

Kathy Somerville

*Les femmes ont historiquement été largement ignorées dans la recherche en physiologie; les déclarations sur les femmes ont été des généralisations basées sur les statistiques masculines. Des données physiologiques plus récentes ont cependant inclus spécifiquement la recherche sur les femmes. Bien qu'elles aient certaines limitations quand on les compare aux hommes sur ce sujet, les femmes semblent avoir un avantage dans les études faites à haute altitude et par grande chaleur. Certaines études montrent que les femmes peuvent réagir de la même façon que les hommes à un exercice maximal, mais que chaque sexe a des mécanismes physiques différents qui sont responsables de ces réactions.*

In the past, when women weren't the "weaker sex," they were the invisible sex. Exercise-physiology research has not been an exception; women were either cautioned against strenuous activity lest they injure their "delicate female organs" or were ignored altogether. Thus much of the research available contains outdated ideas of the limitations of women or does not include women at all.

Although more research is now being conducted on women and their responses to physical training, very little is known about women in comparison to men. Some of the information we have about women is based on generalizations from the data available on men. Due to basic differences between men and women, such as organ size, hemoglobin levels, blood volume, amount

# WHAT RESEARCH TELLS US ABOUT THE PHYSICAL POTENTIAL OF WOMEN



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of muscle, and hormone levels and types, generalizations are not always valid. The fact that not all of the differences between males and females are known further decreases the value of generalizations.

This brief summary of research available is therefore not as accurate and comprehensive as one might desire, but it may shed some light on the physiological status of women as compared to men.

Research to date shows that women react in much the same way as men to physical training. A closer look at this research will reveal where the differences between men and women lie and how they may affect performance.

Before looking at the changes that training programs can effect on individuals, we must look at the body size and composition of men and women. Women are usually shorter than men and don't weigh as much, even when compared by height. This weight difference can be attributed to the different body compositions of men and women.

The average man's body contains approximately 85 per cent lean body mass (muscle, water, and bone) and 15 per cent fat. Of this fat, 3 per cent is generally regarded as essential fat — that which is stored primarily in the organs and which is needed by the body in order to function properly. Women's bodies have approximately 75 per cent lean body mass and 25 per cent fat, which includes 12 per cent essential fat. Women have more essential fat due

to the mammary glands and other organ tissues. Although it is difficult to determine exactly how much of the lean body mass is muscle, men have approximately 40 per cent and women have approximately 23 per cent. The larger muscle mass of men gives them a physical advantage.

Because of the greater amount of essential fat found in even the most highly conditioned women athletes, some people think that women will always have a performance disadvantage in weight-bearing events. The amount of work required to perform any task increases with an increase in body weight, meaning the women will reach their maximum level of performance at a lower level than men. Essential fat does give women an advantage in swimming competitions, in which the extra fat decreases body drag in the water. This decreases the amount of energy required to swim a given distance.

A regular exercise program measurably improves the fitness levels of both men and women. The increased fitness levels are the result of improved bodily aerobic capacity, strength, and efficiency.

Women as well as men can expect increases in total heart size or volume, total blood volume, and total hemoglobin levels with training. Working muscles use oxygen for fuel and produce waste in burning the fuel. Since the blood carries oxygen to the muscles and carries away waste products, an increase in the amount of blood that can be pumped by the heart will increase the amount of work the muscles can do. An increase in heart size allows more blood to be pumped by the heart. A larger blood volume means that more blood is available to carry oxygen to the muscles and to clear waste products. Finally, since hemoglobin is the compound in the blood that carries the oxygen from the lungs to the rest of the body, an increase in hemoglobin will increase the muscles' supply of fuel.

In conjunction with the increases in heart size and blood volume, training produces increases in cardiac output and stroke volume during maximal exercise in men and women. The amount of blood pumped per unit of time is called

the "cardiac output." "Stroke volume" refers to the amount of blood pumped by the heart in each beat. Once again, if more blood is pumped, the muscles have more fuel. Women have smaller values for stroke volume and cardiac output than men, mainly due to the smaller heart volume of women.

The above increases are closely associated with an increase in "max  $VO_2$ " that occurs with training in males and females. This term refers to the maximal aerobic capacity of the body, or the capacity of the body's oxygen system. Increasing this capacity is important for improved athletic performance and fitness. An increased max  $VO_2$  allows the body to become more efficient and powerful.

Although improvement in max  $VO_2$  in response to training is similar in women and men, women as a rule have lower values than men. These lower values are a partial result of the lower heart and blood volumes, hemoglobin levels, stroke volume, and cardiac output found in women. All of these factors can limit maximal aerobic power because they are a part of the body's oxygen-carrying system.

