Zone training: why low-tech can work too!

Andrew Hamilton looks at training zones and shows that you don't need to go hi-tech to successfully target your desired training zone…

AT A GLANCE

This article:

- **Explains why training zones are important and how they're dependent on energy systems**
- **Looks at different ways of monitoring training intensity**
- **Shows how you can use two very simple low-tech methods to target your preferred training zone(s)**

Understanding the concept of training zones is vital for maximising your performance. For example, to improve your muscles' ability to burn carbohydrate very quickly, you need train in the 'lactate' zone – not in a different zone! And to know how to do this, you need to know where the zone boundaries lie and how to know which zone you're in… In short, if you don't understand training zones, knowing how hard to train and how to vary your training intensity becomes nothing more than guesswork.

Energy systems and training zones

Underpinning the concept of 'training zones' are the energy systems that power the body. Unlike a car, which has one engine and runs on one type of fuel, your muscles are fuelled by four distinct energy systems, enabling you to perform immediate, very high intensity work and also sustained lower intensity work. However, thanks to Nature's ingenuity, these energy systems are seamlessly integrated together, which is why it's not apparent that energy use changes as you work harder and harder.

These energy systems are as follows:

1. Stored adenosine triphosphate (ATP) – this is an immediate source of energy that lasts for just 3-4 seconds. Although all muscular contraction uses ATP, most of this is generated in situ by the other three energy processes described below;
2. Phospho-creatine (PC) system – helps bolster flagging ATP stores very rapidly by regenerating broken down ATP using donated phosphate from a reservoir of high-energy phosphate in the muscles known as creatine phosphate (this is the energy system enhanced by the food supplement creatine). The PC system provides about 10 seconds' worth of energy;
3. Lactate system (also known as the 'anaerobic' system) – takes a bit longer to kick in, but helps to regenerate ATP fairly rapidly by the incomplete breakdown of carbohydrate without oxygen. The lactate system runs out of steam not because carbohydrate is exhausted, but due changes in muscle biochemistry, which results in intense fatigue. Flat out, the lactate system can supply about a minute's worth of ATP;
4. Aerobic system – uses fat, carbohydrate and even protein to produce ATP. It's the slowest system to kick in, and can't generate ATP as rapidly, but providing there's enough oxygen available, the aerobic system can provide energy for several hours!

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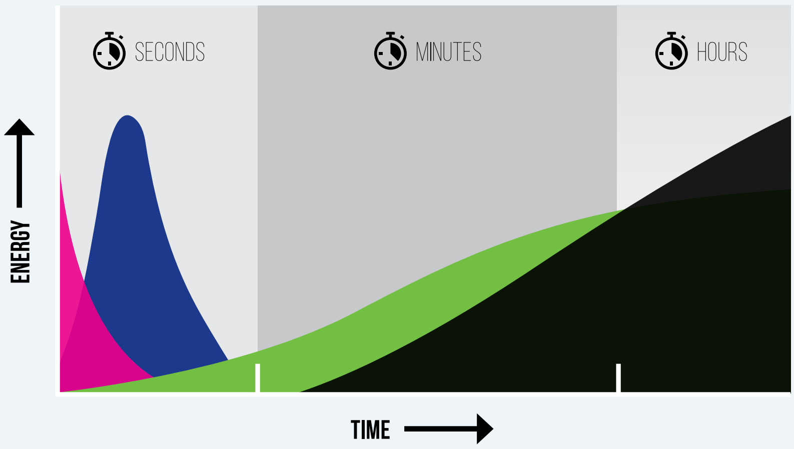
Because all energy expended in the muscles ultimately occurs via the breakdown of ATP (system #1 above), there are actually just three trainable energy systems: the PC system (#2), the lactate system (#3) and the aerobic system (#4).

A quick look at figure 1 (overleaf) shows the contribution these energy systems make to total energy demand during periods of maximum sustainable exercise. Notice how each system overlaps with the one it precedes. This is necessary for seamless integration of the systems – you wouldn't want to stutter and hesitate as your exercise intensity increased! So while there are discreet 'zones' corresponding to the different energy systems, the boundaries of these zones are rather 'fuzzy'.

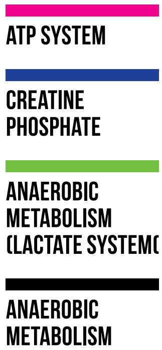
FIGURE 1: SCHEMATIC REPRESENTATION OF CONTRIBUTION OVER TIME OF THE BODY'S ENERGY SYSTEMS



Pink = ATP system; blue = CP system; green = lactate system; black = aerobic system

For example, if you're doing 20-30 second bursts of high-intensity cycling, you're using (and training) both the PC and lactate systems. Likewise, a hard 5-minute effort would use both the lactate and the aerobic systems. It's also important to realize that these zones aren't fixed; for example, by training your aerobic system, it can kick in earlier and supplement energy output at higher training intensities.

Hopefully you can see that because your muscles use distinct energy systems at different levels of intensity, your training needs to target these energy systems in a way that reflects the demands of the event you do. And if the kind of event you do places demands on more than one energy system (it nearly always does), you'll need to target each energy system with specific types of training.



Targeting the zone

In order to successfully target a particular training zone, you need to know two things:

- What zone am I in now?
- How will I know when I transition up or down into another zone?

Unfortunately, because of the overlap in energy systems, this isn't always easy. In particular, the lactate and aerobic energy systems have a large degree of overlap (see figure 1). If you're doing a 3-hour easy bike ride on the flat, there'll be very little contribution to energy from your lactate system. But ride flat out for 10 miles and your lactate system is making a substantial contribution. It's this large and 'fuzzy' area of overlap that often catches out athletes, who can easily and unwittingly end up in the wrong training zone (more later)!

The good news is that there are a number of ways to determine what zone you're in. Briefly, these are as follows:

- Your perceived effort level
- Your breathing (ventilation) rate
- Your heart rate
- Your power output
- Your level of blood lactate

Of these, you might assume that perceived effort and breathing rate are far too simplistic to use as a means of targeting a particular zone. However, this isn't necessarily the case. Besides, while heart rate, power and lactate measurements are very useful, they still have some significant limitations (see box 1). For athletes who enjoy using sophisticated technology, this may come as a surprise.

BOX 1: LIMITATIONS OF TECHNOLOGY

While devices such as heart rate monitors, power meters and lactate measuring can be very useful in helping you to monitor and target a certain training intensity, they still have limitations:

Heart rate monitor limitations

Formulae used to predict maximum heart rate may not be accurate for all individuals, leading to inaccuracies in zone determination;

As fitness levels improve, heart rates at the transitions between zones may increase a little too, especially the boundary between zones 1 and 2.

Heart rate during exercise can be affected by other factors – for example poor recovery after previous training sessions, or if you're fighting off a virus, both of which will your elevate heart rate for any given workload.

Power meter limitations

While power meters are available for cyclists and indoor (ergo) rowers, no such direct-measurement devices are yet available for runners and swimmers.

Although becoming cheaper, accurate power meters for cyclists are still expensive.

As fitness levels change, your sustainable power outputs for a given zone or blood lactate concentration will change considerably, which means that you'll need to recheck your power output/blood lactate concentration regularly, especially if you're a relative novice or are returning from a layoff, when quite large fitness changes can occur in a relatively short timescale.

Lactate meter limitations

Unless you're in the lab, you can't use lactate monitoring as a guide to intensity. For example, riding along while stabbing yourself in the finger to take a blood sample and then inserting a test strip into a machine and awaiting a reading is hardly practical!

Because of the above, the real value of using lactate measurements is in combination with other measurements such as power, speed and heart rate. Blood lactate should be seen as an adjunct rather than a prime means of targeting a zone.

Power of perception

Perceived level of effort is the easiest (and perhaps most underrated) way of knowing which zone you're in. It doesn't require any equipment or technology and can be used regardless of your fitness level. To give you an idea of what this means in practice, take a look at table 1 right, which relates sensation of effort, blood lactate and energy system used.

You can see how the subjective 'feel' during exercise closely relates to levels of blood lactate and typical heart rates, which in turn are associated with differing use of energy systems. In the zones above, zone 1 equates to almost pure use of the aerobic system, zone 2 to the aerobic system supplemented by the lactate system, while zone 3 is virtually all lactate system but supplemented by the PC system.

When gauging perceived effort, researchers have found that a numbering system can be useful; not only does it help users to more accurately report effort levels, the 'Borg' 1-20 scale also provides an approximation to heart rates (see table 2). Relating the Borg scale to the zone system above, we would have:

Zone 1
approximately
11-14

Zone 2
approximately
14-17

Zone 3
18 and above

The beauty of using perceived effort is that it's extremely simple and costs nothing. It has also been found to correlate closely with work rate and actual oxygen consumption[2]. Moreover, technophobes who enjoy training without being wired up like a NASA astronaut will also appreciate the freedom from technology it allows!

Of course, you might think that while good enough for amateurs, when it comes to elite or pro athletes, relying on perceived effort is no substitute for sophisticated technology. But you'd be wrong. A study on pro cyclists competing in 5, 7 and 21-day race found that using perceived exertion alone was every bit as accurate as using sophisticated heart rate monitoring for measuring both riding intensity and total workload over the races[3].

One possible downside however is that the subjective nature of perceived exertion means that it may not be quite so suitable for very inexperienced athletes who are less able to gauge where they are on the intensity scale and how it relates to their performance. The good news though is that research shows that inexperienced athletes who use it regularly very quickly learn how to get accurate perceptions of their work rate[4].

TABLE 1: PERCEIVED EFFORT AND ZONE TRAINING

ZONE	SOMETIMES KNOWN AS:	SUBJECTIVE FEEL:	TYPICAL BLOOD LACTATE	TYPICAL HEART RATE
1	'Aerobic', 'easy', 'recovery', 'long slow distance' etc	Easy – you feel like you can keep going and going	Less than 2mmol per litre (mM/L)	Under 80% and typically around 70-75% of maximum
2	'Threshold training', 'intensive endurance' etc	Moderately hard to hard (you know you've had a workout)	Between 2 and 4mmol per litre (mM/L)	Around 80-85% of maximum
3	'Very high intensity', 'race pace' etc	Very, very hard (you won't want to stay in this zone for long!)	More than 4mmol per litre (mM/L)	Significantly over 85% of maximum

Recent research suggests that for endurance athletes seeking maximum gains, zone 1 training should comprise the bulk (over 80%) of the training volume, while ensuring some time (10-15%) is set aside for zone 3 training. Zone 2 training meanwhile should not form a major part of your training volume[1].

Using ventilation rate

Another very useful method that can be used to target a particular zone is your ventilation (breathing) rate. Without delving too deeply into the biochemistry, it turns out that as exercise intensity increases, your ventilation rate follows a very similar pattern of change as that observed with blood lactate (see box 2 overleaf). In other words, your rate of breathing increases but not linearly, instead undergoing two distinct step changes – known as 'VT1' and 'VT2' (see figure 2, overleaf).

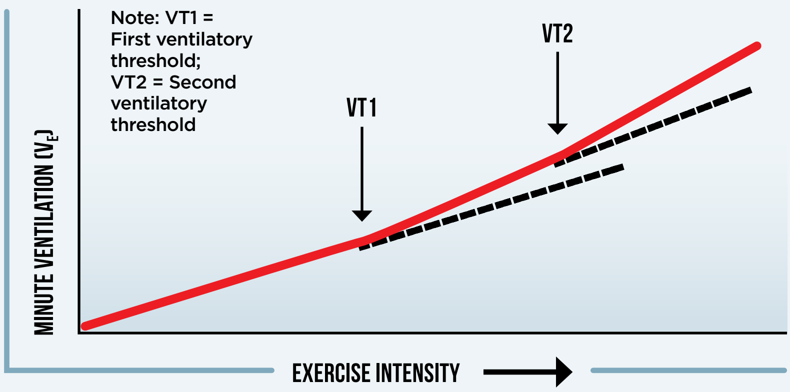
The relationship between lactate and ventilatory thresholds is remarkably close; figure 3 shows an overlay of typical ventilation rates and blood lactate levels during incremental exercise. Given that the first and second lactate thresholds can be used to determine the boundaries between zones 1&2

TABLE 2: BORG'S 'PERCEIVED RATE OF EXERTION'

SCALE NUMBER	PERCEIVED EFFORT LEVEL	APPROXIMATE HEART RATE
6	Rest	60-70
7-8	Very, very light	80
9-10	Very light	100
11-12	Fairly light	115
13-14	Somewhat hard	130
15-16	Hard	150
17-18	Very hard	160-170
19	Very, very hard	180
20	Total exhaustion	Maximum heart rate

Heart rates shown are approximate and will also depend on age.

FIGURE 2: STEP CHANGES IN BREATHING RATE DURING INCREASING EXERCISE INTENSITY



and 2&3 respectively, this close relationship means that you can also use breathing rate as a cheap, simple and non-invasive method of targeting your preferred zone.

Studies on trained cyclists show that using ventilation rate to monitor intensity and target training zones can be extremely accurate, especially when combined with perceived exertion[5]. And like perceived exertion, being mindful of your ventilation rate can be extremely useful even when using heart rate monitors and power meters, helping you to confirm and add context to any data you see on your monitor. Indeed, despite the explosion in technology that manufacturers tell us is absolutely essential for optimizing training, it's quite possible to undertake extremely effective targeted zone training using only your perceived exertion and ventilation rate!

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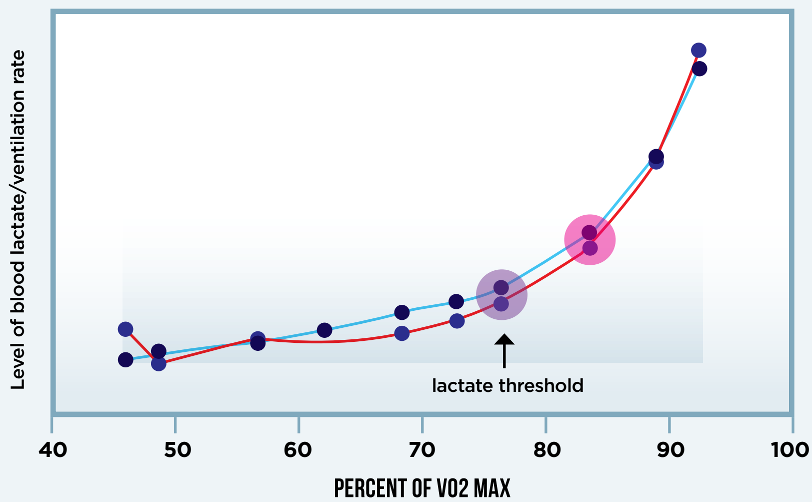
FIGURE 3: OVERLAY OF BLOOD LACTATE/VENTILATION RATE



Above: Red plot = lactate concentration; blue plot = ventilation rate. The 1st lactate threshold is reached in the purple area, as is VT1. The 2nd lactate threshold is reached in the pink area, as is VT2

BOX 2: UNDERSTANDING LACTATE AND TRAINING ZONES

Measuring lactate concentration in the blood provides a direct insight into what's actually happening biochemically in muscles, and by implication, exactly how intense the exercise is. During light exercise (zone 1), blood lactate remains at or near to resting levels (there's always some lactate production during energy metabolism) – ie under 2mM/L.

However, as exercise intensity increases, there comes a lactate concentration at which blood lactate levels rise sharply – usually around 2mM/L. This is commonly known as 'lactate threshold' – also sometimes referred to as 'first lactate turn point' and (perhaps incorrectly) as 'aerobic/anaerobic threshold'.

While you can exercise for several hours below lactate threshold without significant fatigue, move above it and fatigue will slowly begin to accumulate, even though lactate levels themselves aren't steadily rising. Using our zone system above, lactate threshold would mark the boundary between zones 1 and 2.

However, as exercise intensity increases further, there's another important blood lactate reference point, which occurs shortly after lactate threshold. This is the point where there is a 'sudden and sustained' increase in blood lactate concentration. There are a number of terms used to describe this second point including 'second lactate threshold', 'lactate turnpoint', the 'onset of blood lactate accumulation' (OBLA), 'functional threshold' and 'maximum lactate steady state' (MLSS).

In terms of actual blood lactate, this second threshold occurs around 4mM/L and is characterised by a large increase in breathing rate and sense of effort, and a rapid buildup of fatigue. At this point, lactate production begins to outstrip the body's ability to remove it.

Using our zone theory, this second threshold represents the border of zones 2 and 3. In terms of what it means, the intensity at this second lactate threshold point (or just below) is the maximum pace you will be able to sustain over a period of time – eg in a race or time trial (hence the term MLSS). Muscular fatigue will still accumulate but not so rapidly that you have to slow down or stop in the short term.

Combining perceived exertion and ventilation in practice

To use ventilation rate and perceived exertion to monitor your intensity, all you need to know is the following:

- Below VT1 equates to zone 1 training.
- Above VT1 but below VT2 equates to zone 2 training.
- Above VT2 equates to zone 3 training.
- Below VT1 you can speak comfortably, recite the alphabet etc.
- At VT1: you can no longer speak comfortably; it requires some effort at this point
- Above VT1/below VT2, speaking is possible but not really comfortable. For example, you can't recite the entire alphabet with ease at this point.
- At VT2 and above, speaking is no longer possible with the exception of one or two-word statements. You won't be able to maintain this intensity for long above this point!

You can combine this knowledge with perceived exertion, which yields the following guide:

Pure zone 1 training
- Effort level – easy; you feel like you can keep going and going
- Ventilation - you can speak comfortably, recite the alphabet etc

Transition from zone 1 to zone 2
- Effort level – sustainable but becoming a little harder
- Ventilation – speaking requires some effort at this point

Zone 2 training
- Effort level - Somewhat hard but still sustainable (for an hour or two)
- Ventilation - speaking is possible but not at all easy (you'd struggle to hold a conversation)

Transition from zone 2 to zone 3 (race pace)
- Effort level – exercise starts to feel much, much harder
- Ventilation – speaking is still possible but becomes difficult to utter more than a few words

Zone 3 training
- Effort level – very hard indeed; exhaustion soon sets in!
- Ventilation - speaking is virtually impossible apart from the odd word

References

1. Front Physiol. 2014 Feb 4;5:33 2. J Sports Sci. 2008 Jan 15;26(2):131-9 3. J Strength Cond Res. 2012 Aug;26(8):2249-57
4. Int J Sports Med. 2014 May;35(5):379-84 5. J Strength Cond Res. 2013 Jul;27(7):1942-9