BREATHING & EXERCISE

ARTICLE 5: Why POWERbreathe® training is an ergogenic aid that does exactly what it claims, won't break any rules, and does it all in less time than it takes to brush your teeth!

Introduction

In the first two articles of this series, we considered the structure and function of the breathing pump, the individual demands of swimming, cycling and running, as well as the challenges posed by combining these activities into a single competitive event – the triathlon. Within the information provided by these articles we saw that fatigue of the breathing pump, specifically the inspiratory muscles, is a 'normal' part of triathlon. In the third article we got a bit more technical and considered the unexpected and wide-reaching physiological implications of 'breathing fatigue'. In the fourth article in the series, we considered the best strategies and tactics for maximising breathing comfort, and minimising the chances of 'breathing fatigue'.

In this, the fifth article in the series, we will consider the evidence that POWERbreathe® training is a proven ergogenic aid. We will also put the time it takes to add POWERbreathe® to your routine into context; its quite simply the quickest fix around.

Seeing is believing

Like most people involved in sport, I'm very sceptical of the claims made by sports product manufacturers, so when a manufacturer claims that using their product will improve performance, I want to know by how much, where the evidence has been published, the physiological rationale for the ergogenic effect, and whether using it breaks any rules.

Sadly, virtually none of the products that I encounter pass my credibility check, ie they produce quantifiable improvements, are backed-up by research that's published in credible journals, have a basis in current understanding of exercise physiology, and don't drive a horse and cart through the doping regulations.

As a scientist, numbers are very important to me, so for a so-called 'ergogenic aid' to be considered credible, the first test it must pass is that it produces an improvement in performance that can be quantified. Related to this criterion are two other factors:

1 - The measured improvement must be reliable;
2 - It must be meaningful from a competition performance perspective.

Why reliable? Well a product that claims to improve performance, but only does this for 10% of the people who use it is letting down the 90% of people for whom it does nothing. And what does meaningful mean? According to Dr Will Hopkins[1], the smallest enhancement in performance that makes a meaningful difference to an athlete's performance is half of the typical variation in performance between events. For example, for a 40km cycling time trial the variation is around 1 to 2%[2, 3], so a meaningful improvement needs to be at least 0.5 to 1.0%.

Placebo and task learning effects

Now you're probably thinking that 1% is a pretty small change, and that it should be pretty easy to show that a product produced a 1% change. The problem is showing this 1% improvement in all of the test subjects, and in excess of any 'placebo' or 'task learning' effect.

What are these effects? There is a strong psychological influence on any performance test; if you're taking part in a trial of a new product and you've been told that it will improve your performance, the chances are that you will try harder (even sub-consciously) after you've used it than you did before; you may also feel that the task was easier or more comfortable after you've used the new product, but this may also be due to a placebo effect. This is because you're expecting to do better, or feel better, after you've used the new product. In addition, people tend to get better at physical tasks on the second occasion that they undertake them, so if the first occasion that you undertake the task is before you've tried the new product, and the second occasion happens to be after it, then you will show an improvement just because you got better at doing the task.

In order to get over these problems, well-designed research studies include a 'placebo group', which is a second group of participants who are also told that they are going to try something that will improve their performance. In reality, they are doing something that the experimenters know won't result in a performance enhancement.

If the placebo group also improve their performance, then the real test group's performance must increase by more than this in order for the change to be related to the new product. Including a placebo group is a well-established method that is used in medicine to test new pharmaceuticals; in this situation the placebo group takes a 'sugar pill' instead of the real drug. Well-designed studies also make sure that all of the participants in the trial (real and placebo) are familiarised with the performance tests before their baseline performance is assessed. This ensures that any improvements are not just due to getting better at the test.

As it happens, a 1% change in performance is actually very hard to detect unless you have extremely robust methods and a very reliable ergogenic effect; if you don't, then the effect will be lost in the 'noise' of the measurement (placebo effect, day-to-day variations in performance due to biological variations, small variations in the accuracy of measurement equipment, etc.).

Sadly, very, very few studies examining the efficacy of ergogenic products incorporate the basic safeguards I've described above. In fact, most products aren't supported by ANY scientific data at all; the manufacturers expect their customers to take their outlandish claims at face value, or they use the worst con trick of all - a celebrity endorsement.

