HOW MUCH HUFF & PUFF?
TRAINING ENDURANCE

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COMPONENTS OF AEROBIC FITNESS

In simple physiological terms endurance fitness is the product of oxygen transport and oxygen utilisation. The importance of the cardiovascular system in delivering oxygenated blood to the active skeletal musculature (oxygen transport) and the capacity of those muscles to burn carbohydrate and fat in the presence of oxygen (oxygen utilisation) to sustain physical activity is well described. However this simple model can be further divided into several different physiological systems: the respiratory system which draws oxygen into the alveoli of the lungs, the cardiovascular system which takes freshly oxygenated blood from the lungs and delivers this to the various tissues and organs of the body, and the skeletal musculature that contains the machinery to convert substrates (energy sources) into useable energy.

Two other related physiological systems, often overlooked in the preparation of trained athletes, are worthy of consideration. Firstly the neuromuscular system which links the central nervous system, the peripheral network of nerves and the skeletal muscles, must be finely controlled to maintain the high level of skill necessary for competitive swimming. Secondly, there is a strong relationship between endurance training and the immune system of blood cells and soluble antibodies. Aerobic fitness and a well-balanced program of endurance training can boost immune function and decrease the risk of illness and infection. Paradoxically, prolonged exhaustive training coupled with inadequate recovery, can suppress immune function and consequently increase the risk of illness and infection. Hormones released during intense physical activity play a key regulatory in the body's cardiovascular, metabolic and immunological response to exercise. These physiological responses to acute exercise are converted into long-term adaptations that underpin an improved ability to swim at competitive speeds.

RATIONALE FOR ENDURANCE TRAINING

What are the reasons that can be put forward to support a major role for endurance training in the preparation of competitive swimmers? Firstly, it is evident that the energetic demands of middle-distance (200 and 400m) and distance events (800 and 1500m) events are endurance-oriented and swimmers in these events require well-developed endurance capacities to be successful. It follows that endurance training should form a substantial part of the overall training program for middle-distance and distance swimmers. However even the 100m events necessitate a substantial contribution from aerobic energy sources (Table 1). Recent research in several sports has indicated that maximal exercise over 60 seconds is approximately 50% aerobic and 50% anaerobic in make-up. On this basis, it is only the 50m-sprint event that is primarily anaerobic in nature.

Table 1
Energy contributions to different swimming events

Event	ATP-PC	Lactic Acid	Aerobic
50m	60%	35%	5%
100m	15%	35%	50%
200m	10%	30%	60%
1500m	2%	20%	78%

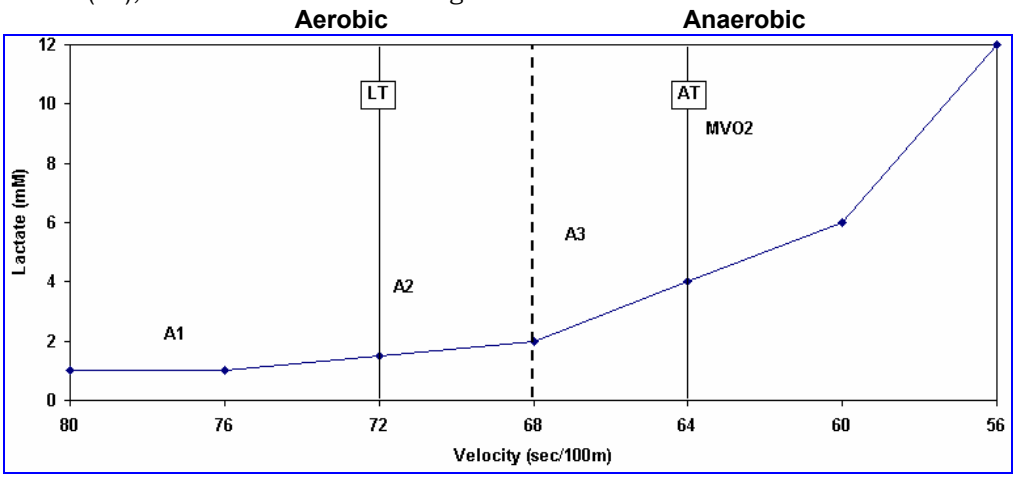
Apart from the direct need to maximise aerobic capacities, endurance fitness is needed indirectly to maximise anaerobic and speed adaptations. The skills and technique necessary to swim at competitive speeds must be learned and developed at slower speeds and gradually developed to race levels. Swimming is certainly more technique-limited than other **grunt** sports and skills must be continually practiced and refined. The concept of **feel for water** is intuitively understood by most coaches and this can only be developed in the pool. Finally exercising in an aquatic media protects the musculoskeletal system from the dangers of breakdown evident in sports like running, football and various court sports. Weight-supported swimming permits greater training volumes to be completed. Maintenance of desirable body composition can be achieved with aerobic work, and low to moderate-intensity training can be used for recovery from competition, quality training and/or illness/injury.

