria D, et al. Effects Of Exercise Training on Heart Rate and QT Interval in Healthy Young Individuals: are there gender differences?. *EP Eur.* 2007; 9 1: 55-60.

[21] Wheatley CM, Snyder EM, Johnson BD, Olson TP. Sex Differences in Cardiovascular Function During Submaximal Exercise in Humans. *Springerplus.* 2014; 3: 1-13.

[22] Vink AS, Clur SAB, Wilde AAM, Blom NA. Effect of Age And Gender On The Qtc-Interval in Healthy Individuals And Patients With Long-QT Syndrome. *Trends Cardiovasc Med.* 2018; 28;1: 64-75.

[23] Beltrame T, Rodrigo V, Hughson RL. Sex Differences in The Oxygen Delivery, Extraction, and Uptake During Moderate-Walking Exercise Transition. *Appl Physiol Nutr Metab.* 2017; 42 9: 994-1000.

[24] Friedlander AL, Casazza GA, Horning MA, Buddinger TF, Brooks GA. Effects Of Exercise Intensity and Training on Lipid Metabolism in Young Women. *American journal of physiology. Am J Physiol.* 1998; 275 5: 853-863.

[25] Jessup J V, Horne C, Vishen RK, Wheeler D. Effects of Exercise on Bone Density, Balance, and Self-Efficacy in Older Women. 2003; 4;3: 171-180

[26] ACSM's Guidelines for Exercise Testing and Prescription. 10th ed. Philadelphia, United States of America: Wolters Kluwer; 2018.

[27] Grgic J, Schoenfeld BJ, Davies TB, Lazinica B, Krieger JW, Pedisic Z. Effect of Resistance Training Frequency on Gains in Muscular Strength: A Systematic Review and Meta-Analysis. *Sport Med.* 2018; 48 5: 1207-1220

[28] Kraemer WJ, Ratamess NA. Fundamentals of Resistance Training: Progression and Exercise Prescription. *Med Sci Sports Exerc.* 2004; 36 4: 674-688.

[29] Schoenfeld BJ, Grgic J, Ogborn D, Krieger JW. Strength and Hypertrophy Adaptations Between Low- Vs. High-load Resistance Training: A systematic review and meta-analysis. *J Strength Cond Res.* 2017; 31 12: 3508-3523

[30] Hughes DC, Ellefsen S, Baar K. Adaptations to Endurance and Strength Training. *Cold Spring Harb Perspect Med.* 2018; 8

[31] McNulty KL, Elliott-Sale KJ, Dolan E, et al. The Effects of Menstrual Cycle Phase on Exercise Performance in Eumenorrheic Women: A Systematic Review and Meta-Analysis. *Sport Med.* 2020

[32] Romero-Parra N, Alfaro-Magallanes VM, Rael B, et al. Indirect Markers of Muscle Damage Throughout the Menstrual Cycle. *Int J Sports Physiol Perform.* 2020: 1-9

[33] Elliott-Sale KJ, McNulty KL, Ansdell P, et al. The Effects of Oral Contraceptives on Exercise Performance in Women: A Systematic Review and Meta-analysis. *Sport Med.* 2020

[34] Carter A, Dobridge J, Hackney AC. Influence of Estrogen on Markers Of Muscle Tissue Damage Following Eccentric Exercise. *Fiziol Cheloveka*. 2001; 27 5: 133-137

[35] Hagstrom AD, Marshall PW, Halaki M, Hackett DA. The Effect of Resistance Training in Women on Dynamic Strength and Muscular Hypertrophy: A Systematic Review with Meta-analysis. *Sport Med.* 2020; 50 6: 1075-1093

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