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Polarized and pyramidal training intensity distributions in distance running: an integrative literature review

Polarizált és piramis alakú edzésintenzitás-eloszlás a távfutásban: integráló szakirodalmi áttekintés

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Abstract: This study aims to investigate the differences and similarities between the polarized and pyramid-intensity training methods described in the literature as the most typical training methods for elite international distance runners (1500- 10,000 m). Material and Methods: 26 literature articles analyzing the training intensity distribution of international distance runners were found after a review of internet databases. Results: In both training methods, elite track runners cover an average of 120-180 km per week, 75-80% of which is done at low intensity, below the aerobic threshold (vLT1). In the pyramid method, runners perform interval or continuous tempo running workouts at speeds below the anaerobic threshold (vLT2) on average 2-4 times per week. In contrast, in the polarized intensity distribution, interval training is performed on average 1 time per week above the anaerobic threshold at 90% of vVo2max. Intensities near race speed are performed as short intervals (< 800m) during the base period. Conclusions: The training of modern distance runners is characterized by an emphasis on the development of aerobic capacity, achieved primarily through high amounts of low-intensity work and 1-4 anaerobic threshold training sessions per week. Athletes use short intervals and short sprints to maintain their anaerobic abilities and their coordination at race speed. They start using longer, intensive race-specific work in the period leading up to races. During the racing season, runners maintain endurance with a significant amount of low-intensity running and less pronounced anaerobic threshold training.
Keywords: polarized training, pyramid training, intensity distribution, distance running

Absztrakt: A tanulmány célja, hogy megvizsgálja a különbségeket és hasonlóságokat a szakirodalomban a nemzetközi elit távfutók (1500-10.000 m) legjellemzőbb edzésmódszereként leírt polarizált és piramis-intenzitású edzésmódszerek között. Anyag és módszerek: Az internetes adatbázisok áttekintése után 26 szakirodalmi cikket találtunk, amelyek a nemzetközi távfutók edzésintenzitás-eloszlását elemzik. Eredmények: Mindkét edzésmódszerben az elit távfutók átlagosan heti 120-180 km-t tesznek meg, amelynek 75-80%-át alacsony intenzitással, az aerob küszöbérték (vLT1) alatt teljesítik. A piramis módszerben a futók átlagosan heti 2-4 alkalommal végeznek intervallumos vagy folyamatos tempó futás edzéseket az anaerob küszöb alatti sebességgel (vLT2). Ezzel szemben a polarizált intenzitás eloszlásban átlagosan heti 1 alkalommal végeznek intervallokat az anaerob küszöb felett a futók a vVo2max 90%-ánál. Mindkét edzésmódszerben versenytempóhoz közeli sebességet rövid intervallumok (< 800 m) formájában végeznek edzéseket az alapozó időszakban. Következtetések: A modern távfutók edzését az aerob kapacitás hangsúlyos fejlesztése jellemzi, amelyet elsősorban nagy mennyiségű, alacsony intenzitású munkával és heti 1-4 anaerob küszöb edzéssel érnek el. A sportolók rövid intervallumokat és rövid sprinteket alkalmaznak az anaerob képességek és a versenysebességhez kapcsolatos koordináció szintentartása érdekében. A versenyeket megelőző formábahozó időszak-

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ban kezdik el a hosszabb, intenzív versenyspecifikus intervall edzések alkalmazását. A versenyszezonban a futók az állóképességet jelentős mennyiségű alacsony intenzitású futással és kevésbé hangsúlyos anaerob küszöb edzéssel tartják fent.
Kulcsszavak polarizált edzés, piramis edzés, intenzitás eloszlás, távfutás

