The Benefits of Polarized Training

Polarized training (POL) is the combination of three other types of training: prolonged high-volume low-intensity exercise (HVT), training at or near the lactate threshold (THR) and a low-volume, high-intensity interval training (HIIT). [1] Distribution of amount of time dedicated to each type of training is usually around 75% of HVT, 5-10% of THR and 15-20% of HIIT [2] or even eliminating threshold training all together ending up with 80% of high-volume, low intensity and 20% of low-volume, high intensity training. This model is used mostly by endurance athletes like cyclists, runners, rowers, triathletes or cross-country skiers to improve overall performance.[1] Still, there is an on-going debate on what distribution of training intensity will maximize overall results. Two of above mentioned approaches seem to have most relevance: threshold training (THR) and polarized training (POL).[3] Studies on THR have shown that training at lactate threshold (point at which high increase of lactate level in blood is observed during increase of work load) can produce significant improvements in untrained people. However, there is no proof that training at intensity close to lactate threshold can improve performance of well-trained individuals. [4] Polarized training on the other hand, includes very small amount of THR while focusing on HVT (training clearly below first ventilator threshold) with addition of HIIT (training above second ventilatory threshold) what seems to be giving optimal result for performance improvement in professional athletes. [3]

In order to investigate benefits of polarized training main parameters that are used to investigate level of performance have to be mentioned. They are: peak oxygen uptake (VO$_2$ (peak)), velocity/power output at the lactate threshold (V/P$_{LT}$), work economy, peak running velocity or power output (V/P$_{peak}$) and time to exhaustion (TTE). [1] They are measured in laboratory conditions usually on treadmill or cycle ergometer and comparison of the values before and after including a specific training style can determine whether performance has in fact increased. Multiple studies [1,6] show that polarization of training gives great results in endurance athletes and some improvement can also be observed in recreational athletes. [7]

Level of intensity at which training is performed can be usually determined by means of first (aerobic) and second (anaerobic) ventilatory thresholds. It can be assessed either by measurement of blood lactate (invasive method) or by measurement of ventilation and gas exchange (non-invasive). Training below first LT can be characterized by lower amount of oxygen expired and therefore increase of $O_2$ consumption and $CO_2$ output. In this phase blood lactate remains low. Training between first and second ventilatory thresholds (phase II) increases production of lactate over metabolizing capacity of muscles. Lactate concentration in blood increases and simultaneous increase of $H^+$ ions is buffered by $HCO_3^-$ promoting production of $CO_2$. Consumption of $O_2$ increases linearly with workload. At this point steady state exercise will create equilibrium of blood lactate. Highest workload performed for 30 min in this phase without the significant increase of blood lactate is called maximal lactate steady state and determines second ventilator threshold. Training above this threshold (phase III) causes much higher rate production of lactate compared to rate of its elimination.
There is a further rise of H⁺ ions as well as CO₂ in expired air. All those changes are schematically presented in the figure [Figure 1] below. [8]

![Figure 1 Model of exercise intensity: relation between blood lactate concentration (BL) and exercise intensity. HR, heart rate; VO₂, oxygen consumption; Borg scale: subjective rating of perceived exertion. [8]](image)

The main idea is that low intensity training that will include running, rowing or cycling, improves endurance without bringing much damage to the body. It makes sense than that it will contribute to most part of overall training program. Low-intensity means training below first ventilatory threshold for a prolonged time. In HVT most aerobic energy system is activated and it involves mostly slow twitch muscle fibres recruitment. Training at low intensities can contribute to high skeletal muscle energy, ability to sustain high muscle power for prolonged time as well as faster recovery after high intensity exercise. What is more high volume of exercise results in rise in intramuscular calcium that activates mitochondrial calcium-calmodulin kinases [9] stimulating muscle glucose uptake, increasing oxidative capacity, mitochondrial biogenesis, and expression of fibre myofibrillar proteins [10]. This is achieved by activating a protein called peroxisome proliferator-activated receptor-γ coactivator-1α (PGC-1α). It has to be noticed that improvements coming from low intensity high volume training can usually be visible after longer period of time. Study performed on a group of endurance runners showed greater improvement in both 4km and 10km run when training below first ventilatory threshold than when training at lactate threshold for a 6 month period [11]. It shows that although HVT is performed at much lower intensity than during exercise competition it allows adaptations and maintaining proper body composition that both improve higher intensity performance. [9]

High intensity training at levels above second ventilatory threshold is performed for a short time as it activate mostly fast twitch muscles that can be characterized by a low fatigue resistance. HIIT activates primarily anaerobic energy system at first, with more of aerobic contribution over time. [9] HIIT training should usually be constructed
as 1-5 minutes of warm up, followed by 10 intervals of 1 minute of high intensity (90% of maximal effort) and 1 minute of recovery (10% of maximal effort) followed by a low intensity cool down of 2-5 minutes, what gives around 30min of training in total. [12] However length of intervals is often altered to 40s of high intensity, 20s of rest or even 20s of work and 10s of rest. Studies have shown that adding a high intensity to already high volume exercise plan of well-trained athletes in very effective. For example, adding 6 to 8 sessions of HIT performed at 80-150% VO2max power output for 4 weeks to exercise plan of group of cyclists has visibly improved their performance (peak power output, fatigue resistance at 150% of peak power output and 40km time trial). [13] Physiological explanation behind this phenomenon is improvement in ventilator and lactate thresholds and increase in volume of muscle mass. [9] High intensity exercise leads to changes of energy status in muscles what raises levels of adenosine monophosphate (AMP), which activates AMP-activated kinase (AMPK) in skeletal muscle that is responsible for glucose uptake and oxidation of fatty acids. Interestingly, study of AMPK deprive mice lowers their running performance, suggesting that AMPK is also responsible for sports endurance. [14] This is possible because AMPK activates (as CaMK mentioned in case of high-volume training) protein - peroxisome proliferator-activated receptor-γ coactivator-1α (PGC-1α). In general it was proven that high intensity low volume training can improve intense exercise performance while maintaining the level endurance performance. [9]

It was mentioned that both types of training (HVT and HIT) are means for stimulating peroxisome proliferator-activated receptor-γ coactivator-1α (PGC-1α) protein that is important factor influencing exercise performance. This phenomenon is illustrated on the figure [Figure 2] below.

![Figure 2. Activation of PGC-1α during HIT and HVT](image)

That being said, many studies point out that restraining to one type of those training styles is not optimal. Too much focus on high-intensity training that produces high stress on the organism may lead to overtraining and injuries. Periods of low
intensity high volume training promote recovery while improving endurance. Keeping in mind that high-intensity training in crucial for maintaining proper body composition as well as improving ventilator thresholds. All those factors allow to conclude that polarized training can in fact have extremely beneficial result on endurance of athletes.

Sources: