

Influence of Training on Physical and Physiological Characteristics of Male and Female Children, Adolescents and Adults

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Abstract

Physical activity level of an individual or society is considered as a faithful reflection of their state of health and quality of life. Women are said to be less responsive to training and require more time and work to increase their strength, but others have stressed that pubertal girls respond to training in the same fashion as adolescent and adult males. This paper is titled “effects of training on physical and physiological characteristics of male and female children, adolescents and adults. It takes into consideration, physical characteristics, cardiopulmonary characteristics, skeletal and cardiac muscle and hormonal and metabolic characteristics of male and female. Suggestion/recommendations were also made.

Introduction

Physical performance depends in large part on the ability to take in and utilize oxygen. Oxygen consumption depends not only on pulmonary and cardiac functions, but also on the transport of oxygen from the lungs to the tissue. The delivery of oxygen from the heart and lungs depends on hemoglobin which is synthesized from iron and proteins within the body. Female may easily become deficient in iron and in hemoglobin because the requirement for iron is considerably higher because of loss during menstruation (Heyward, 1998, Wilmore and Costil, 1999). Maximal oxygen uptake is the best measure of cardiovascular fitness. It also is the “gold standard” for design of aerobic-type exercise training programme and in comparison of individuals and/or group of individuals. The difference in maximal oxygen consumption between men and women can be explained

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by difference in body mass, percent body fat, and hemoglobin concentration, (Wilmore, 1996; Bouchard, 2001, Bilman, 2002).

Authorities in exercise and sports science report that the physical performance of girls up to the menarche is equal to that of boys. Ireland and Ott (2004) pointed out that in females, the development of performance ability stops or even declines after puberty. The maximum endurance declines rapidly in girls after the age of 14 as well.

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The characteristics of women response to moderate exercise is greater and results in more rapid elevation in pulse rate than noted in men under similar condition. Limitations on women's responses to strenuous activity and the tests or endurance are the more rapid heart rate, fewer red blood cells and less hemoglobin, smaller maximal pulmonary ventilation, lung capacity less than that of males, lower maximal oxygen uptake and endurance (Heyward, 1998; Bouchard, 2001; Brooks, et al., 2002).

The overall responses to acute and chronic exercise in women appear to be similar to the responses in men. There are, however, several gender specific differences. The apparent differences were observed in studies that characterize the metabolic, hormonal, and cardiovascular response to exercise in women. For example, during the phases of the menstrual cycle, receptors for both testosterone and estrogens are founded on cardiac and the skeletal muscles. The relative role these receptor plays in the overall structure and function of striated muscles is unknown; however, results from animal studies demonstrate gender specific adaptation to chronic exercise in cardiac muscles. Result from human studies suggest the possibility of gender specific differences in the relative size of muscle fibers and fiber type distribution in skeletal muscle. The adaptation of striated muscle for exercise are central to the health and functional status of individual. Knowledge about the role the sex hormones play in the overall functioning of striated muscles is critical to the health-related aspects of physical activity programmes (Bilman, 2002; Brooks, et al., 2002).

Physical Characteristics

Although there is no significant difference in size of boys and girls of the same age during the first ten years of life, girls are ahead of boys in maturation throughout this period. There is a slight difference in bone age at birth and by ten years the girls are definitely 12 to 18 months ahead of

boys of the same age in this particular aspect of physiological development. Girls begin their adolescent growth spurt in the period between 10¹/₂ and 13 years of age, and it is growth. About two more inches of growth occur after the menarche, total growth being completed by about 16 years of age. (Ireland and Ott, 2004).

Boy's growth spurts occur between the age 12¹/₂ and 15 years. These extra years of physical growth are under the influence of growth hormone. Prior to sexual maturity, account for the greater size of males. Young men generally are about 10 percent larger than young women when growth ends. This applies to height, weight and other external measurements. Union of all epiphyses to the main portion of the bone has occurred by the age of 16 years in girls and 18 years for boys. Late maturing girls would have a longer period of skeletal growth and thus greater height and longer legs and arms than would occur on the usual schedule, (Heyward, 1998, Foss and Keteyian, 1998).

The amount of muscle is almost identical children of either sex in the first decade of life. Muscles, like other tissues, increase during adolescence, their peak growth occurring a few months after the greater increment of height growth. At maturity the muscle mass in women is about one-half that of men. The reason for this is the effect of androgens (male sex hormone) on muscles.

