

Recent trends in high-intensity aerobic training for field sports

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Introduction

Field sports such as football, team handball, hockey, rugby union and rugby league, Australian & Gaelic Rules football are characterised by a typically stop-start nature, with varying movement speeds, multiple changes of direction and the execution of decisions and individual skills under conditions of game pressure and/or fatigue. The nature of the movements in these sports requires the utilisation, and therefore training, of all three energy systems (ATP-PC, Glycolitic/Lactic acid and Aerobic systems). Despite the often stop-start nature of these sports, which heralds an increase in anaerobic energy contributions⁵, high-intensity aerobic power and conditioning can be critical for success in many field sports.^{5,6,7}

Due to the high-intensity and less predictable nature of movement of field sports compared to steady state "aerobic" long-distance sports (eg. triathlon, distance running, cycling, swimming etc), the aerobic and anaerobic conditioning for these sports should differ considerably to the aerobic requirements of "steady state" long-distance sports. To address this, there now appears to be a growing trend towards utilising recent research and training trends to fully develop the high-intensity aerobic power of the field sport athletes.⁹

Historical approach to aerobic conditioning training

Anecdotal evidence gathered by the author suggests that, historically conditioning coaches for field sports would look at the aerobic conditioning programmes of elite steady-state aerobic athletes and basically attempt to mimic these by implementing long, slow distance training (LSD) for 20-40 minutes or more, at intensities equivalent to zones 2 and 3 (and sometimes the more difficult "anaerobic threshold" (AT) or "critical speed" zones from zone 4) listed in *Table 1*. In practical training terms, the AT and critical speed are the highest speed that can be maintained in a single prolonged effort.⁴

The nature of field sports however, is that there are important explosive bursts that come at unpredictable times for unpredictable durations with critical decisions to be made "under the fog of fatigue or game pressure". Continuous aerobic training for 20-40 minutes or more is relatively ineffective for improving performance in field sports in experienced athletes, as this type of training does not take into account all the changes in speed, direction and work time at higher intensities that actually occur during field sports. Therefore, continuous aerobic training, even if it is performed at difficult "critical speed" based intensities, can be seen as less specific to the needs of experienced field sport athletes.^{5-7, 9-12}

Recent applied research in aerobic training

The most recent research shows that the amount of time spent at or above the 100% Maximal Aerobic Speed (MAS) appears to be the critical factor for improving aerobic power.^{2-8,10} It has been determined that performing a number of short intervals at $\geq 100\%$ MAS was a more effective method of building aerobic power than LSD training.¹⁰ This approach was also more effective than attempting to train only one interval continuously at 100% MAS.⁸

Specifically, an intensity of 120% MAS was determined to be the best single speed for short intervals that are followed by a short respite (passive rest) interval, based upon the fact that this intensity allowed the greatest supra-maximal training impulse (intensity x volume), in comparison to 90, 100, and 140% MAS.⁸ Especially, intervals of 120% MAS for 15-30 seconds



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Table 1. Aerobic training zones.

| Aerobic Training Zones | Zone 1. Aerobic Recovery | Zone 2. Aerobic threshold | Zone 3. Aerobic #2 | Zone 4. Anaerobic threshold | Zone 5. Maximal aerobic | Zone 6. Supra-maximal aerobic |
|------------------------|--------------------------|---------------------------|--------------------|-----------------------------|-------------------------|-------------------------------|
| MAS Zone | <70% MAS | 70-77% MAS | 78-85% MAS | 86-92% MAS | 93-100% MAS | >101% MAS |
| Heart rate Zone | <70% | 70-77% | 78-85% | 86-92% | 93-100% | 93-100% |

followed by an equal respite interval of passive rest and continuing on for 5-10 minutes. This is the basis of the Eurofit method that will be detailed below.

A Japanese researcher called Tabata¹⁰ also found that athletes working at $\geq 100\%$ MAS (actually 170% VO2 Max. but the % MAS was not reported) for 20 seconds followed by 10 seconds passive rest, and continuing on this manner for 4-minutes produced excellent changes in aerobic and anaerobic power, far better than performing LSD training sessions of 60-minutes at 70% MAS. This type of training is typically known as the Tabata method.