But I ask you, would you buy a car on the basis that the brochure just said 'faster and safer than other cars'? Of course not, you'd want to see the horsepower, 0-60 times, and safety ratings in black and white. Only then could you compare results and decide which car offer you the best value for money. In my view, consumers also have the right to expect sports product manufacturers to support their marketing claims with hard data.

In the context of breathing during exercise, nasal dilator strips are a typical example of a product that claims much, but delivers nothing[4, 5]. To my knowledge, no scientific study has shown any convincing physiological benefits of nasal dilators, let alone to improvements in exercise performance in time trials.

But this doesn't prevent the manufacturers of these products from making claims such as '*More air equals more energy...nasal strips gently lift open nasal passages to help you breathe freely...they're ideal for every athlete*'. These claims have been toned down considerably since the heady days of the mid-1990s when these strips first hit the NFL (National Football League), but nonetheless, they remain misleading and completely unsupported by scientific facts. Indeed, the scientific facts completely contradict key claims such as '*[Product name] nasal strips help you breathe easier with less energy while exercising*'[6], and that nasal strips reduce heart rate and the perceived effort of exercise[5].

Some manufacturers even try to boost the relevance of their nasal product by claiming that '*breathing through your nose is more energy efficient*'! If that's the case, then why is exercise tolerance impaired when breathing through the nose compared to breathing through the nose and mouth[7]? Claims such as these are not only counter to scientific fact, they are also counter to good old fashioned common sense.

As a consumer you have the right to expect manufacturers of products that claim to be ergogenic to back up their claims with good quality scientific evidence, which is exactly what POWERbreathe® is able to do.

POWERbreathe®: the research tool that became a sports product

What exactly is POWERbreathe®?

Some years ago when asked to sum up what POWERbreathe® was, I coined the term 'Dumbbells for your diaphragm'. POWERbreathe® is a device that is designed specifically to allow you to resistance train the muscles that are used to inhale (the inspiratory muscles). Figure 1 illustrates the Ironman model from the POWERbreathe® range.

Inside POWERbreathe® are two one-way valves. The first allows you to breathe out without any resistance. The second is a spring-loaded valve that will only open when sufficient inspiratory muscle force (pressure) is generated to overcome the tension of the spring. When this occurs, the valve opens and the user can inhale. However, they must maintain the same effort throughout the breath, otherwise the valve will close again. The tension on the spring, and thus the 'weight' of the valve can be adjusted easily to allow accommodate improvements due to training, as well as different starting abilities.

The training intensity that we have shown to be effective in terms of improving inspiratory muscle strength and exercise performance is the 30-repetition maximum, which corresponds to approximately 50-60% of the maximum strength of the inspiratory muscles. A training session requires around 2 minutes to complete, and we recommend training twice daily for 4-6 weeks. We will discuss the practicalities of POWERbreathe® training in the next article in the series (number 6).

Figure 1

Where did POWERbreathe® originate?

Unlike many sports products, POWERbreathe® didn't begin life in the office of a marketing guru, it came into being as part of a research project at a major university in the UK. The project began in 1990 and examined the influence of inspiratory muscle strength on breathlessness and exercise tolerance in older people.

I was the lead investigator on the project, and I needed a reliable training device to test my hypothesis that strengthening the inspiratory muscles would reduce breathlessness and improve exercise tolerance. When I couldn't find one on the market, I set about designing my own, and POWERbreathe® was the result.

To cut a long story short, my research team found that strengthening the inspiratory muscles did reduce breathlessness and improve exercise tolerance in older people[8]. This led us to examine whether a similar effect was also present in young, well-trained people; to our surprise, we found it was[9-13], which in turn led to the realisation that inspiratory muscle training had huge commercial potential, and I was encouraged by my University to turn my research tool into a sports product.

During the intervening years, my team has also undertaken research to gain insights into the physiological mechanisms that underlie POWERbreathe's ergogenic effect, and just this year, we published a study that finally provides evidence of a direct link between POWERbreathe® training and improved limb exercise tolerance[14]. Understanding how an ergogenic product exerts its effect physiologically is important, not only because this provides credibility, but also because this understanding is essential if we are to harness its full potential.

Having told you that you have the right to expect sports product manufacturers to support their claims with hard scientific evidence, I propose to outline the key scientific data that support POWERbreathe®'s claims to '*improve performance, reduce heart rate, blood lactate concentration and effort sensation during exercise*'. The data that follow in support of POWERbreathe® have all been published in high-quality peer-reviewed scientific journals such as 'Medicine & Science in Sports & Exercise' (this is published by the American College of Sports Medicine; the journal publishes research at the frontiers of sports science, and is the most respected sports science journal in the world).

The scientific evidence supporting POWERbreathe®

Training the respiratory muscles has been shown to produce a number of key physiological and performance improvevments[15] (see table 1). These changes provide some clues about the underlying mechanisms for increased performance after POWERbreathe® training, but we'll deal with those later.

Respiratory training has also been shown NOT to induce a change in the two factors that are most commonly associated with improvements in performance – maximal oxygen uptake (VO_{2max})[15] and the lactate threshold[16]. At first sight, this is paradoxical, because its hard to conceive of a form of training that doesn't exert its effect either through an increase in VO_{2max}, or the lactate threshold. It's especially perplexing when one considers the nature of the training – surely training breathing must increase VO_{2max}?

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).

Supra-lactate threshold: Any exercise intensity above the lactate threshold. Exercise within this domain is non-sustainable, resulting in fatigue due to an escalating increase in blood lactate concentration. The further above the lactate threshold the exercise intensity, the more rapid the onset fatigue.

As I explained in article 1, breathing does not limit VO_{2max} at sea level, so we shouldn't expect breathing training to improve VO_{2max}. Instead, we need to think about POWERbreathe® training in terms of its effect on the metabolic and sensory repercussions of the work of breathing. Breathing is a process brought about by a complex group of muscles. These muscles are subject to the same limitations as other muscles, so they impose demands upon the cardiovascular system for blood flow, and they show fatigue if they are worked beyond the limits of their capacity.

Table 1. Improvements induced by respiratory muscle training.

	STUDY								
	[17]Boutellier & Piwko 1992	[18]Boutellier et al 1992	[9]Caine et al, 1998	[19]Spengler et al, 1999	[10]Volianitis et al 2001	[20]Romer et al, 2002a	[12]Romer et al, 2002b	[21]Gething et al, 2004a	[22]Gething et al, 2004b
Exercise performance	√	√	√	√	√	√		√	√
Breathing effort					√	√	√		
Whole body effort			√			√	√	√	√
Inspiratory muscle fatigue					√	√			
Breathing pattern				√	√	√			
Lactate turnover	√	√	√	√	√	√	√		
Heart rate			√			√		√	√

Improvements in exercise performance following respiratory muscle training have been shown using two main approaches:

1. Fixed intensity tests to the limit of tolerance (in other words, asking someone to exercise at the same non-sustainable intensity until they cannot continue);
2. Time trials (completing a fixed distance against the clock).

Both approaches have their merits and limitations. Method 1 enables the comparison of physiological and perceptual data under identical exercise conditions pre- and post-training. Unfortunately, this type of test does not mimic any competitive event, and therefore has limited validity in respect of translating any increases in exercise time into improvements in actual competitive performance.

Time trials, on the other hand, have 'real world' validity, but make the comparison of data pre- and post-training problematic, because if your intervention has worked, the athletes will be exercising harder (going faster) after the training.

The size of the effect of IMT upon performance also differs depending upon whether a fixed intensity or time trial is used. After inspiratory muscle training, fixed intensity performance improves by 30-50%, whereas time trial performance improves by 2-5%. The difference is due to the differing metabolic domains of the two types of test. POWERbreathe® has been tested using both methods.

In an early study we showed that 4 weeks of POWERbreathe® training reduced perceived effort, blood lactate concentration and heart rate[9]. In addition, our subjects were able to sustain exercise for 33% (7 minutes) longer after POWERbreathe® training. These data are shown in figure 2.