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Introduction

Over the past decades, there have been numerous publications in the international literature on the physiological, anthropometric, and morphological factors that are essential for successful performance in middle and long-distance running (*Kovács, Kóbor, Sebestyén and Tihanyi*, 2021). In terms of physiological factors, these are maximal oxygen uptake (VO2max), running economy (RE), and velocity associated with maximal oxygen uptake (vVo2max) (*Noakes Myburgh and Schall*, 1990; *Noakes*, 2001, *Conley and Krahenbuhl*, 1980). In addition to these factors, the anaerobic threshold and associated running speed (vAt) are the best predictors of distance running performance (*Tjelta, Tjelta and Drystad*, 2012). Since the beginning of the last century, training methods to improve these abilities have been continuously improved based on empirical observations by coaches. A consensus has emerged among coaches and researchers that interaction between three main factors plays a role in the development of these parameters: training volume (number of kilometers over a given period), training density, and training intensity (*Foster, Daniels and Seiler*, 1999; *Midgley, McNaughton and Jones,* 2007; *Brandon*, 1995). However, these combinations may vary from one event to another, from one athlete to another (*Seiler and Tonessen*, 2009). There may also be variations in the training tool that coaches use to achieve a given physiological adaptation. The literature uses different intensity-zone-based schemes to classify the training performed by endurance athletes (*Seiler and Kjerland*, 2006). The most widely used is the 3-zone scale associated with the name Stephen Seiler (see Table 1.) (*Seiler*, 2010). Here, work below the aerobic threshold (vLT1) is classified as Low-Intensity Training (LIT), between the aerobic and anaerobic thresholds (vLT1 and vLT2) as Moderate Intensity Training (MIT), and above the anaerobic threshold as High-Intensity Training (HIT). In addition to the above-mentioned scales, 5-zone (*Tjelta*, 2016) and 9-zone scales (*Haugen, Sandbakk, Enoksen, Seiler and Tonnessen,* 2021) for middle-distance runners are also used. These are mainly based on physiological parameters (aerobic and anaerobic threshold) (*Seiler*, 2010), but some researchers also suggest the use of pace relative to race pace (*Kenneally, Casado, Gomez-Ezeiza and Santos Concejero*, 2020; *Kelemen, Benczenleitner and Tóth*, 2023a). The training intensity distribution (TID) is the most commonly distinguished training method used in research:

- **Traditional/ Pyramidal distribution:** most of the training volume (around 70-80%) is done at low intensity (Zone 1). The remaining 20-30% is at medium to high intensity, such that there is more medium intensity (Zone 2/ Anaerobic threshold training) and less of the highest intensity (Zone 3). As the workloads get higher, the amount of work done by the runner decreases, so, a pyramid is drawn.
- **Polarized training:** in the method described by Stephen Seiler (*Seiler and Kjerland*, 2004), athletes perform large amounts of low-intensity (Zone 1 ~ 80%) and high-intensity (Zone 3 ~ 20%) work, while very little or no effort is performed at moderate intensity (Zone 2). A Polarization Index (PI): $PI=\log_{10}$ (Z1/Z2 x Z3*100) calculus was created by Treff and his co-workers to determine whether the training intensity distribution counts as Polarized, where Polarized if PI > 2.00 a.U. (*Treff, Winkert, Sareban, Steinacker and Sperlich*, 2019).
- **Anaerobic threshold training/ Threshold training:** in contrast to the other two methods, the majority of training (>35%) takes place in Zone 2, which is associated with the anaerobic threshold, but here too the majority of work (60-62%) is performed at low intensity (Zone 1). However, this latter method is not typical of the ascent of professional international distance runners, according to the work of Casado et al. (*Casado, González-Mohíno, González-Ravé and Foster*, 2022).

As the running distances between 1500 m and 10,000 m are dominated by aerobic energy expenditure (*Gastin*, 2001), their training shows a homogeneous picture. However, the preparation of 800 m athletes, differs from these longer events (*Haugen et al.,* 2021). For the shorter distance of 1500 m, 75-80% of the energy is derived from aerobic energy, while for the 10 km, 95% is derived from aerobic energy. The races' energy production differences are also reflected in their pacing (*Tucker, Lambert and Noakes,* 2006; *Kelemen, Csányi, Révész, Gyimes, Benczenleitner and Tóth*, 2023b; *Filipas, Nerli, Bonato, La Torre and Piacentini*, 2018).

Table 1. The Stephen Seiler 3- intensity zone scale (Seiler, 2009)

Zone	Intensity	Lactate (mmol/liter)	VO2max %	HR max %	Training type
Zone 3	High Intensity (HIT)	>4.0	>90%	92-100%	Aerobic power; Anaerobic intervals; Speed development
Zone 2	Moderate Intensity (MIT)	2.0-4.0	80-89%	82-92%	Lactate threshold training
Zone 1	Low intensity (LIT)	1.0-2.0	55-79%	62-82%	Aerobic endurance; Aerobic recovery

Several studies have been published on different intensity-based approaches. Some of these were short-term and focused on local, amateur-level athletes *(Filipas, Bonato, Gallo and Godella, 2022).* In the literature on the training of elite athletes, examples of both polarised and pyramidal distributions can be found, so different approaches appear to be used to achieve similar levels of results in distance runners *(Kenneally, Casado, Gomez-Ezeiza and Santos Concejero, 2020; Tjelta, 2013; Tjelta, 2016; Ingham, Fudge and Pringle, 2012; Seiler, 2010).* In the present study, we have sought to explain the phenomenon of how it is possible to achieve similar results with seemingly two different approaches, and what are the key training elements that enable this high level of endurance performance. Finally, how these observations can be put to use in practical preparation.

