BREATHING & EXERCISE

ARTICLE 4: Breathe better and improve your performance

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. We also 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 this, the fourth article in the series, we are going to consider the best strategies for maximising breathing comfort, and minimising the chances of 'breathing fatigue'. Your strategy will be specific to the task at hand, and will differ between the swim, cycle and run phases. It will also need to be responsive to changes in course conditions, and to your own physiological condition. The information here should help you to build a strategy that works for you, as well as helping you to know when to make tactical changes.

General principles of good breathing technique

Good breathing technique doesn't just happen by accident, and in the same way that efficient swimming, cycling or running technique needs to be coached and practiced, so too does breathing.

As we learnt in article 1, the most efficient way to breathe is deeply and slowly, because rapid shallow breathing is inefficient. We also learnt that this poor technique ('bad

breathing' as I call it) is surprisingly common, even in well-trained athletes, and that it can be a hard habit to break. This is because despite your best efforts to breathe more deeply and slowly, if your breathing muscles are unaccustomed to this (ie they are functionally weak), then breathing correctly may actually make you feel even more breathless. However, all is not lost, because 'bad breathing' and weakness of your breathing muscles can be corrected by specific exercises and inspiratory muscle training using POWERbreathe®.

Common signs of 'bad breathing' during running include tense shoulders, discomfort that develops around the collar bones and lower neck, and sometimes discomfort radiating from the collar bone down the bicep. These are all indications that the inspiratory accessory muscles of the rib cage and neck (inspiratory intercostals, sternomastoids, scalenes) are doing too much of the work of breathing.

The major inspiratory muscle is the diaphragm; it is the largest of the inspiratory muscles and should be doing most of the work. Diaphragm breathing is something that needs to be practiced and learnt. Breathing against a small load on the POWERbreathe® is an excellent way to 'feel' your diaphragm working, as well as beginning to understand how you can focus breathing activity on this major muscle.

Once you can focus the work on the diaphragm using the POWERbreathe®, you can practice using your diaphragm to breathe during exercise. This will be challenging at first, and may even give you a 'stitch' (see below), but persevering is well worth the effort. If diaphragm breathing during exercise proves too challenging, you can give yourself a bit of a head start by training with POWERbreathe® for 2-4 weeks before attempting to switch to diaphragm breathing during exercise.

Once you've got the hang of it, you'll find that breathing with your diaphragm will help to relax your upper body, making breathing feel powerful, controlled and, most importantly, comfortable. It will also minimise the chances of the smaller inspiratory muscles of your chest wall and neck becoming fatigued (see article 3 for information on the negative repercussions of this).

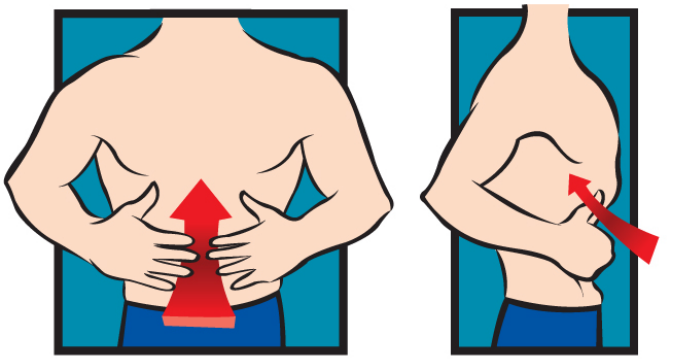
Getting in touch with your diaphragm:

Using the POWERbreathe® to get a 'feel' for how to focus breathing on your diaphragm is described above, but in addition, you can use an exercise that involves wrapping a 'Powerband®', or similar around your lower rib cage to impede the movement of your lower ribs (below your sternum).

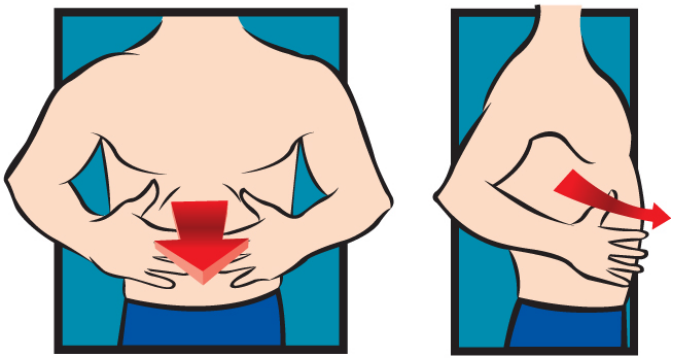
Place the band over a single layer of light clothing, or directly over your skin. The latter is preferable in the first instance because it allows you to see the movements more clearly. With a small amount of tension in the band, stand in front of a mirror (large enough to see your torso) and place your palms lightly on your lower ribs with the fingers facing forwards and the tips of your fingers almost touching. Relax your abdomen, shoulders and chest; take a deep, slow inhalation through your nose, and observe the movement of your abdomen and rib cage in the mirror.