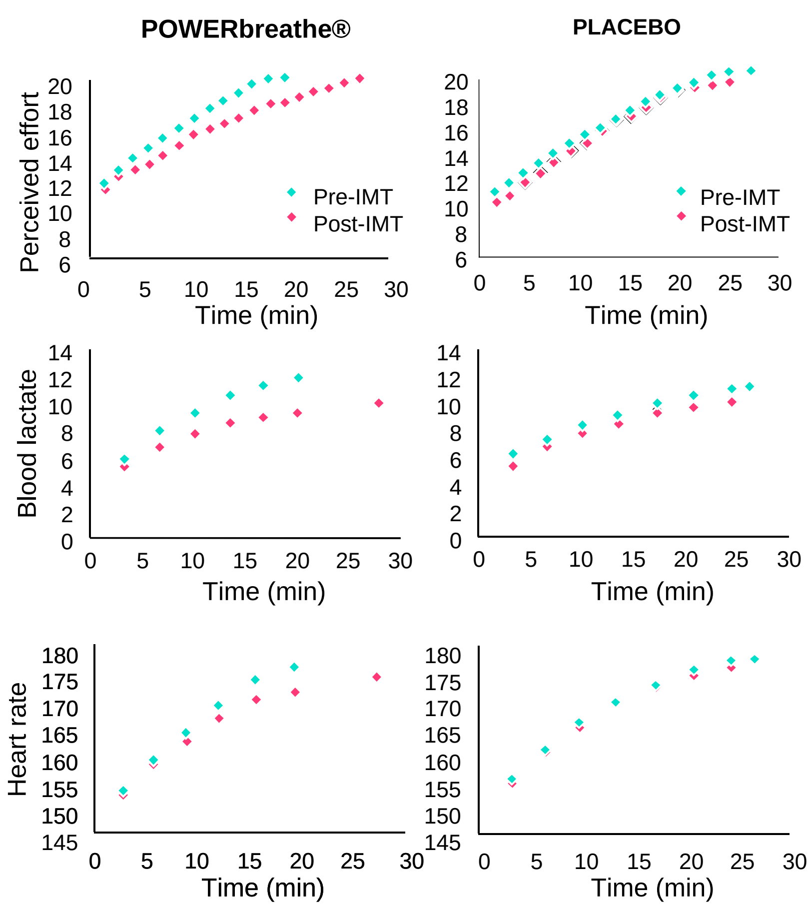
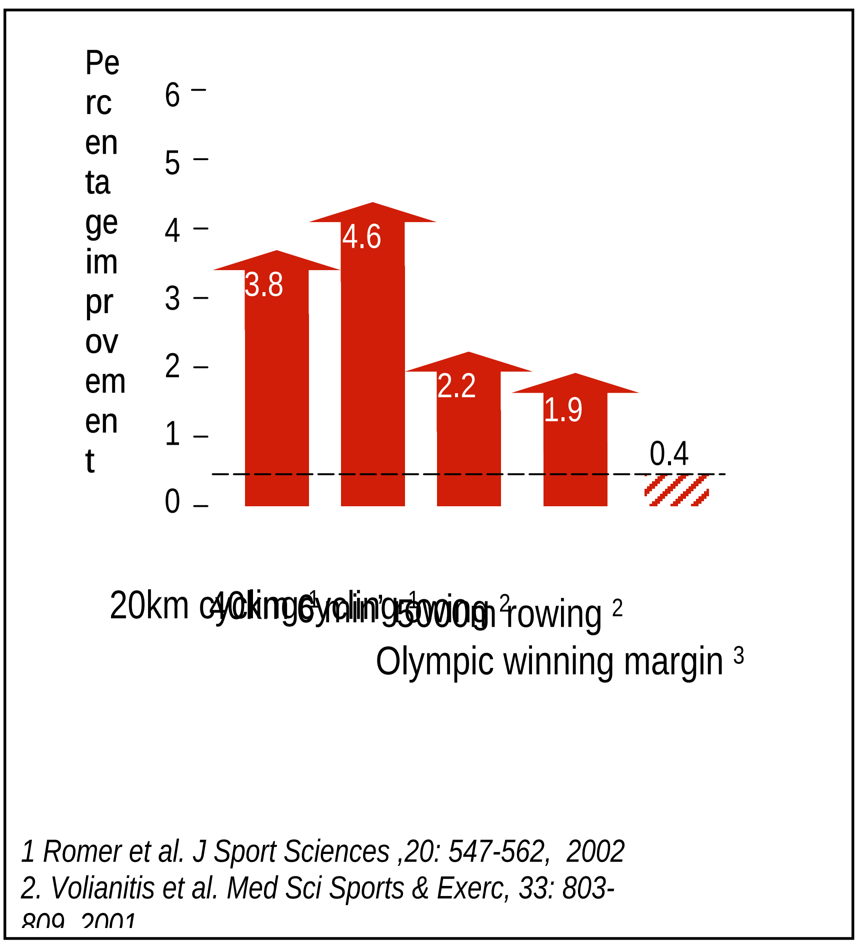