ENERGY SYSTEMS & TRAINING ZONES

There are three main systems that contribute energy to sporting performance: ATP-PC system for explosive movements, anaerobic glycolysis (lactic acid) for high intensity but short duration (minutes) exercise, and aerobic glycolysis of carbohydrates and fats that sustain exercise over longer periods. The main considerations for coaches are that all three systems operate simultaneously during exercise, with the relative contribution of each system determined by the volume and intensity of the exercise bout being undertaken. In practical terms, many

coaches and scientists have developed training zones based on the energy systems for use in prescribing training.

In terms of endurance training, a typical classification system as used at the Australian Institute of Sport is presented in Figure 1. This scheme divides the range of endurance training into two initial zones: aerobic and anaerobic. The transition between the aerobic and anaerobic zones is known as the anaerobic threshold (AT): knowledge of what swimming speed this point corresponds is used to prescribe training in this area. Computer-based programs can also pinpoint the aerobic or lactate threshold (LT), defined as the swimming speed beyond which blood lactate begins to accumulate. Below this speed (<72 seconds per 100m in this example), swimming is defined as low-intensity aerobic or aerobic-1 (Al). A2 or moderate intensity aerobic swimming (sometimes referred to aerobic maintenance) is defined as the speeds between LT and mid-way to AT (68-72 seconds per 100m). The A3 or aerobic development occurs between 64 and 68 seconds per 100m. Anaerobic threshold training would be based on intervals around 64 seconds per 100m, perhaps in the range of 66-62 seconds. These figures are a guide only and will vary between individual swimmers.



While many different training systems have been developed, coaches need to be aware of their inherent limitations [Counsilman, 1993 #266]. Two points are important here when evaluating the worthiness of a training system for swimming. Firstly, the system should be based on scientific principles. Secondly, the system must be practical and easy enough to use on the deck. There have been many very clever and intricate training systems devised, but their complexity has limited their usefulness and consequently they are rarely used in practice.

The current AIS training classification system is presented in Table 2.

Table 2. – Classification of training zones used at the Australian Institute of Sport

Zone	Symbol	Fuel	Intensity	HR (bpm)	La (mM)
Low-Intensity	A1	Fat	65-75%	-70 to –50	<2
Aerobic Maintenance	A2	Fat/CHO	75-80%	-40 to –50	<2
Aerobic Development	A3	Fat/CHO	80-85%	-30 to –40	2-3
Anaerobic Threshold	AT	Fat/CHO	85-92%	-20 to –30	3-6
Maximal Aerobic	MVO2	CHO	92-100%	-20 to max	5-10
Sprint	SP	ATP-PC	>100%	N/a	N/a

HIERARCHY OF TRAINING ADAPTATIONS

How long does it take to develop a reasonable level of endurance fitness? The length of time required largely depends on the initial fitness level, the desired level of fitness to be achieved and the nature of the training program undertaken. From a completely sedentary level, it would take months to years to develop a level of endurance fitness necessary to be a competitive athlete. For younger competitive swimmers, endurance fitness is usually developed over a period of weeks to months during a training season. With a well-developed training program comprising about 10 sessions per week with a balance of aerobic and anaerobic work, endurance fitness can be developed in several weeks.

At a senior level, Australian Swimming Inc. has adopted a 12-week training cycle between selection trials and major international competition. This seems to suit most senior swimmers who should be in reasonable shape

throughout the year. Some coaches of distance swimmers and 400m individual medley swimmers contend that longer cycles (up to 16-20 weeks) are necessary to fully develop endurance fitness. Finally, detraining over several weeks will cause training adaptations to gradually disappear - for this reason swimmers are encouraged to stay active throughout the year. One of the more elegant models summarising the hierarchy and timecourse of training adaptations is presented in Figure 1. Skills and techniques are developed and maintained for decades, strength is built and maintained over years, aerobic fitness over months and peak anaerobic power and speed only for a few weeks.

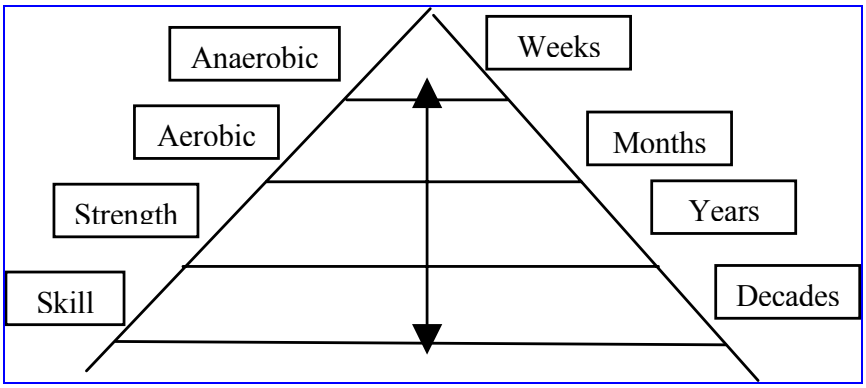


Figure 1

Hierarchy of training adaptations showing the time for both development and decline of different physiological and sporting attributes (from Counsilman, 1993).

TYPES OF AEROBIC TRAINING

Although the classification of aerobic intensities and training zones in different classifications system has some merit, there are several different types of aerobic training that used by coaches when prescribing endurance work. The most common types are:

Overdistance/Continuous

3000m Freestyle for time
5x1000m Freestyle on 13:00 holding 12:30 per 1000m
10x400m Freestyle on 5:20 holding 4:48 per 400m
20x200m Freestyle on 2:45 holding 2:30 per 200m

Comment: This work should form the basis of preparing distance swimmers and also for the endurance training of middle-distance and sprint swimmers.

This work, swum primarily in Freestyle or a mixture of Freestyle and Backstroke, provides both a metabolic and mechanical overload in terms of holding speed with good technique over extended distances. This work is rather unfashionable and many coaches and swimmers avoid this type of training altogether.

While it may be more appropriate to swim this work early in the season to build general fitness, overdistance training should be considered right up to the taper period.

Short Rest Sets

40x50m Freestyle on 40 seconds
16x100m Freestyle/Backstroke on 1:20 holding 1:15 per 100m
10x (50m Freestyle on 40 sec, 100m Breaststroke on 1:40, 50m Freestyle on 40 sec)
400 IM broken for 5 seconds at each 50m

Comment: Similar to overdistance work, short rest sets seem to have gone out of fashion in the last few years. After continuous or overdistance work, short rest sets are the next step in progression to faster race-pace interval training. The rest periods should be fairly short (approximately 5-15 seconds) as swimmers can train and hold cycle on work/rest ratios of 5-10:1 – e.g. 60 seconds of swimming, 5-10 seconds of resting recovery. This work should be introduced with Freestyle, but in a graded fashion, the different forms strokes can also be used. Depending on the intensity or speed swum, this work can range from low-intensity right through to maximal aerobic training.

Descending Sets

3 x 10x100m (Set 1: on 1:40, Set 2: on 1:50, Set 3: on 2:00)
2 x 4 x 100 (D1-4) + 100m recovery after each set of 4
3 x (200m Freestyle, 150m Backstroke, 100m Breaststroke, 50m Freestyle)

FS versus Form versus IM (i.e. Freestyle, form stroke, IM order, IM switching)

4 x (50 Butterfly, 100 Backstroke, 150 Breaststroke, 200 Freestyle)
3 x 3x150 (as 1.50 Butterfly, 50 Backstroke, 50 Breaststroke, 2.50 Backstroke, 50 Breaststroke, 50 Freestyle, 3.50 Butterfly, 50 Breaststroke, 50 Freestyle)

8 x 50 in reverse IM order on 60 seconds

Apart from varying the distance and intensity of different swimming intervals, all coaches but especially those preparing Individual Medley swimmers, need to incorporate a proportion of medley work into their programs. This work should focus on building sets using the order of strokes in IM swimming (i.e. Butterfly, Backstroke, Breaststroke, Freestyle).

Pull & Kick

16x100 Freestyle pull + paddles
8x50 Freestyle Kick D1-4 on 50
4x200 Freestyle Kick on 3:30

In simple terms pulling and kicking are used to vary the loading on the body. While pull and kick sets are traditionally oriented towards shorter faster race-pace intervals such as 8x50 kick descending 1-4 to maximal effort on 1:15, there is a place for longer more aerobic intervals … e.g. 4x200 or 4x300 kick. Again a combination of both shorter-faster and longer-slower intervals should be used. Overdistance pulling is a very effective means of training for both aerobic conditioning, breathing control and technique work such as timing in the stroke.

Simple versus Combination Sets

In the design of workouts it is possible to categorise them as either simple (a small number of sets involving fewer but longer repetitions) or combination sessions (a larger number of sets involving many combinations of sets, distances, strokes and intensities).

Obviously there is a place for both approaches: the art of coaching is to know when to create simple and effective workouts, and when to create subtle, clever and intricate combination workouts.

The answer lies in how the swimmers are responding to the program both in terms of their progress in standard training sets, competitive results and confidence. For endurance swimmers, there should be an emphasis on **simple** sets.

Simple	Combination
1600 Freestyle/Backstroke	800 as swim, kick, pull, swim
8x50 IMO D1-4	8x50 (alt. H-E, E-H)
4x800 on 11:00	16x50 choice drills on 60sec
3x200 kick on 3:30	3 x (200 Freestyle, 150 Backstroke, 100 Breaststroke, 50 Freestyle)
3x200 pull on 2:45	3 x 3 x 150m IM switches
300 swim down	6 x 25! On 60
	200 swim down

Final Considerations

Based on experience the following suggestions are offered to maximise the benefits obtained from endurance training.

1. **Emphasise swimming quality over effort.**
   While the need for swimmers to **tough out** very exhaustive workouts cannot be discounted, it is preferable for swimmers to reach the desired speeds with good technique.
2. **Avoid one-pace training.**
   One of the most common mistakes of novice swimmers is to train at the one pace. Swimmers should be encouraged to become proficient throughout the full range of swimming speeds (through the different training zones).
3. **Isolate where necessary.**
   As a swimmer advances and their training must become more complex, it is evident that more specific isolated training is required. In relation to endurance training, this means that all the different aerobic training zones should be targeted and developed.
4. **Maintain fitness yearlong.**
   Maintaining fitness throughout the year is a more effective approach in the long run. Considerable time can be lost by regaining lost fitness - time that should be spent on making progressions. The increasing number of competitions in the calendar have forced many swimmers to keep a base level of fitness.
5. **Don't forget strength.**
   Strength-endurance in swimming is an important consideration for endurance as well as sprint swimming. Some athletes cannot swim a high quality overdistance effort (e.g. 3000m for time) because their muscular endurance is low, rather than a limited aerobic capacity per se.
6. **Consider cross training.**
   This is particularly useful early in the season when general fitness is being developed. This may take the form of alternative aerobic activities such as walking, running, cycling, aerobics or aerobic-oriented circuit classes. At times other ball or skill-related sports such as basketball, tennis or touch football may be used. Most coaches do not use cross training in the weeks prior to major competition.
7. **Improvements in 10 days to 3 weeks.**
   While moving from an untrained to a trained state may take several weeks to months, it is possible to make significant gains in fitness in 10 days to 3 weeks with extensive endurance training. The AIS has demonstrated that 70-80km training weeks can improve submaximal indicators of fitness (heart rate and blood lactate responses) in this timeframe.
8. **Use endurance to support speed.**
   The high intensity - low volume approach works for some senior swimmers, but in

general too radical a training program *is* unlikely to produce consistent results over a longer period or lead to further improvements in performance.

9. **Avoid excessive quality.**
   What burns most swimmers is excessive quality. Even with just limited fitness and some patience it is possible to complete good mileage at low to moderate intensity. However experience has shown that excessive mileage coupled with excessive intensity is a risky approach.
10. **Use a periodised approach.**
    A periodised approach to training is very widely used. In essence this means dividing the training season or plan up into more manageable sections. This gives rise to terminology such as **endurance** and **quality** weeks, and **microcycles** and **macrocycles**.
11. **Train twice or three times a day.**
    The heritage of Australian distance swimming is built upon extensive endurance training involving at least two and sometimes three training sessions a day. Multiple training sessions allow the swimmers to perform at a higher level without excessive fatigue. They are also in contact with the water more frequently and this may be important for developing a **feel** for the water.
12. **Use overdistance sets.**
    It is apparent that one of the main reasons why standards have fallen in the middle-distance and distance events is that coaches and swimmers are no longer happy to undertake sets like 3,000m for time, 5x800m, or 20x200m. While this may have helped the sprint and form stroke swimmers, it has been detrimental to distance Freestyle.