Aim

The literature on the subject shows that at the highest level, the training of elite international distance runners (1500-10,000m) is mainly characterised by Polarised and Pyramidal intensity distribution methods *(Foster, Casado, Esteve-Lanao, Haugen and Seiler, 2022; Casado et al., 2022*). For this reason, the aim of this study is to investigate the differences and similarities between these two methods. The study investigated the following aspects: training volume, intensity distribution, training tools and periodization. A further aim of the research is to draw conclusions from the training of elite athletes that can be used by coaches in their practical work.

Material and Methods

An integrative review was conducted to evaluate training intensity studies in elite-level distance running. An integrative review is a broad research review that allows the researcher to combine theoretical and empirical literature and includes different types of data and different methods (*Whittemore and Knafl*, 2005). The present review followed the process described by Whittemore and Knafl (2005), which includes problem identification, literature search, data evaluation, data analysis, and presentation of results. A literature search was conducted on Feb 20, 2023. After a review of the following internet databases (Pubmed, Scopus, Web of Science), 26 literature articles were found analyzing the training intensity distribution (TID) of international distance

runners. Databases were searched from inception up to February 2023, with no language limitation. Citations from scientific conferences were excluded. The title, abstract, and keywords search fields were searched in each database. The following keywords, combined with Boolean operators (AND, OR) were used: „Training", „Running", „Long-distance", „Polarised", „Pyramidal", „Intensity", and „Intensity distribution". The types of articles analyzed were review articles, original research, case studies.

Results

Similarities

In terms of the amount of training per week, both methods are similar. Elite 1500 and 10,000-meter runners average between 120 and 180 kilometers per week, with 10 to 14 running sessions weekly (Haugen, Sandbakk, Seiler and Tonessen, 2022; Casado et al., 2022; Karikosk, 1984; Tjelta, 2016; Tjelta and Enoksen, 2001). A significant part of the training volume is done at low intensity (see Figure 1.), both in the pyramidal and polarised models. Runners complete 75-80% of their weekly mileage at low intensity (Zone 1), below the aerobic threshold (vLT1), which in their case is roughly the pace of their estimated marathon race pace (Kenneally et al., 2017; Enoksen, Tjelta and Tjelta, 2011). The most commonly used forms of exercise in this category are 30-70 minute aerobic maintenance runs and shorter warm-up and cool-down runs, and morning shake-outs. Most elite runners do a long run once a week for 90-120 minutes, at the end of which the intensity can reach Zone 2 (Seiler, 2010; Stöggl, 2015, Esteve-Lanao, San Juan, Earnest, Foster and Lucia, 2005). The highest intensities, close to race pace, are performed at short intervals (< 800 m) 1-2 times per week in both training regimes during the base period, with lactate levels below 8 to 10 mmols/l (Casado, Hanely, Santos-Concejero and Ruiz-Pérez, 2021). These short interval workouts are done either on hills or on flat terrain (track). The duration of the intervals is usually 0.5-1 minute and they are often done in sets (for example 2x10x200 meter hills), usually running about 4-8 kilometers of intense distance per session. In the 4-8 weeks before the race season the use of longer, race-specific intervals with high lactic acid levels (> 8 mmol/l) is started to mimic the fatigue the runners will face on the race day (Casado et al., 2021; Haugen et al., 2022).

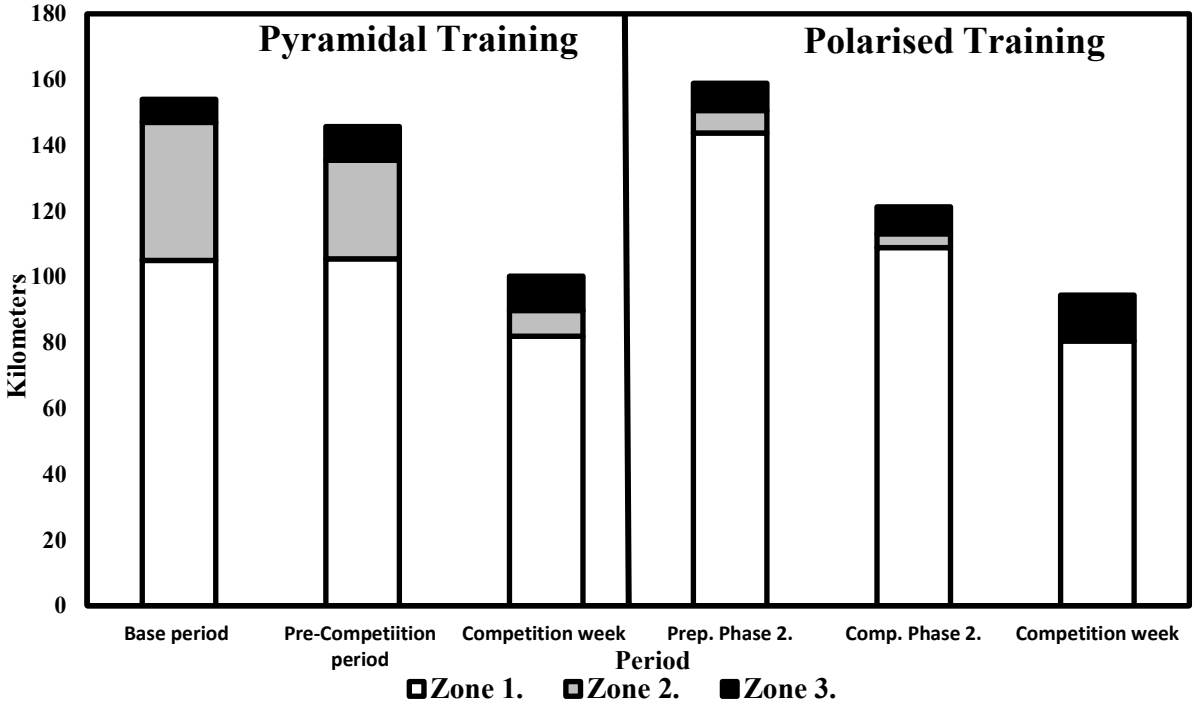

Figure 1. Training volume and training intensity distribution data for different periods of season in the Pyramid and Polarized training methods (Kelemen et al., 2023a; Tjelta, 2013).

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Differences:

The biggest difference between the two methods was found in high-intensity aerobic work **(See Table 2)**. In the pyramid method, runners performed interval or continuous tempo running workouts at speeds below the anaerobic threshold (vLT2) on average 2-4 times per week (*Tjelta, Tonessen, and Enoksen*, 2014). More recently, the use of interval training controlled by lactate measurement has become more common (*Casado, Foster, Bakken, and Tjelta*, 2023). The specification of the Norwegian method, which has been very well published in the literature, is that twice a week, so-called double-threshold days are performed, whereby runners run 20 km worth of intervals below the anaerobic threshold during the day **(see Table 2)**. In the mornings, they mainly run longer 6-10 minutes marathon-paced intervals with short breaks, while in the afternoon they run shorter, faster (5km to half-marathon paces) part-distances between 1000m and 400m. Because of the short rest periods and the interval format, they can run faster than the laboratory threshold speed without exceeding a blood lactate level of 4 mmol/l. (*Bakken*, 2021; *Tjelta*, 2013; *Tjetla*, 2016; *Tjelta*, 2019). In contrast, in the polarised intensity distribution, interval training was performed on average 1 time per week above the anaerobic threshold (vLT2) at 90% of vVo2max, which for elite racers is approximately 10 km or 30-minute race pace. Typically, 30-40 minutes of intensive work is done in 3-10 minute intervals (1-3 km distances) with a rest-to-run ratio of about 1:3 or 1:2. Light jogging or walking is typical during the rest periods. A common example of this type of training is the 5-6x mile (1609 meters) or 8x1000 meters workout (*Keneally, Casado, Gomez-Ezeiza and Santos-Concejero*, 2022; *Ingham, Fudge and Pringle*, 2012; *Billat, Lepretre, Heugas, Salim, and Koralsztein*, 2003), or the 8x4 minutes with 2-minute rest recommended by Stephen Seiler, up to 4x8 min with 4 min rest at 90% of vVo2max, or 90-93 % mHR (*Filipas, Bonato, Gallo and Godella*, 2022; *Seiler, Joranson, Olesen and Hetleid*, 2013). These training sessions can also take a more typical directional-fartlek form at the beginning of the build-up period, where the intense part is given in time and not distance. Common examples of these fartlek-sessions are 8-10 x 3 minutes hard (so-called „on") with 1.5-2 minutes rest („off"), or pyramidal/ladder sets like 1-2-3-4-5-4-3-2-1 minute intense runs with the same time of easy running in between hard efforts. In addition to the isolated use of these two methods, there are many examples of athletes' training following a pyramidal distribution in the base period and then a polarised pattern as the race period approaches (*Kenneally et al.,* 2022).