Figure 2. Changes in effort sensation, blood lactate concentration and heart rate following 4 weeks of POWERbreathe® training during cycling at a fixed supra-lactate threshold power output. Left panels are data for the POWERbreathe® training group, right panels are data for the placebo control group. Note reductions after POWERbreathe® training, but no change in the placebo group. Subjects also cycled for 33% (7 minutes) longer after POWERbreathe® training. From Caine & McConnell, 1998[9].

How much does POWERbreathe® improve actual time trial performance?

In two later studies, we used time trials to examine the effects of POWERbreathe® training upon 'real world' performance. The first of these studies was undertaken in a group of highly-trained oarswomen[10]. Within 4 weeks, they had improved their performance in a 6-minute rowing ergometer time trial by 1.9% above that of the placebo group. This translated into a 36m improvement in the distance covered on the rowing ergometer in 6 minutes. They also improved their 5000m rowing performance by 25 seconds (2.2%) more than the placebo group. Figure 3 puts these time trial performance improvements into context.

Figure 3 here



When assessed at fixed power outputs on the rowing ergometer, the athletes also reported lower ratings of both breathing and whole body effort sensation, so they felt as though they were working less hard at the same power output after POWERbreathe® training. Finally, the POWERbreathe® group also benefited from a reduction in the severity of inspiratory muscle fatigue that was induced by the 6-minute rowing time trial. Before training, the time trial induced an 11% decrease in inspiratory muscle strength, whereas after the POWERbreathe® training there was no significant decline in strength; fatigue remained unchanged in the placebo group.

In our most comprehensive analysis of POWERbreathe® training to date, we studied the influence of POWERbreathe® upon laboratory time trial performance in highly-trained cyclists[11, 13]. Two time trials were undertaken (20km and 40km) under strictly controlled laboratory conditions.

As is the case in all of our studies, we also incorporated a placebo control group, but we enhanced the scientific rigour of the study still further by ensuring that the experimenters did not know which group the subjects were in. This removed any potential experimenter bias. Finally, we also monitored all of the athletes' other training to ensure that any improvements in performance could not be attributed to enhancements arising from their other training.

After 6 weeks of POWERbreathe training the POWERbreathe® group showed the following improvements in their performance and physiological response to exercise, compared with the placebo group:

- 20km time trial – 66 seconds faster (3.8% improvement)
- 40km time trial – 115 seconds faster (4.6% improvement)
- Breathing and whole body effort sensation reduced during cycling (16-18%)
- Oxygen uptake requirement of exercise reduced (3%)
- Blood lactate concentration lowered (8%)
- Inspiratory muscle fatigue attenuated

None of these changes were observed in the placebo group, and there were no changes to the athletes' whole body training. The latter observation confirmed that our findings could only be explained by the addition of POWERbreathe® to the athletes' training. These data are probably the most relevant to triathlon performance and confirmed the earlier findings in oarswomen (see Figure 3).

All of the key benefits reported above have been confirmed by other researchers, so they are by no means unique to my research laboratory (see table 1). Some of other researchers have used different methods of training the inspiratory muscles, which brings me to another important benefit of POWERbreathe® training – time, effort and financial investment.

The improvements I've described above were achieved after 4-6 weeks of POWERbreathe® training. The training consisted of 30 breaths (repetitions) at a moderate load on the POWERbreathe® twice daily (50-60% of inspiratory muscle strength). This required a time commitment of around 4 minutes per day. The training itself is challenging (if done well), but by no means strenuous or unpleasant.

In this respect, POWERbreathe® training is in stark contrast to two other methods of respiratory training that have been reported in the literature[17-19, 21, 22]. The first requires near maximal voluntary hyperventilation. The second requires slow resisted breaths through a very small hole; each resisted inhalation requires around 15 seconds during which near maximal effort is required. Although these other methods are effective, they are very time-consuming (at least 30 minutes per training session) and extremely physically demanding (both require maximal effort). In addition, they require bulky complex equipment costing at least ten times the price of POWERbreathe®. One method also requires that the equipment is linked to a PC.

Got time to clean your teeth? Then you've got time to enjoy the benefits of POWERbreathe®

In a previous article (article 2), I illustrated how supremely time efficient POWERbreathe® training was using a simple comparison. The results of two training studies that both improved 40km time trial performance by about 5% were contrasted. One study added POWERbreathe®[13] and the other study added high intensity cycle interval training[23]. Both resulted in an enhancement of time trial performance of around 5%, but the cycle training required a 53-minute training session, with the work phase of the training being at an intensity equivalent to VO_{2max}, whilst POWERbreathe® training required 2 minutes per session at an intensity that was moderate for the inspiratory muscles. The choice is yours, and call me lazy by all means, but I'd prefer to add 2 minutes of POWERbreathe® training twice a day, to slogging my guts out for almost an hour.

How does POWERbreathe® work?

In previous articles I've already alluded to the two main mechanisms by which we believe that POWERbreathe® training improves performance (article 3). The first is fairly self evident; POWERbreathe® training makes exercise feel easier, which means that you can go faster for the same effort. Most of us pace ourselves at the limit of what we find tolerable; after POWERbreathe® training, this limit is increased, and so is our pace.

The second mechanism contributes to the reduced effort sensation, but also improves performance independently. In article 3, I explained that when the inspiratory muscles are required to exercise at an intensity that will result in their fatigue, they send out signals to the brain that result in blood flow restriction to the limbs. With less blood flow, the limbs also receive less oxygen, and this impairs their ability to sustain the same intensity of exercise, so the pace is lower than if blood flow was normal. POWERbreathe® training prevents or delays the activation of this signal to restrict limb blood flow, thereby enabling a faster pace to be sustained for longer (for more details please see article 3).

What about expiratory muscle training?

Since inspiratory training seems to be so beneficial, I'm often asked whether it's worth training the expiratory muscles. We have examined this specifically in a study on oarsmen[24]. The crux of our findings was that expiratory muscle training did not improve rowing performance, and it also didn't produce any additional improvements when it was added to inspiratory muscle training. We also noted that improvements in inspiratory muscle strength in response to inspiratory training were impaired if the subjects attempted to train their inspiratory and expiratory muscle simultaneously. This means that the improvements that are guaranteed if you train the inspiratory muscles are jeopardised if you also attempt to train the expiratory muscles. This might be a compromise worth making if expiratory muscle training actually improved performance, but it doesn’t.

It’s a ‘no brainer’…

Everyone would like to get a bit faster, the question is what are you prepared to do to achieve it. Some athletes take the illegal route and resort to pharmacological assistance, but most of us accept that if we want to improve performance we have to train harder or longer, or both.

POWERbreathe® training means that you don’t need to do any of those things. You can achieve a 4.6% improvement in cycle time trial performance by adding just 4 minutes per day to your training. What’s more, you can do the training anywhere you like, because POWERbreathe® is small and convenient enough to fit into your kit bag. It even looks good enough to grace the shelf in your bathroom. Keep it with your toothbrush – that way you won’t forget to take advantage of the easiest and quickest performance booster known to sport science!

The next article in the series (article 6) will consider the practicalities of POWERbreathe® training. We’ll establish how to lay down the foundations of your POWERbreathe® training by considering the fundamentals of setting-up your POWERbreathe®, as well as how to optimise the outcome of the training by using the correct breathing techniques. These foundations will provide a platform for the more advanced training techniques that I have used with international athletes, and which I will share with you in articles 7 to 10.

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