Why women have it even tougher than men when it comes to triathlon…

In a series of articles prepared for the Ironman and Iron Girl websites, sports scientist and respiratory physiologist Professor Alison McConnell has described the role of breathing in limiting exercise performance, and what can be done to overcome this limitation. Whilst the content and advice in these articles apply equally to both sexes, there are some unique issues facing female athletes that mean there is even more reason for women to pay serious attention to their breathing.

In this article, which has been written specifically for the Iron Girls, Alison explains that women have been dealt a particularly unfair blow by Mother Nature when it comes to meeting the breathing demands of their sport, but one that can overcome be overcome, with the right equipment.

NOTE: Before reading this article, it is advisable to get yourself up to speed with some of the fundamentals of breathing and exercise by reading Article 1 in the series (Breathing and exercise 1 – the individual challenges of swimming, cycling and running) available at www.powerbreathe.com

Breathing during exercise: a female perspective (or…the problem with being a woman)

Introduction…are men really from mars?

The average difference in the finishing time of men and women over the Ironman distance is currently around 60-90 minutes, or 10-20%, depending upon the venue. This apparently large difference belies how far the women's event has come since the inception of the Ironman competition almost 30 years ago. Gordon Haller won the inaugural Hawaii race in 1978 in a time of 11:46:40, which would have earned him only 49th place in the 2006 women's race. Admittedly, over the same time period, the men's finishing time has been pared down to 8:11:56, but the first woman home in Kona in 2006 finished in 90th place, and Michelle Jones did so with several hundred men trailing in her wake, including several of the 'Professionals'.

Much as I'd love to be able to tell you that one day women will finishing on almost level terms with the men, its a depressing fact of life that men are physiologically better endowed when it comes to physical performance. Of course, women can console themselves with the knowledge that they got the looks and the brains, so evolution has brought some compensations.

Generally speaking, women are physically smaller than men, and evolution has adapted female physiology to meet the demands of bearing and caring for children. In contrast, men have evolved to meet the demands of a more physically demanding daily existence. This means that there are differences in all of the major systems that play a role in determining physical performance.

Determinants of race performance

Fundamentally, swimming, cycling and running requires the application of muscular power, resulting in movement of the human body. All other things being equal (e.g., mechanical efficiency), the greater the ability of an athlete to generate and sustain power, relative to their body weight, the faster they will go. The ability to generate and sustain muscular power is determined by a number of factors, including muscle mass and the ability to produce that power using metabolic pathways that do not generate fatiguing by-products such as lactic acid. These 'non-fatiguing' pathways are known as *aerobic* pathways,

because they utilise *oxygen* to release energy from the body's energy stores. Hence, the maximal oxygen uptake (VO_{2max}, see Definitions) is an important determinant of performance, as is the proportion of the VO_{2max}, that can be sustained before exceeding the threshold for lactic acid accumulation (lactate threshold, see Definitions below). What are the main determinants of VO_{2max} and the lactate threshold?

1) The ability to pump oxygenated blood to the exercising muscles
2) The ability of the muscle fibres to utilise the oxygen that is delivered

Unfortunately, when it comes to number 1, women are not as well endowed as men.

You need a big 'pump'

Men have larger hearts, a greater blood volume and more haemoglobin (see Definitions) than women, which means that their ability to transport oxygen to the muscles is superior. Even when men and women are matched for body size, the men still come out on top[1]. In addition, women generally have a larger percentage body fatness compared to men, which means that some of their muscular power is 'wasted' because its simply propelling the 'dead weight' of fat. So when the superior ability to transport oxygen is combined with a [generally] larger muscle mass and lower body fatness, men are able to generate and sustain more muscular power, with the inevitable consequence that they can swim, cycle and run faster than women of a similar training state.

Not-so sweaty Betty

When it comes to regulating body temperature, women cannot match the sweat rates of men, even when differences in body surface area are accounted for (larger people have a larger body surface area). This means that women rely more heavily upon dissipating heat through dilation of blood vessels at the skin surface[2]. A consequence of this movement of blood to the skin is that it compromises blood flow to the exercising muscles, and places a greater strain

on the cardiovascular system (the heart does not have an unlimited capacity to increase its output). Furthermore, the female sex hormones influence regulation of body temperature during exercise[3] , with the consequence that body temperature regulation can become a challenge for women during certain phases of the menstrual cycle.