The basis of all this recent research is that high intensity intervals of typically 15-30 seconds, interspersed with 10-30 seconds of either low intensity active recovery (eg. $\leq 40-70\%$ MAS) or passive rest, continued in this manner for total set times of 4-10 minutes and repeated for 2 or more sets, greatly enhances aerobic power and capacity. This research emphasised that it didn't matter if the work/rest patterns were 20 seconds work, 10 seconds recovery or 15:15, instead the key fact was **that training at, or above, 100% MAS was the key intensity parameter, and how long you spent there was the driving volume parameter under-pinning improvements in aerobic power.**

Consequently, high-intensity interval training at 100% MAS (Maximal) or at 120%+ (Supramaximal) now appear to be increasingly used for training elite or lower-level field sport athletes. The practical implementation of three of these methods will be detailed below.

How to determine 100% MAS for the strength and conditioning coach?

Many coaches in intermittent sports work with large groups of athletes. To allow for organised and efficient training, the first step in implementing the following training methods is to do a MAS test to determine each athlete's capabilities.

There is some debate in the literature about how to exactly determine 100% MAS. For many strength and conditioning coaches working with elite athletes around the world, MAS is simply determined by calculating the speed attained during the last successful stage of the Montreal Track Running test.^{9,10} This will apply to a speed in km/hr, which is then used to prescribe the training intervals (the km/hr figure can be reduced to m/s for easier calculation of intervals). Typically, field sport athletes such as soccer and futsal players display MAS's of 4.4 to 4.8 m/s.⁹⁻¹¹

Alternatively MAS can be calculated by performing a time trial of between 5 and 6 minutes duration in any mode of training.¹ The time trial can be either as a set time (eg. 5-minute time trial) and monitor the distance covered in that time or conversely a set distance (eg. 1.5 km) and monitor the time to complete that set distance. There is little difference between the methods

of set time or set distance, except that when dealing with large groups with disparate fitness levels it may be easier to implement a set distance and monitor time to completion. However, if most of the running conditioning is to be shuttle based, then use a shuttle based test⁵ and conversely, if the running is mainly straight line based, use a straight line test (or around a track/field, such as the Montreal Track test), or a coach can decide to use both types of time trials. Obviously, a running test around a track will garner a higher MAS than a shuttle based test. If using rowing ergometers, a 5- or 6-minute or a 1500-m or 2000-m time trial is typically used.

Either way, you end up with a distance and time in seconds. Divide the distance by the time to complete that distance and the result is the 100% MAS for that individual for that particular mode of exercise. For example, if an athlete runs 1200 m in 300 seconds, then their 100% MAS equals 4 meters per second, expressed as 4.0 m/s or 14.4 km/hr. To determine other training percentages, such as 120% MAS, then simply multiply the 100% MAS by 120% (eg. 4.0m/s x 120% = 4.8 m/s).

Table 2 displays some theoretical results of testing with a group of 30 athletes who performed a 5-minute running time trial around a track. The reality of training large groups is that athletes of similar abilities can be grouped together. So the athletes are identified as being of six broad capabilities in this example, based upon their running times. In reality, there may be more groups ~ if you are dealing with 100+ athletes, there may be 8 or more bands of distinct running MAS capabilities. The results for this theoretical group of athletes will be used to illustrate the three methods below.

Practical implementation of high-intensity aerobic methods

#1. The Maximal Aerobic "grids" method (also termed the 100% MAS:70% MAS method).

Based upon French research, coaches have developed a system called (among other names) the Maximal Aerobic Grids method. This entailed training initially with short intervals of 15-30 seconds at 100-110% MAS interspersed with 15-30 seconds of active recovery at 50-70% MAS, continuing on for 5-10 or more minutes.

For running training, implementing this method basically entails devising rectangular concentric grids of various dimensions that equal 100% MAS along the long side of the rectangle and 70% MAS along the short side (see Figure 1). The fastest group are on the outside grid or running channel, with the slowest group along the inside grid. The coach can stand in the middle of the rectangle, but if two staff are available, one would monitor the finish point of each long side of the rectangle.