Though women have lower values for absolute max  $VO_2$ , this value can be expressed proportional to lung volume, heart volume, muscle mass, or other bodily dimensions. When maximal aerobic power is expressed in proportion to lean body weight, the values for top male and female athletes are quite close. This doesn't mean that women have the same aerobic power as men during activity, however, because women have a lower percentage of lean body weight than men. Women who decrease body fat and increase lean body weight are able to approach the performances of men through increased strength and aerobic power.

In addition to improving the maximal aerobic power of men and women, training also improves the anaerobic power. The aerobic energy system requires the presence of oxygen to function, whereas the anaerobic system operates without the presence of oxygen. The anaerobic energy system is used by the body when it needs quick energy;

events such as the 100- and 200-metre sprints in track require such outputs of energy.

Two types of anaerobic systems are available: the ATP-PC system and the lactic-acid system. In the ATP-PC system phosphocreatine (PC) is broken down in order that adenosine triphosphate (ATP) can be formed. ATP is an immediate source of energy and is provided more quickly by the ATP-PC system than by any other energy system. Women have approximately the same amount of ATP and PC stored in their muscles as men, but because of a lower percentage of muscle mass they have a lower total store of ATP and PC for energy.

In the lactic-acid system, glucose (sugar) is broken down and forms lactic acid as a by-product. The breakdown involves a series of chemical reactions, one of which is the formation of ATP. The lactic-acid system of women is of a lower capacity than that of men, once again because of the smaller muscle mass of women.

Highly conditioned men and women have a lower heart rate at rest and at any given level of exercise than do untrained or less conditioned men and women. Since athletic training causes an increase in stroke volume and the amount of oxygen pumped out in each stroke, the trained individual's heart need not beat as often in order to supply the body with the required amount of oxygen. A lower heart rate saves energy as well as wear and tear on the heart; it is a sign of fitness.

Trained women have a higher heart rate than trained men during exercise because of women's lower stroke-volume values. Since a woman's heart sends out less blood with each beat, it must beat more often to provide adequate blood supplies to the body.

The body compositions of men and women change with training. The percentage of fat in the body decreases and the percentage of lean body weight increases. Women usually have a smaller increase in lean body weight, indicating a smaller increase in muscle mass with training.

Strength training can be used to increase the muscular strength of women since they generally show the same per cent increase in strength from weight training as do men. Though women can increase muscular strength through training, very few women experience any real increase in muscle mass or in girth measurements as do males. When women do experience an increase in muscle mass, it is offset by the decrease in body fat that occurs at the same time, often leaving girth unchanged. Large increases in muscle mass occur in the presence of the male hormone testosterone, which is only found in small amounts in females.

The size of a muscle (regardless of whether it is in a male or female body) determines the strength of that muscle. Since women have a smaller muscle mass than men they have a lower absolute strength, usually two-thirds that of men. If strength is expressed relative to total body weight or lean body weight, the strength difference almost disappears. Unfortunately, this equality is only theoretical in events such as running or jumping, where women actually have less muscle per kilogram to propel themselves.

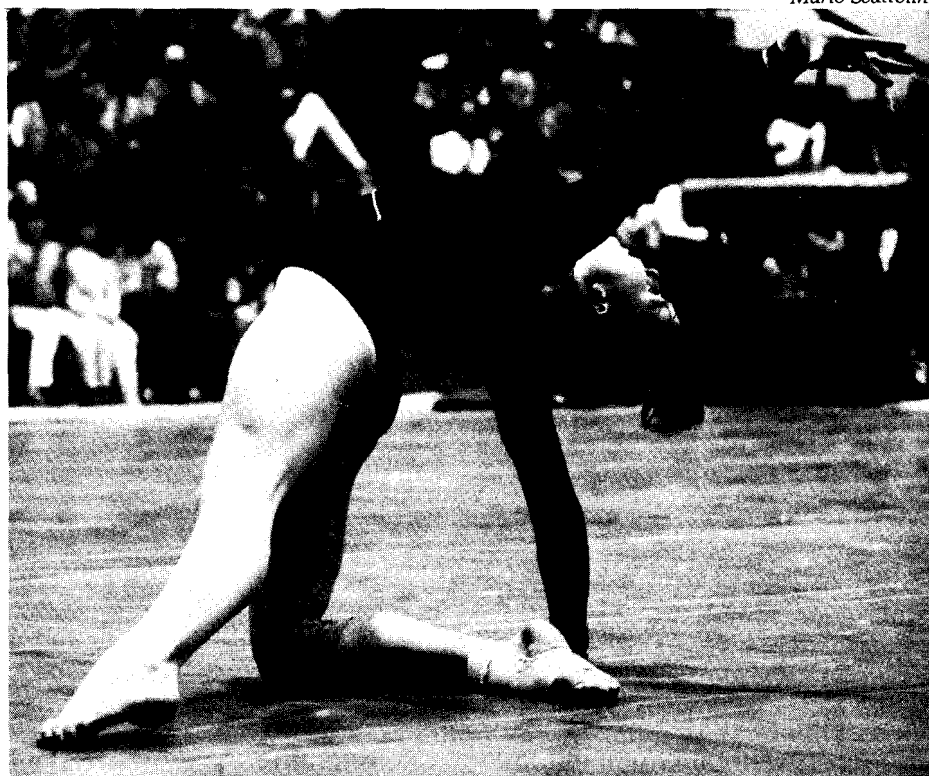
Recent research concerning exercise at altitude and in heat has un-

covered significant differences between men and women that may give women a physiological advantage. Research on exercise at altitude is of interest to athletes because events are sometimes held at altitudes that are significantly higher than sea level. Unaccustomed athletes find it difficult to supply their bodies with enough oxygen at such heights because fewer oxygen molecules per unit volume of air are available. The lack of oxygen decreases performance through a decrease in max  $\text{VO}_2$ . Unacclimatized individuals may also suffer from altitude sickness, which involves loss of appetite and energy.

Over a relatively short period of time acclimatization takes place in the form of hyperventilation, increased hemoglobin concentration, and a decrease in bicarbonate levels. Hyperventilation allows more air and thus more oxygen to reach the lungs. An increased hemoglobin concentration allows more oxygen to travel through the blood stream. Lowered bicarbonate levels help to keep the body's chemistry in balance after the previous two adaptations have taken place.

Some evidence suggests that women do not experience as much altitude sickness as men and therefore have more energy.

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Women have also been shown to hyperventilate more than men, experience hemoconcentration earlier than men, and excrete greater amounts of bicarbonate earlier than men. In the early stages of altitude exposure, then, women seem to have a faster rate of acclimatization than men. This fact could lead to advantages in performance at altitude for women.

Exercise over a lengthy period of time (such as endurance running) or exercise in the heat tends to expose an athlete to thermal stress. The body is equipped to handle a certain amount of this stress through such measures as sweating and cutaneous vasodilation. The evaporation of sweat from the skin provides a cooling effect. Cutaneous vasodilation refers to an increased amount of the body's blood flowing to the skin. Thus the heat generated in the core of the body is sent via the blood to the body's surface, where the blood cools and then returns to lower the body's core temperature.

Research seems to indicate that women react with different mechanisms to heat than do men. The most recent studies with acclimatized male and female subjects have found equal sweat losses in men and women but greater cutaneous vasodilation in women. This suggests that women regulate their body temperature through their cardiovascular system more so than do men. The decreased metabolic cost involved in cardiovascular regulation would be an advantage to women competing, for example, in marathon runs on a hot day.

Some studies have noted (as did the thermoregulation studies above) that women may react in the same way to maximal exercise but have different mechanisms responsible for that reaction. This is one of the least-studied and most important areas concerning women's physiology. Until we examine not only the performance of women but the physiological mechanisms by which these performances are achieved, we will not know the true potential of women. It may be that women have untapped resources that need only be discovered to be utilized to increase performance.

Physiological research on women

is scarce; most studies are carried out on men. In fact, some studies don't even bother to mention whether the subjects were male or female; the assumption is that they were male.

Research carried out on women must be examined with caution. Although researchers strive to carry out studies in an unbiased fashion by eliminating personal expectations of results, it seems that in some cases the "men-are-superior-to-women" bias has been overlooked. For this reason it is difficult to examine research on women; existing cultural biases may invalidate results or conclusions.

One example of this bias is in research on the comparative thermoregulatory abilities of men and women. Many studies compared trained and untrained men under thermal stress and found that trained men handled the stress better. When women were compared to men, however, their fitness levels were not noted. As a result, researchers thought for many years that women behaved as untrained males did to thermal stress and were therefore inferior. All new evidence was evaluated with this "fact" in mind. Researchers only recently discovered that the reason that women reacted similarly to untrained males was that they were untrained females. When studies examined trained males and trained females, researchers found that women could adapt just as well and

perhaps even better to heat stress than do males.

Women's performances may be limited by their greater essential body fat, smaller muscle mass, lower max  $\text{VO}_2$ , smaller anaerobic capacities, and higher heart rates during exercise. Women may have physical advantages at altitude and in situations involving thermal stress. More research must be carried out to determine the mechanisms of women's response to training and exercise. Results of this research may improve women's performances. In the meantime, existing research must be closely examined in order to determine whether the results have been influenced by the cultural biases of the researchers.


#### Further Reading:

J.P. Hannon, "Comparative Altitude Adaptability of Young Men and Women," in *Environmental Stress: Individual Human Adaptations*, ed. L.J. Folinsbee *et al.* San Francisco: Academic Press, 1978.

C.L. Wells, "Responses of Physically Active and Acclimatized Men and Women to Work in a Desert Environment," *Medicine and Science in Sports and Exercise* 12 (1980): 9-13.

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