A big 'bellows' helps too

The respiratory system is essentially a bellows pump that fills and empties the lungs with air. You guessed it; women also have smaller lungs than men, even when matched for body size[4]. As well as having a smaller overall volume, the airways (breathing tubes) of women's lungs are also smaller than those of men[5], which means that women have to overcome a larger resistance to airflow as they breathe. The greater the airflow resistance, the greater the work that has to be performed by the breathing muscles in order to move air in and out of the lungs, which clearly places women at a disadvantage. This disadvantage of an increased requirement for breathing muscle work is compounded by the fact that women also have weaker breathing pump muscles[6]. Thus, women have a higher requirement for breathing muscle work, but a lower breathing pump power with which to achieve it – 'double-whammy'.

Around 50% of the sense of whole body effort sensation (how hard the exercise feels) arises from the breathing muscles and the sense of breathing effort (breathlessness) that they generate. Generally speaking, athletes pace themselves based upon what they find tolerable for a given duration of activity. Clearly, the longer the activity must be sustained, the lower the intensity of discomfort that is tolerated (contrast the effort sensations associated with a 400m sprint and a 10k and you'll appreciate this). Its therefore not too hard to see how having smaller lungs and a higher breathing effort can impair performance - for any given level of breathing, women work at a higher percentage of their breathing pump's maximum capacity, have a

higher intensity of breathing effort sensation, and a greater sense of overall effort.

Definitions:

Maximal oxygen uptake VO_{2max}: The maximum rate at which the body can transport and utilise oxygen. It corresponds to the exercise intensity above which further increases in exercise intensity fail to yield further increases in oxygen uptake (VO_2).

Lactate threshold: The exercise intensity above which the concentration of lactate within the blood increases progressively during an incremental exercise task. This corresponds to the exercise intensity at the production of lactate exceeds its removal (catabolism).

Haemoglobin: a blood protein that binds to oxygen in the lungs where oxygen is high, and releases it in the tissues (e.g., muscles) where oxygen is low.

Women have one 'edge'

Almost the only system in which women may have a slight edge over men is the way that stored energy substrates[7] are used. The most plentiful source of energy (fuel) within the human body is fat. The ability to use fat rather than the more limited stores of carbohydrate (glycogen) is an advantage for endurance athletes, as it reduces the likelihood of running out of fuel ('hitting the wall'). An important adaptation that occurs in response to endurance training is that athletes become better at utilising their fat stores, which spares their limited carbohydrate stores. However, women naturally tend to utilise more stored fat than men to fuel endurance exercise, which means that they

are able to use a more plentiful fuel source in preference to one that is in limited supply (carbohydrate). Accordingly, women may be better suited to ultra-distance events, where carbohydrate stores may become exhausted. In other words, women may outlast men in events where there is no opportunity to top-up carbohydrate stores (a tortoise and hare scenario).

Can training help?

Physical training induces adaptations in most of the body systems that affect exercise performance; the pumping capacity of the heart increases, we become more efficient in our use of stored energy, and better at dissipating heat by sweating. However, a highly trained man will always have a superior physiological make-up to that of a highly trained woman.

There is one system that is the exception to the rule that physical training improves physiological function. It surprises most people to learn that the lungs appear to show no adaptation to training at all, with their physical size and ability to transfer oxygen remaining unchanged, even after many years of hard physical training. However, this fact should not be interpreted as meaning that breathing is not trainable, or that there aren't any performance gains to be made from specifically targeting the aspects of breathing that DO respond to training. Remember, breathing is brought about by the action of the breathing pump muscles, and these are very trainable (more on this below).

The remainder of this article will consider the specific limitations imposed by breathing; these are not confined to women, but made more prominent by the fact that women have smaller lungs than men. Firstly, we will consider in more detail the physiological repercussions for women of having smaller lungs and weaker breathing muscles; secondly, we will consider how women can overcome the limitations arising from breathing that Mother Nature has imposed.

Limitations due to breathing - yes, size DOES matter…

Most of the research on exercise physiology has been undertaken on men, and in men, the lungs are generally not considered to be a limiting factor in the transport of oxygen (see Article 1). How do we know this? The main function of the lungs is to facilitate the transfer of oxygen from the air and into the blood. If the lungs were a site of limitation to this first stage in the supply of oxygen to the muscles then, during exercise, we would expect to see a decrease in the amount of oxygen in the blood as it left the lungs, i.e., if the lungs were not operating optimally in the transfer of oxygen into the blood, then the blood would not be completely replenished with oxygen after passing through the lungs. As it happens, the amount of oxygen in the blood leaving the lungs does not fall during exercise. In addition, neither the amount of oxygen in the blood, nor maximal oxygen uptake (VO_{2max}) are improved by breathing more during exercise.

However, there is a caveat to this. A small proportion of male athletes (around 2%[8]) do show a decrease in the amount of oxygen in their blood during very heavy exercise. This oxygen de-saturation (as it is known) has a negative impact upon VO_{2max} and exercise performance. De-saturation is thought to occur in these athletes because their hearts and muscles are so well developed that their lungs have become a limiting factor. Since women have smaller lungs than men, it comes as no surprise to learn that the proportion of women who experience this limitation is larger than the proportion of men (around 10% vs. 2%[8], respectively). The theory that the fall in oxygen is due to women having smaller lungs is supported by the finding that when women are compared with a carefully matched group of men (matched for age, height, VO_{2max}), there is no difference in the oxygen delivery responses of the men and women[9]. So it appears that the smaller physical size of the female lungs is at the root of the problems that arise in oxygen transport. Unfortunately, as we've already learnt, the physical size of the lungs is not trainable, so there is nothing that can be done to overcome this particular limitation.

Having smaller lungs also contributes to another disadvantage for women. The mechanical work of breathing (energy required to pump air in and out of the lungs) also appears to differ between men and women, and this is also attributed to the fact that women have smaller lungs and narrower airways than men. Having smaller lungs means that women are more likely to be functioning at the upper limits of their ability to generate flow and volume changes. Unfortunately, the mechanical resistances that must be overcome in order to move air in and out of the lungs are greater the closer one is to the physical limits of the system. In addition, being close to the limits of the respiratory system's capacity mean that there is a greater risk of breathing muscle fatigue, and a higher intensity of breathing effort, both of which slow you down.

One very interesting study has compared the mechanical work of breathing directly between men and women, and the results were surprising. Despite having a lower absolute breathing requirement (139 vs. 147 litres per minute), the female athlete's breathing muscles required more than 50% more oxygen than her male counterparts[10]. The functional implications of this are very serious from a performance perspective, because it implies that, 1) women require a greater proportion of the available oxygen just to breathe, 2) the greater demand for breathing results in a higher intensity of breathing muscle work and a potentially greater susceptibility to inspiratory muscle fatigue, 3) fatigued breathing muscles can steal blood from the limbs (see Article 3), so women may therefore experience a greater competition for blood flow between respiratory and locomotor (arm and leg) muscles (see Article 3).

It's not all bad news

Before you Iron Girls start feeling too hard done by, let me tell you the good news. Although the limitations described above put women at a disadvantage relative to men, they certainly don't constitute a 'show-stopper' when it comes to women achieving phenomenal feats of human endeavour. Women have scaled the heights of Everest, and the world free-diving record was held by

Tanya Street between 2003 and 2006 (on a single breath lasting 3:38 min:sec, she descended 121 meters), so female physiology should be viewed as an inconvenience rather than a barrier to achieving your goals.

Furthermore, many of the problems that are described above (increased breathing muscle work, greater breathing effort sensation, breathing muscle fatigue, blood flow stealing) can be overcome by applying some simple training theory – what's the logical solution to an increased requirement for work from a group of muscles that are weak? How about training the muscles to make them stronger, better able to cope with the increased demands, and more resistant to fatigue? This is now possible thanks to POWERbreathe®, a laboratory-proven inspiratory muscle trainer that boosts performance in women and men.

If you want to know more about overcoming the breathing limitations that all women must contend with, then it can be found on the Ironman website. In Article 4 of the series on breathing and exercise for triathletes, tips are provided on breathing more efficiently. Article 5 reviews the evidence that training using POWERbreathe improves performance, and in Articles 6-10 sport-specific POWERbreathe® training tips are provide, to help minimise the limitations imposed by breathing.

The take home message for the Iron Girls is that training breathing is even more important for women than it is for men, because breathing represents an even larger limitation in women. Put another way, you've got even more to gain!

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