In girls the most rapid increase in strength occurs before the menarche, with a diminishing increment for a few years thereafter. Wilmore (1988) pointed out that the "early maturing individuals are on the average superior in strength to the late maturing". This is most marked on boys at about the age of 14.5 years and in girls at 13. Early maturing girls show a characteristically early arrest in development of strength as well as height. Dempsey (1986) found that the motor skills of girls do not improve after the age of 14 years.

Cardio Pulmonary Characteristics

Oxygen delivery capacity or maximal aerobic uptake (Vo_2max) is a measure of the ability of the cardiovascular and pulmonary system to deliver oxygen to the exercising muscle. The apparent large difference in Vo_2max between the two sexes (52%) when expressed as Litre $\text{L}\cdot\text{min}^{-1}$ and 19% when expressed Vo_2 $\text{ml}\cdot\text{kg}^{-1}$ have been partially accounted for the normalizing for mass free mass and training status (Heyward, 1998). However, it appears that approximately a 15% difference in Vo_2max remain and is thought to represent inherent biological differences that exist between men and women (Sparling, 1980, Foss and Keteyian, 1998). Therefore,

well-design experiments are required to determine whether these inherent differences are attributed to women's genetic determinants (Foss and Keteyian, 1988). The smaller components of the oxygen transport system, and the smaller ventricular mass to lean body mass ratio. Cardiopulmonary factors that may explain the inherent biological differences include a cardiovascular factors such as oxygen carrying capacity of the blood, left ventricular mass, cardiac output and left ventricular function, blood volume, skeletal muscle blood flow, and the autonomic nervous systems regulation of the circulation as well as pulmonary factors such as pulmonary diffusion capacity, pulmonary capillary blood volume and transmit times, and ventilation perfusion ratios.

Women have a smaller blood volume, heart size, lower hemoglobin concentration, and oxygen content of the blood (Heyward, 1988; Fox and Keteyian, 1998). Studies using magnetic resonance imagine determining left ventricle mass in sedentary men and women and endurance athletes of both sexes have been published. Women have smaller left ventricular mass both in absolute term and when expressed as left ventricular mass/lean body mass ratio (Milliken, et al; 1988).

Women have lower arterial oxygen content at rest and during maximal dynamic exercise. Also the arterial venous difference in women is lower, and there is no different in the calculated mixed venous oxygen content between men and women at rest and during maximal exercise (Fox and Keteyian 1998 and Heyward 1998). The ratio of Q/V_{O_2} during the sub maximal work is high in women than in men (Astrand and Rodahl, 1986; Drinkwater, 1984). This difference in the Q/V_{O_2} ratio reflect a hyperkinetic circulation in a response to a reduced oxygen delivery. However, cardiac output and V_{O_2} max where expressed as $l \cdot min^{-1}$ in this comparison, and no normalization for body mass or surface area differences where made. Clearly, as noted for the difference in V_{O_2} max, when comparisons between the sexes are made, the influence of surface area-to-mass ratio on cardio vascular variables need to be accounted before assuring differences due to gender. Other function such as lower circulating blood volume resulting in a lower stroke volume and therefore a higher heart rate at the same V_{O_2} need to be accounted for in terms of difference in body size (Astrand and Rodahl, 1986; Drinkwater, 1984; Heyward, 1998).

Women have lower pulmonary capacities and exercise ventilation volumes than men, and this appears to be the result of a structural difference. There are few data concerning the difference in diffusion capacity and diffusion/perfusion ratio of women's lungs during exercise. Perhaps the recently defined pulmonary limitation to V_{O_2} max in the well-trained

male athlete (Dempsey, 1986; Rowell, 1986) is more likely to be present in the female athlete because of her smaller pulmonary capillary volume. The average isometric strength is approximately 30% greater in men than in women and is probably related to man's greater mass of lean tissue. Isometric strength increases to a maximum through ages of 30-40 years but then declines progressively as age advances. However, when one incorporates strength training or works at a job requiring strength maneuvers age-related decline in isometric strength is reduced or absent. Isometric endurance measures at any given force of contraction is better for women than men and appears to increase in both sexes with advancing age (Brooks et al, 2001).

The cardiovascular responses associated with isometric exercise including an increase in blood pressure, an increase in heart rate and cardiac output with minor changes in vascular resistance. Once again, despite the apparent increase in incidence of clinical manifestation of autonomic dysfunction in women compared with men, there is relatively few documented investigations comparing the cardiovascular responses of men and women to isometric exercise, (Wilmore and Costill, 1999; Fox and Ketgerian, 1998).

Skeletal and Cardiac Muscles

Although there are absolute differences in the mass of skeletal muscle between women and men after puberty, a gender difference in strength is not observed when maximal strength is normalized for cross-sectional area (Ireland and Ott, 2004). The greater strength of men apparently results from a larger size of the individual muscle fiber since the number of muscle fibers within a specific muscle are the same between men and women. Costill et al; (1976) reported that the size of the individual muscle fiber since the number of muscle fibers within a specific muscle is the same between men and women. Costill et al; (1976) reported that the size of the individual muscle fibers in women was 70-85% of the men's size, the magnitude depending on the type of the muscle fiber (slow-twitch or fast-twitch). Furthermore, there is no gender difference in the proportion of muscle fiber types within, the same muscle (Astrand and Rodahl, 1986; McArdle et al., 1984). Relatively greater muscle hypertrophy accounts for the greater muscle mass and higher absolute strength in men.

The mechanism(s) underlying the greater muscle hypertrophy in men is unknown. Skeletal muscle and cardiac muscle possess receptors for both androgens and estrogens (Fox and Ketgerian, 1998; Jackson et al; 1999). Because the role of androgens and estrogens in stimulating protein synthesis is well known, the higher circulating levels of androgens may account

for the greater muscle hypertrophy in men compared with women. On the other hand, the higher circulating estrogens in women may be important in regulating energy metabolism rather than protein synthesis in muscle. The interaction of the sex hormones on protein synthesis metabolisms in striated muscle requires further investigation. Similarly gender difference in smooth muscle structure and function are unknown.

Hormonal and Metabolic

The role of estrogens and progesterone in the hormonal and metabolic response to exercise in women is unclear despite several years of research. The regulation of metabolism during exercise is complex, requiring the integration of several systems. These systems, hormonal and otherwise, regulate the mobilization of substrate (glucose and fat) from storage depots, the transport of substrates to work muscles, the entry of substrate into the working muscles, and the metabolism via specific metabolic pathways of the substrates once in the cell (Galbo, 1983); thus, there are several layers of complexity in the precise regulation of metabolism during physical activity. Although menstruating women may utilize more fatty acids as an energy source during sub maximal exercise more so than men (Tarnopolsky, et al; 1990), Bunt, (1990) however pointed out that true gender differences in substrate metabolism are difficult to demonstrate in human, mainly because of the inability to control several confounding variables. These variables include menstrual status, training history in the previous year, diet, precise matching of physical performance (Vo_2max whether expressed $1\text{min}^{-1}\cdot\text{kg}$ total body weight, or kg lean body weight), and so forth. Similarly, Tarnopolsky, et al; (1990) reported a gender difference in fat utilization during sub maximal exercise during the follicular phase in women who were matched with men for performance status, training status, and maximal Vo_2max . The diet was controlled for 3 days prior to the run. The women utilized more fat (as estimated by the lower respiration exchange ratio) and less muscle glycogen than the men during the run. Plasma insulin decreased in the exercise in both groups; however, the resting plasma insulin was higher in the women prior to the exercise bout. This higher plasma insulin in the women throughout the exercise bout could result in an alteration of substrate mobilization/utilization during exercise.

The interplay between estrogen and progesterone on metabolism during exercise also is unclear. In comparing the distinct phases of the menstrual cycle, investigators often observe minor if any differences in plasma glucose, fatty acids, the gluco-regulatory hormones, and catecholamine. For example, Bonen et al (1983) reported no apparent phase differences in women during

light and heavy exercise whether the women fasted or were fed glucose before exercise. On the other hand, Lavoie, et al, (1987) demonstrated a phase difference in women who were fed a carbohydrates-poor diet for one day before exercising for 90 min at 63% Vo_2max .

Conclusion

Evidence has been presented that from the sixth week of embryonic life there are anatomic and physiologic differences, which affect physical growth and development. In the female, her pattern of growth and development leads to certain characteristics such as smaller body size and dimensions of organs, more body fat, leading to proportionately less muscle, reduced hemoglobin mass, physiologic variations related to the reproductive system after puberty. All of these require special consideration in programming physical activities and sports for women. The overall responses to acute and chronic exercise in women appear to be similar to the response in men. There are however, several gender specific differences. The energy substrate utilization during exercise and the adjustments in the hormonal milieu for substrate mobilizing depend on the type of exercise; and the exercise status, among many other factors.

Recommendations

It is recommended that since age and gender differences exist in the body's responses to physical activity, professionals in the field of sports and sports science should be responsible for handling physical fitness training. Physical training should vary in terms of mode of activity, duration of activity, frequency of activity and intensity of activity putting into consideration the age and gender of participants.

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