It can be seen from Figure 1 that theoretical Group 1 runs 72 m in 15-s along the long side of the rectangle

Table 2. Determining 100% MAS from a 5-minute running test with 30 athletes. Based upon the results, the athletes were assigned to 6 training groups. Other % MAS running speeds to be used in training (110%, 120%, 130%, 70% etc) are then easily calculated with a spreadsheet.

| Group | Distance completed during a 5-minute running test | 100% MAS = Mean distance / 300 s | 120% MAS = m/s |
|-----------------|---|----------------------------------|----------------|
| #1 (3 athletes) | 1400 – 1450 metres | 1425 / 300 = 4.8 m/s MAS | 5.8 m/s |
| #2 (4 athletes) | 1350-1399 metres | 1375 / 300 = 4.6 m/s MAS | 5.5 m/s |
| #3 (5 athletes) | 1300 – 1349 metres | 1325 /300 = 4.4 m/s MAS | 5.3 m/s |
| #4 (6 athletes) | 1250 – 1299 metres | 1275 / 300 = 4.2 m/s MAS | 5.0 m/s |
| #5 (6 athletes) | 1200 – 1249 metres | 1225 / 300 = 4.0 m/s MAS | 4.8 m/s |
| #6 (6 athletes) | 1100 – 1199 metres | 1150 / 300 = 3.8 m/s MAS | 4.5 m/s |

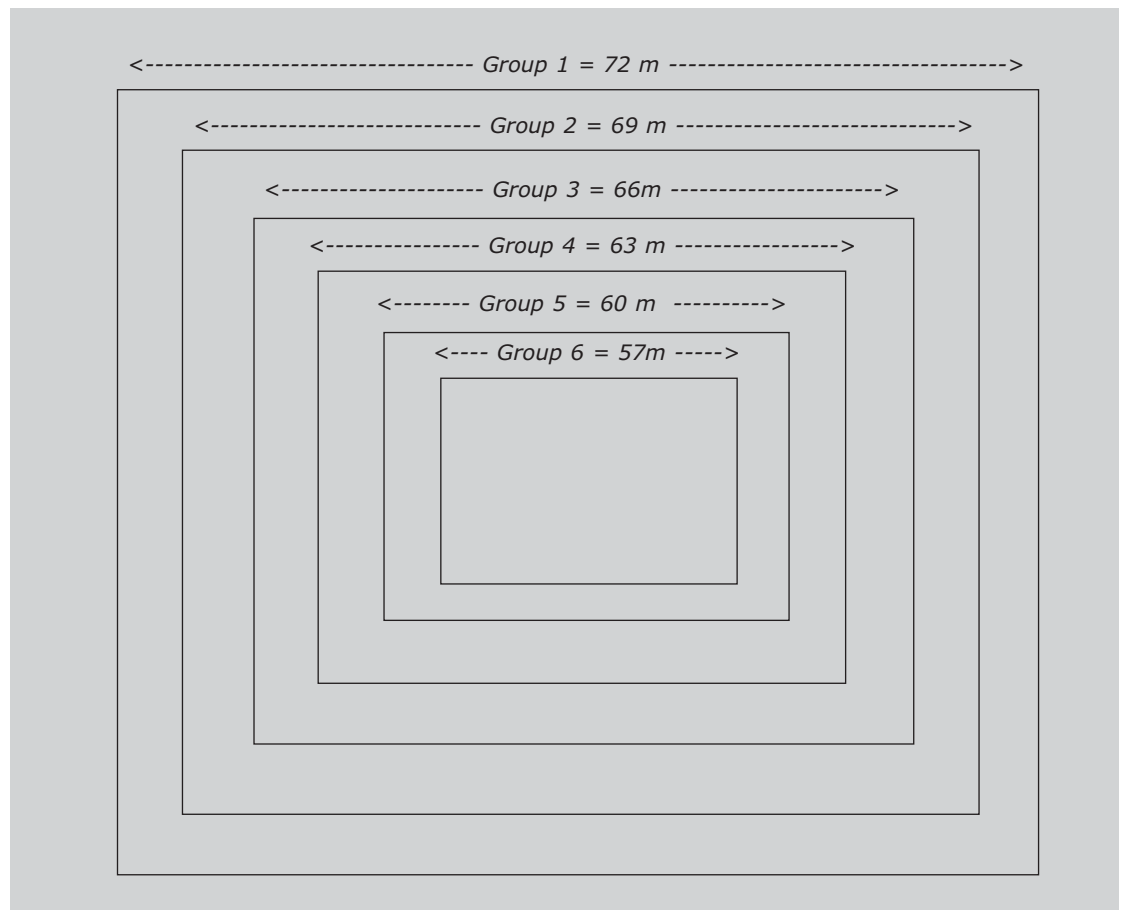
followed by 50 m along the short side and so forth. It takes 1 minute to complete one lap of the rectangular grid and this is completed without pause for 5-minutes and can be done for 2-4 sets with a 2-3 minute rest in between sets. The key point here is that each group has their grid based upon their own MAS capabilities ~ however, despite differences in MAS capabilities among such large group, each group should be at their respective corner of the rectangular grid each 15-s, which makes training compliance easy to monitor. The athletes are not allowed to speed up during the 70% sides to get a headstart on the harder sides – this just makes the grid an anaerobic threshold grid, something to avoid! This is enforced by making the athletes momentarily stop and hold the start position on the start of each long side of the grid.