If you are using your diaphragm to breathe, you should see and feel your ribs move sideways and forwards; your abdomen will also bulge forwards (see Figure 1). Your fingertips will move apart, making it easier to visualise the movement of your lower rib cage. The movements occur because diaphragm contraction results in a flattening and downward movement of the diaphragm dome (into the abdominal cavity), which causes the lower rib margins to move outward, and the abdominal contents (liver, stomach, intestines) to be pushed outwards and forwards.

Figure 1:
Practicing diaphragm breathing.



Breathing out (exhaling) with the diaphragm



Breathing in (inhaling) with the diaphragm

If your chest rises, you are not using your diaphragm properly; relax your shoulders and chest as you inhale. Exhalation should be relaxed, with no muscle activity; just allow the air to ‘fall out’ of chest as your lungs and rib cage ‘spring’ back passively. Be careful not to hold the breath at the end of the inhalation; relax and let the air fall out.

The resistance of the band allows you to experience the sensation of working with your diaphragm more intensely, but if you experience problems completing the exercise with the band in place, try it first without (if you still can’t master it, see below). Continue the exercise until you feel confident that you know how to activate your diaphragm, and what a diaphragm inhalation feels and looks like. Once you think you’ve mastered the technique, try it with your eyes closed, focussing on the sensation of the air filling your lungs.

You should aim for a breathing rate of no more than 12 breaths per minute and with practice, it should be possible to work your way down to 6. The inhalation phase will be slightly shorter than exhalation, because exhalation is passive. Try counting the breath in and out. For example, if you are aiming for 12 breaths per minute, this means that each breath should take 5 seconds (60/12); count ‘1-2’ during inhalation, and ‘3-4-5’ during exhalation. If your exhalation is faster than this, you need to relax more.

Practicing diaphragm breathing

Complete four minutes of diaphragm breathing exercise each day until you feel that relaxed diaphragm breathing has become ‘second nature’ (two minutes with visual feedback and two without). In addition, keep checking yourself periodically throughout the day to make sure that you are putting your newfound skills into practice. Introduce the technique into everyday activities such as walking up stairs (breathe in for 2 steps and out for 3), as well as during your routine workouts.

In the case of these exercise-related practices, you will need to switch from nose to mouth breathing (see below for recommended breathing pattern for your workouts). The aim of this process is to use conscious control of breathing to restore your unconscious control of breathing. I say restore, because as infants, we all breathed almost exclusively with our diaphragms; we then got into bad habits that require conscious effort to undo.

Practicing while lying down

If you find it difficult to get a feel for diaphragm breathing using the exercises described above, you can take a step back and start the process by getting in touch with diaphragm breathing by whilst lying on your back. There are a number of benefits of practicing this way:

- Your breathing muscles are no longer involved in postural activities (holding you upright), which makes it easier for you to focus on relaxing everything except your diaphragm;
- Your abdominal contents rest against the underside of your diaphragm, giving it something to work against;
- It's much easier to completely relax when in the lying position.

Start the exercise with small breaths 'into your abdomen' through your nose, then relax and let the air 'fall' out of your chest. Gradually increase the size of the breaths until you are taking slow, deep breaths. Be careful not to hold the breath at the end of the inhalation; relax and let the air fall out. As described above, you should be aiming for a breathing rate of no more than 12 breaths per minute, but it should be possible to work your way down to 6.

These exercises may be very challenging for your diaphragm at first, but when combined with POWERbreathe® training, your diaphragm will quickly become stronger and more able to accommodate a breathing pattern in which it does most of the work of breathing.

As well as these 'modern' methods of learning to breathe correctly, there are more ancient methods that can be called upon to improve the comfort and efficiency of your breathing. Yoga offers an excellent means of getting in touch with your breathing, and of developing good breathing technique through its 'pranayama', or breathing exercises.

Triathlon and breathing technique

In the following sections we'll consider some event-specific issues relating to breathing:

The swim phase – As we learnt from previous articles, the aquatic environment, wetsuits, and regimented breathing patterns associated with swimming pose a huge challenge to breathing; so much so, that swimming generates the most severe inspiratory muscle fatigue of any sport so far assessed.

The necessity to synchronise your breathing to your stroke rate is self-evident, but what is less obvious is the detrimental effect of allowing your breathing to dominate your stroke rate. When using a fixed breathing to stroke ratio, there is a tendency for this to lead to a shortening of the stroke as you get tired (unpublished observations). This is because the overwhelming urge to breathe drives the swimmer to increase their stroke rate, which leads to an inevitable decrease in stroke length. The end result is that you go slower. When this occurs, it's better to switch to a lower stroke to breathing ratio (from, say, 4 strokes per breath to 3) so that you can breath more frequently, without shortening the stroke.

I have worked with a number of swimming coaches over the years, and they were all, without exception, very keen on their swimmers breathing a little as possible. Some would impose torturous regimens on their charges, requiring them to sit on the bottom of the pool for as long as they could tolerate, or to swim lengths with a 7:1 stroke to breathing frequency! However, all of them reported that swimmers who used POWERbreathe® were able to adopt and maintain higher stroke to breathing ratios. In some cases, swimmers who'd been in a rut at a 3:1 ratio (strokes:breaths) for months (sometimes years) were able to make the step up to 5:1 within four weeks of commencing POWERbreathe® training. The other result was that they also went faster, and personal bests are be no means uncommon after a period of POWERbreathe® training.

In a later article in this series, we'll consider how to use POWERbreathe® in sport-specific ways that target the particular challenges to your inspiratory muscles posed by swimming.

The cycle phase: - In previous articles we've learnt that synchronising breathing and pedal cadence appears to have some advantages, including reducing the energetic cost of cycling. We also learnt that it probably doesn't matter at what point in the pedal stoke you breathe, except during climbing, when pedal forces are high, and there is a need to activate 'core muscles' (including respiratory muscles) to optimise the transmission of force. Evidence from studies on elite cyclists suggests that the most important aspect of breathing and pedal synchrony is keeping a steady rhythm for each, and maintaining a 1:3 ratio between them. So, if your cadence is 90 rpm, then your breathing rate should be no more than 30 breaths per minute.

The 1:3 ratio will optimise the efficiency and comfort of breathing, but will need to be 'worked at'; the reason that cyclists slip into a 1:2 ratio (45 breaths per minute at 90 rpm) is because their breathing muscles become fatigued and they can no longer maintain their tidal volume in the face of an increased need for breathing. This is particularly pertinent for triathletes, in whom inspiratory muscle fatigue is well documented after the cycle phase[4,5].

There is also evidence that cycling in the crouched position, especially with 'aerobars', can exacerbate inspiratory muscle fatigue. This is because of the restriction to movement of the diaphragm and rib cage imposed by these postures, which force the inspiratory muscles to work even harder (see article 2). This is where POWERbreathe® can help, because it gives the inspiratory muscles the ability to achieve and tolerate higher tidal volumes, in body positions that are restrictive, without fatigue.

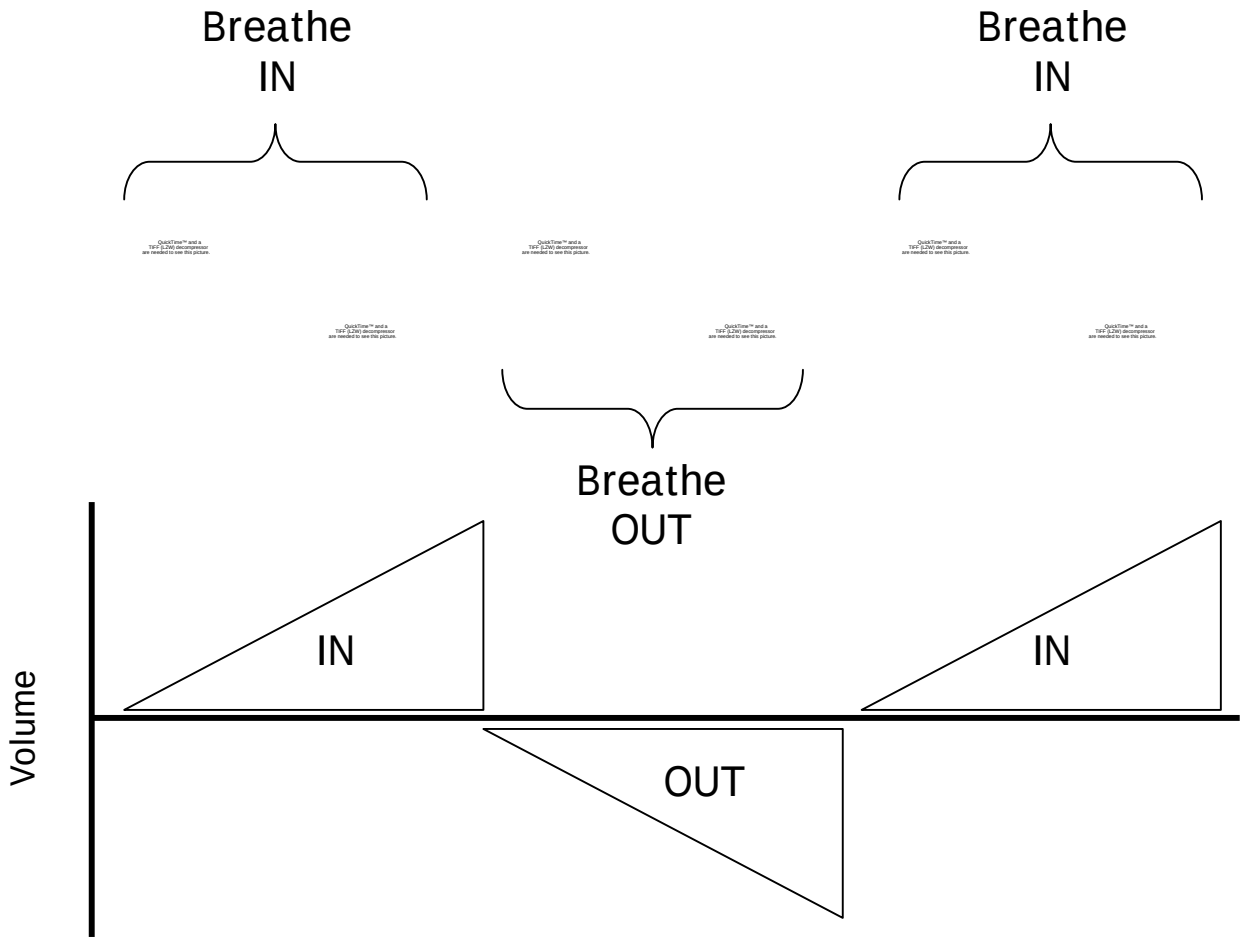
So, in order to adopt and maintain the 1:3 breathing to pedal revolution ratio, especially if you use a posture intended to minimise aerodynamic drag, you need to work hard on building breathing discipline (use your diaphragm and keep a steady rhythm), as well as building specific inspiratory muscle 'fitness'. In a later article in this series, we'll consider how to use POWERbreathe® in sport-specific ways that target particular challenges such as the crouched/aerodynamic body position.

The run phase: - The start of the run phase is a tough time for your breathing, as we learnt in articles 2 and 3; inspiratory muscle fatigue develops during the cycle phase,

making the transition to the run extremely challenging. This is a time when you need to focus especially hard on maintaining good breathing technique.

As with the other phases of the event, the key to efficient, comfortable breathing during running is to synchronise breathing and running cadence. In doing so, you optimise the mechanical factors that affect the function of the core stabilising and breathing muscles. On a steady run you should breathe on every other footfall for the same leg (see Figure 2). This means a ratio of strides to breathing of 2:1, remembering to focus on using your diaphragm. You'll know when you've got it right, because your breathing will instantly feel much stronger and easier. You may find it hard to believe, but simply being aware of your breathing and building a steady rhythm can make it feel so much easier.

Figure 2



What to do if…?

Cadence changes due to changes in terrain - The key to efficient comfortable breathing during both cycling and running is synchrony, so change your breathing frequency and inhaled volume to suit your exercise cadence. Try not to allow your breathing to dictate your running or cycling cadence. If your cadence slows (eg going up a hill), maintain the same breathing ratio, but take deeper breaths in order to meet the increased need to breathe. If your cadence quickens downhill, take fewer breaths by increasing that ratio of strides or pedal revolutions per breath.

Essentially, you should aim to keep your number of breaths per minute fairly constant, and to accommodate any changes in breathing requirements by changing tidal volume. These tactical changes are important, because without an awareness of the need to optimise and regulate the frequency of breathing and the size of each breath, running down a hill could lead to an increase your breathing frequency, which results in wasted effort. Alternatively, running up a hill could lead to a compulsion to increase your stride frequency to match your need to breathe, leading to a shortened stride length and a slower pace.

You get 'stitch', or other breathing muscle discomfort – No one has yet published a definitive scientific explanation for 'stitch'. My personal theory is that it is diaphragm discomfort due to an inability to maintain the demands that are being placed upon it. I came to this realisation many years ago, when I was trying to 'train' myself to breathe using my diaphragm when I ran.

For a period of about 3 weeks I experienced some of the worst, and most frequent 'stitch' pains I'd ever had. However, I persevered, and over that 3 weeks, the pains gradually reduced in frequency and severity, and now thanks to this training, and the continued use of POWERbreathe®, I never get 'stitch' pain. This has also been an anecdotal observation from working with athletes using POWERbreathe®; many of them comment without any prompting that they don't get 'stitch' anymore.

If you suffer a stitch during a race, you should do two things:

1) Make a mental note to get a POWERbreathe® at the next opportunity
2) Give your diaphragm a 'breather' by consciously shifting the work of breathing to your ribcage for a few minutes, or until the 'stitch' subsides. This tactic is a last resort, because your rib cage muscles will also fatigue if you rely on them too heavily.

As I described above, common telltale signs that you are relying too heavily on your rib cage and not using your diaphragm effectively include tense shoulders, discomfort that develops around the collar bones and lower neck, and discomfort radiating from the collar bone down the bicep. If you experience this, you need to consciously shift your breathing effort to your diaphragm

You experience an increase in breathing effort without a change in pace – This can be the first sign of inspiratory muscle fatigue, which is very bad news (see article 3). If this happens, you may need to sacrifice some pace for a while in order to allow your inspiratory muscles to recover.

The phenomenon of 'second wind' is another phenomenon that has yet to be explained scientifically, but I also have a theory for this one. We have shown in our experiments that fatiguing inspiratory muscles not only makes breathing and exercise feel harder, it also induces a reflex that causes restricted blood flow to the limbs (see article 3), which impairs performance. However, this response does dissipate if you allow the inspiratory muscles to rest. Just how much rest is required we don't yet know, but its possible that 'second wind' is a manifestation of the dissipation of the reflex, followed by a recovery of limb blood flow. If this is the case then the best tactic when you feel an increase in breathing effort, is to back off the pace for a while to allow your inspiratory muscle to recover. By doing this, you will be able to catch-up any lost time during the remainder of the race. If you don't then your pace will be driven down by the loss of blood flow to your limbs for the entire remainder of the race.

Summary

In this article we've been able to understand how to maximise breathing efficiency and make recommendations. These include:

1. Breathing with your largest respiratory muscle – the diaphragm
2. Minimising the energy required to breathe by maintaining a deep, slow breathing pattern
3. Synchronising your breathing to the cadence of your activity
4. Not allowing your breathing to dictate your activity cadence
5. Making tactical adjustments to your breathing strategies to accommodate changing conditions

In the next article in the series we'll be considering why POWERbreathe® inspiratory muscle training is the most time efficient [legal] boost to performance currently known to science.

References

1. Lomax ME, McConnell AK. Inspiratory muscle fatigue in swimmers after a single 200 m swim. *J Sports Sci*. 2003 Aug;21(8):659-64.
2. Volianitis S, McConnell AK, Koutedakis Y, McNaughton L, Backx K, Jones DA. Inspiratory muscle training improves rowing performance. *Med Sci Sports Exerc*. 2001;33(5):803-9.
3. Romer LM, McConnell AK, Jones DA. Inspiratory muscle fatigue in trained cyclists: effects of inspiratory muscle training. *Med Sci Sports Exerc*. 2002 May;34(5):785-92.
4. Hill NS, Jacoby C, Farber HW. Effect of an endurance triathlon on pulmonary function. *Med Sci Sports Exerc*. 1991;23(11):1260-4.
5. Sharpe GR, Hamer M, Caine MP, McConnell AK. Respiratory muscle fatigue during and following a sprint triathlon in humans. *J Physiol*. 1996:165P.
6. Garlando F, Kohl J, Koller EA, Pietsch P. Effect of coupling the breathing- and cycling rhythms on oxygen uptake during bicycle ergometry. *Eur J Appl Physiol Occup Physiol*. 1985;54(5):497-501.

Alison K. McConnell, BSc, MSc, PhD, FACSM, Professor of Applied Physiology, Centre for Sports Medicine & Human Performance, Brunel University