When performing the running versions, it is more practical to build up to 6, then 8-minutes and repeating for 2-4 sets (or build up to 10 minutes and performing 1-2 sets) rather than increasing the length of each

100% repetition to 30 s or more. It is difficult to do the running grids for 30 s each side because you can physically run out of room to make a rectangle (eg. 30 s x 4.6 m/s means the long, 100% MAS side would have to be 138 m long, a distance which is hard to find on typical sports fields). If conditioning is performed on rowing machines or bikes, then the interval time lengths can be increased up to 30 s. Therefore 30 s at 100% MAS followed by 30 s at 70% MAS, continued for 5 minutes is appropriate for cycling and rowing ergometers.

Every 3-4 weeks it may be necessary to retest MAS or more simply to advance each group up to the next grid (which would be about 105% of their original or previous MAS). For example, the group that were running 60 m on their long 100% MAS side are sent up to the 63 m grid and so forth. This method is now used by most professional footballers in Australia (soccer, rugby union & league, and Australian Rules football) with excellent results.

Figure 1. Maximal Aerobic Grids method consisting of concentric rectangular grids, with the long side at 100% MAS and the short side at 70% MAS for each running group. Each side takes 15 seconds to complete, with the full rectangle taking 1-minute. The distances (Long, horizontal sides: Short vertical sides) are Group 1 = 72m:50m, Group 2 = 69m:48m, Group 3 = 66m:46m, Group 4 = 63m:44m, Group 5 = 60m:42m and Group 6 = 57m:40m. Groups can start at different corners to allow for better spacing and less congestion. Nonetheless all athletes hit a corner at the same time, every 15 seconds. A single conditioning coach can stand in the middle to ensure that the athletes make it to their corners at the same time or with multiple coaches, a coach can be stationed on each corner.



For rowing and cycling, difficulty can also be increased by lengthening the time of the 100% MAS repetition to 40, 45 and 60 s with also a concomitant reduction in the 70% MAS active recovery repetition from 30 s to 20 s, and finally 15 s. This twofold difficulty progression also sees a change in the work:recovery ratio from 1:1 (when 30s 100% MAS: 30 s 70% MAS) to up to 4:1 (60 s 100% MAS: 15 s 70% MAS). In this last instance the set length would be limited to 5-minutes, 4-minutes of which is spent at 100% of the aerobic capabilities.

#2. The supramaximal Eurofit method.

This method was developed by the French researchers and has been validated with professional soccer players, resulting in large increases in MAS during the pre-season¹¹ or mid-season⁷, as well as in school children.²⁻³ It is very simple to use. Again every athlete's 100% MAS is determined and then increased by either 20% (ie. 120% MAS) or 30% (130% MAS). The athletes are lined up along a line and then run to the marker cone that represents their 120% MAS distance in 15 seconds. They rest there for 15 seconds and then run back to the start line. This process is repeated for 5-minutes, building up to 8- or 10-minutes, with only 1-2 sets being performed. Intensity can be increased up to 130% MAS after 3-4 weeks.

Figure 2. The Supra-maximal aerobic Eurofit method implemented for the 15 athletes assigned into six groups from Table 2. Each group runs to their respective marker cones in 15 s, rests for 15 s, runs back to the line in 15 s, rests 15 s and repeats till the end of the set, typically 6-10 minutes.

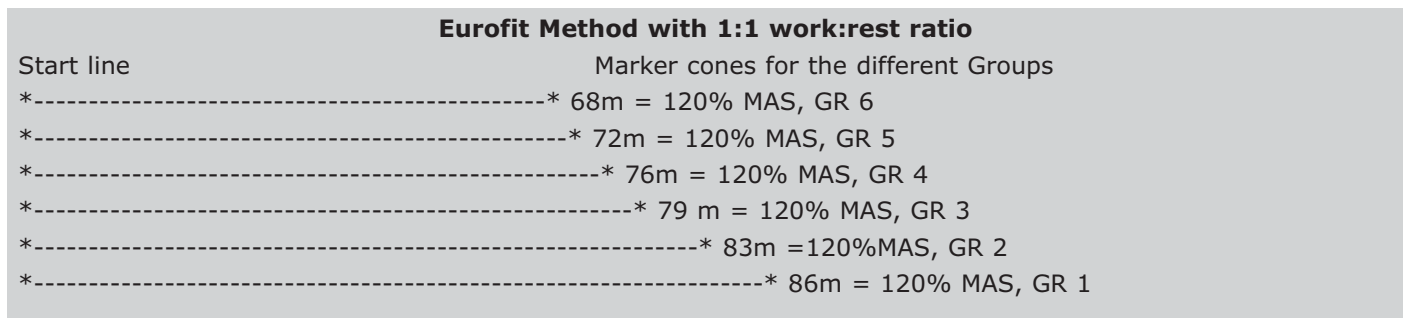


Figure 3. Modified Tabata protocol with the six groups of athletes from Table 2. The athletes must run twice out and back to their respective marker cones in each repetition (20 seconds), rest 10-seconds and then repeat till four or more minutes have elapsed. This method also increases the anaerobic energy.

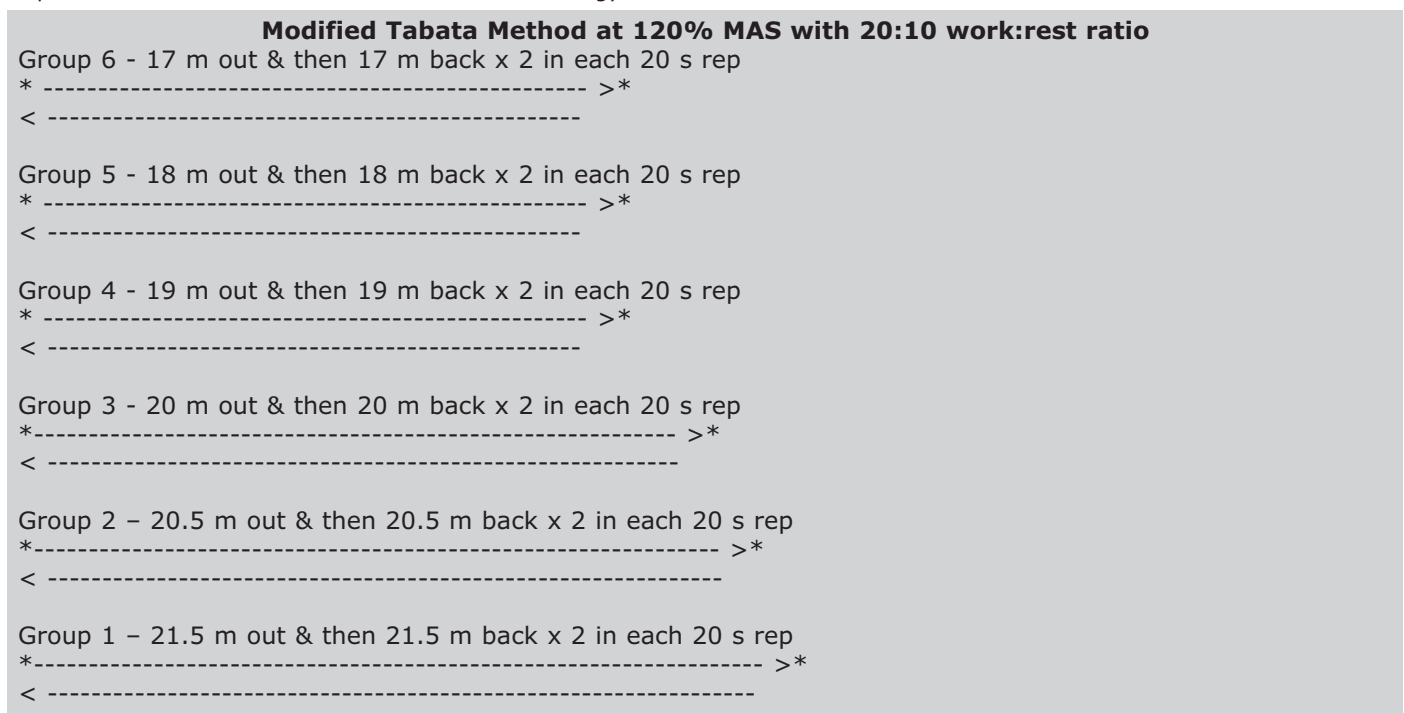


Figure 2 provides a depiction of the simple set-up. Again, this is easily coached ~ all athletes must get to their cone on the 15 second mark, wait 15 seconds and on the return, they all hit the start line at the same time, despite different distances being covered.

#3. Implementing the Tabata method

The original Tabata method is quite exhausting (at 170% VO₂ max) and is typically only performed for one 4-minute set. As athletes typically must compete for longer time durations or multiple rounds (eg. in mixed martial arts fighting there are three or five, 5-minute rounds), the Tabata protocol has been modified by coaches to be performed at a "lower" intensity of 120-140% MAS. This allows the set duration to be increased up to 5-, 6- or even 8-minutes and be performed for 2-5 sets, allowing for more time to be spent at or above the critical 100% MAS intensity.

Figure 3 details how this modified Tabata method can be implemented in a smaller area, such as an indoor sports area like a basketball court. In this example, the Tabata method is performed as 20 seconds at 120% MAS, carried out as 5 seconds out, 5 seconds to return, performed twice (eg. 17 metres out and 17 metres back x 2), rest 10 seconds and repeat until 5 or more minutes are completed. The turns that occur in the run makes this speed quite difficult to maintain and

Figure 4. Modified Tabata protocol with variable interval lengths using ONLY GROUP 4 from Table 2 to illustrate. Group 4's 120% MAS equals 5m/s. Any interval length can be used, but a 2:1 ratio should be maintained. The athletes do not know which cone to run to until after each repetition has started. Set lengths are typically 4-6 minutes.

Modified Tabata Method #2 at 120% MAS with variable interval lengths

20 m out & back 20 m in 8 s *30 m out & back in 12 s* 40 m out & back in 16 s

*----->----->----->
 <-----<-----<-----<

more sport specific for sports such as soccer. Turns also increase the anaerobic energy contribution.⁵

There may appear to be little difference between the Eurofit and Tabata methods, but the critical difference is the Eurofit is based upon a 1:1 (15s:15s) work ratio, whereas the Tabata method utilises a 2:1 ratio (20s:10s). This apparently minor differential has a pronounced effect upon the accumulation of fatigue when multiple repetitions or sets are performed.

Another variation of the Tabata method is to maintain the 2:1 work/rest ratio and ≥ 120 MAS but alter the length of the intervals to 8:4, 12:6, 16:8 etc. One of the limitations of all the above conditioning methods is that there are predictable work periods. Athletes quickly adapt to some sort of pacing strategy or know when they are about to start their next effort. With this second Tabata method the coach can set different coloured cones for each time/distance interval for each group. Upon the "Go" command, the athletes start their effort but not till about 2 seconds later are they given the command which will designate which cone they run to and return from. They do not know until that point will they be running to the cone designating 6s out and back, 8s out and back, 16s out and back and so on (see Figure 4). This strategy disrupts running rhythm and recovery strategies, entails reaction to situational commands and causes repeat high-intensity efforts to occur at less predictable times more than any of the other above high-intensity methods.

Periodisation and progression of training

The three training methods above have an inbuilt intensity progression as athletes work from 100% MAS in the Grids method to 120 and 130% MAS in the EuroFit and Japanese Tabata methods. The other variable for difficulty progression is the choice between the active recovery (at 60-70% MAS in the Grids method) versus the passive rest inherent in the EuroFit and Tabata methods. Furthermore the Tabata method's work:rest ratio of 2:1 may prove even more difficult as compared to the 1:1 EuroFit method. The second Tabata method with variable interval lengths may prove more even difficult for athletes but this may be due to reasons other than just physiological reasons.

Introducing turns in the Tabata, or any method, will also cause an increase in difficulty as this increases the anaerobic contribution.⁵

Training can be progressed via the systematic use of all of these different methods, starting with the 100%:70% grids method, moving to the EuroFit 120% MAS method and finishing with the Japanese Tabata methods within a training cycle. Each method can be implemented for 2-3 weeks before progressing to the next method. Within each 2-3 week mini-cycle, the typical volume progressions would also occur (5-minute sets building up to 8- or even 10-minute sets and/or 2 sets building up to 3 or 4 sets). Consequently, when a progression to the new method occurs after 3-weeks, there is a marked decrease in volume, but an increase

in intensity ~ this week serves as a "volume un-load" week. Therefore, as intensity initially increases with the introduction of the new method, volume is lowest, but builds up over 3-weeks before implementing the next intensity progression, again with a lower volume.

Once an athlete has attained some training experience with these methods, weekly undulating periodisation is also possible with one aerobic training day emphasising increasing the time spent at 100% MAS (and possibly also the time of each repetition spent at 100% MAS) via the grids method and the other training day spent emphasising the time spent well above 100% MAS (ie. The Supra-maximal aerobic Eurofit or Tabata methods). This methodology is based around the Supramax methods **DEVELOPING** new aerobic power and the Maximal method, conditioning the body to **SUSTAIN** the current 100% MAS for longer periods (or to be able repeat it more often). This within-week alternation of methods allows the athlete to toggle between milder active recovery (eg. 15 s @ 70% MAS) and passive recovery (15 s rest). An example of this is depicted in Table 3, which outlines the rowing ergometer training performed twice per week by female surfboat rowers.

Integrating high-intensity aerobic training with sports training and small-sided games

The limitation of the above methods is that there is still some 'predictability' about them. Intermittent sports often require intense efforts at unpredictable times and hence some researchers and coaches have advocated small sided games as a better alternative to traditional conditioning due to the "unpredictability" of games and the fact that games also develop sports skills and game sense. However the overload delivered by games is also unpredictable.

Practical experience has shown that the alternating of 5-8 minute sets of the above conditioning drills with 3-8 mins of small-sided games is an effective conditioning and sports skill development tool in intermittent field based sports. Typically, skills are coached in relatively low stress situations (low heart rate, minimal fatigue, less than full speed or full-force opposition), which is fine for the initial skill development and tactical learning situations. However, does this type of training enhance the skill or tactical sports performance of advanced athletes? The authors' experience is that the fatigue resulting from the performance of the above conditioning drills allows the head skill/sports coach to see fatigue related breakdowns in 1) individual skill technique, 2) decision-making or 3) inability to match the game speed, resulting in the effective dismantling of the teams' defensive or offensive structure/patterns/formation during the ensuing skill- and small-sided games. Typically, these three types of "breakdown" occur in the most fatiguing parts of real competition games but are not so well illuminated to the athlete or coach during "normal" skill or tactical training sessions which are practised in less stressful situations. Thus, the head skill/sports coach can develop and

Table 3. The high-intensity aerobic training program performed on rowing ergometers 2d/wk by female surfboat rowers.

| Type of Training | Week 7 – Unload | Week 8 – Basic | Week 9 – Shock |
|---|---|---|---|
| Day 1 – Supra-max aerobic @ 120% MAS Objective: DEVELOP high-intensity aerobic power | 15:15 x 8 reps x 2 sets Notes: = 2 x 4-minute sets 120% MAS=85m in 15s, followed by 15 s REST 2-min rest between sets | 15:15 x 12 reps x 2 sets Notes: = 2 x 6-minute sets 120% MAS=85m in 15s followed by 15 s REST 3-min rest between sets | 15:15 x 16 reps x 2 sets Notes: = 2 x 8-minute sets 120% MAS=85m in 15s followed by 15 s REST 4-min rest between sets |
| Session Summary: | Time spent at 120% MAS = 240 s Session length = 10-mins | Time spent at 120% MAS = 360 s Session length = 15-mins | Time spent at 120% MAS = 480 s Session length = 20-mins |
| Day 2 – Maximal aerobic @ 100% MAS Objective: SUSTAIN high-intensity aerobic power despite fatigue | 30:30 x 4 reps x 3 sets Notes: = 3 x 4-minute sets 100% MAS=145m in 30s 70% MAS = 100m in 30s 2-min rest between sets | 30:30 x 6 reps x 3 sets Notes: = 3 x 6-minute sets 100% MAS=145m in 30s 70% MAS = 100m in 30s 3-min rest between sets | 30:30 x 8 reps x 3 sets Notes: = 3 x 8-minute sets 100% MAS=145m in 30s 70% MAS = 100m in 30s 3-min rest between sets |
| Session Summary: | Time spent at 100% MAS (Race pace) = 360 s Session length = 16-mins | Time spent at 100% MAS (Race pace) = 540 s Session length = 24-mins | Time spent at 100% MAS (Race pace) = 720 s Session length = 30-mins |
| Weekly Summary | Time spent at or above 100% MAS = 600s | Time spent at or above 100% MAS = 990s | Time spent at or above 100% MAS = 1350s |

implement intense small-sided games that challenge or illustrate which of these types of breakdowns occur (and to which athletes) for different critical sports situations. It has been the author's experience that, for example, an 8-minute supra-maximal 120% MAS EuroFit set, immediately followed by a 3 to 6-minute small sided game, backed up by a 3-minute semi-passive recovery (stationary passing and catching of balls) and followed by a 5 to 8-minute 100%:70% grid set and another small-sided game has been quite challenging, not only to an athletes aerobic and anaerobic conditioning, but also to the athletes' ability to maintain individual skill levels, decision making and team structure during the second small sided game. Accordingly, high-intensity aerobic conditioning can be seen as part of an integrated and coherent sports performance enhancement programme.

Conclusions

Experienced athletes gain little in terms of enhancing their aerobic power from LSD training at 70-80% MAS. Training at, or above, their 100% MAS has been shown to be more effective. Three methods have been presented. Two use supra-maximal intensities ($\geq 120\%$ MAS) interspersed with 10-15 seconds of passive respite. The third method uses maximal 100% intensity for 15-30 seconds, interspersed with either equal time periods of active lower intensity of 60-70% MAS or a 2:1 or 3:1 work:lower-intensity recovery period (eg. 30 s: at 100% MAS: 15 s at 50% MAS). The two supra-maximal methods are believed to be best for developing new levels of high-intensity aerobic power. The maximal method outlined is thought to best condition athletes to be able to sustain high-intensity aerobic power for longer periods or to be able to repeat their high-intensity efforts, such as is the case with many intermittent sports. Despite total training duration being quite short ~ (eg. 1-3 sets of 4-10-minutes duration) ~ this training is quite effective in improving aerobic power, not only for intermittent field sport athletes, but also for athletes competing in events of 4-10 minutes duration (e.g. kayaking, rowing, MMA, wrestling). Integration of this type of training with challenging small-sided games is also highly recommended for field or court sport team athletes (soccer, hockey, basketball, rugby league, rugby union etc) to complement their skill and tactical development under stressful situations akin to the real competitive environment.

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