Discussion

The training of modern distance runners is characterized by a strong emphasis on developing aerobic capacity, primarily through high volume, low intensity running and increasingly interval training 1-4 times per week to develop anaerobic threshold speed. The Pyramid Method is characterized by 2-4 anaerobic threshold (vLT2) tempo/interval training sessions per week. The Polarised Method is characterized by 1 interval training session per week above the anaerobic threshold (90% vVo2max), with 30-40 minutes of intense work. Short (< 800 m) intervals close to the race pace and short sprints are used to maintain anaerobic capacity and race pace coordination during the build-up. In the pre-competition period (4-8 weeks), longer, intensive, competition-specific interval training sessions begin. During the racing season, they maintain the endurance gained in the pre-season, continuing with a significant amount of low-intensity running and less pronounced but present anaerobic threshold training. Monitoring intensity (heart rate, blood lactate, pace charts) and using appropriate intensity zones (e.g. recovery runs/anaerobic threshold runs) is essential to perform high-volume work and prevent overload. During the season, linear periodization is typical in both cases, with the possibility of single or double form timing (one during the winter indoor season and one during the summer competitive season). In both intensity models, the PI (Polarization Index) increases during the season, which is due to the use of more intense training sessions that simulate near-race fatigue as the race approaches, increases, and in parallel the importance of endurance training (zone 2) is pushed back. Apart from using the two intensity models separately, there are several examples in the literature where the intensity distribution of the competitors has shown a pyramidal pattern in the baseline period and then becomes polarised in the pre-race formative

period for the reasons mentioned above (increase in PI). In both cases, an alternation of light and heavy workload days (both in terms of volume and training intensity) can be observed within the micro-cycles of the weekly training schedule. Most runners have 5-10 years of systematic high-volume training before they reach the international level. Those runners who have developed their aerobic skills in their early years, with high volumes of low-intensity runs and frequent high-aerobic training, will achieve greater success in the long term and sustain their best years for longer periods (*Casado, Hanley and Luiz-Pérez*, 2020; *Tjelta*, 2010).

Table 2. Training week examples in the Pyramidal and Polarized training method during the base season. (Kelemen et al., 2023a; Bengtsson, 2019).

Day	Polarized Training	Pyramidal Training
Monday	AM: 16.13 km, average pace 4:06 min/km (Zone 1)	AM 10 km easy (Zone 1) PM 10 km easy, speed development (Zone 1)
Tuesday	AM: 29.02 km, average pace 3:43 min/km (Zone 1)	**AM Anaerobic threshold workout: 5 x 6 minutes (1 min rest), 2.5 mmol/L (Zone 2)** **PM Anaerobic threshold workout: 10 x1000 m (1 min rest), 3.5 mmol/L (Zone 2)**
Wednesday	AM: 16.13 km, average pace 3:52 min/km (Zone 1) PM: 8.04 km, average pace 4:00 min/km (Zone 1) +drills	10 km easy, strength and core (Zone 1)
Thursday	AM: 8.08 km, average pace 3:54 min=km (Zone 1) PM: 4.8 km warm-up (Zone 1) **3x4x200m with 200 m and 400 m jog recovery (28, 27, 26-sec average)** **8x200m hills (33-31 sec)** (Zone 3) 5 km warm-down (Zone 1)	AM Anaerobic threshold workout: 5 x 2 km (1 min rest), 2.5 mmol/L (Zone 2) PM Anaerobic threshold workout: 25 x 400 m (30-sec rest), 3.5 mmol/L (Zone 2)
Friday	AM: 14.52 km, average pace 3:59 min/km (Zone 1) + weight training	10 km easy (Zone 1)
Saturday	AM: 16.13 km, average pace 4:04 min/km (Zone 1)	**AM Hill training: 20 x 219-meter hills (70-sec jog back), 8,0 mmol/L (Zone 3)** PM 10 km easy (Zone 1)
Sunday	AM: 8.07 km, average pace 3:56 min/km (Zone 1) PM: 4.8 km warm-up (Zone 1) **4x (2km-1km) with 2 and 3 min recovery (5:50; 2:42; 5:50; 2:42; 5:50; 2:41; 5:50; 2:40)** (Zone 2-3) 4 km warm-down (Zone 1) *Weekly total: 166.1 km* *(Z1: 89,7%, Z2: 4,81 %, Z3: 5,41 %)*	AM 20 km long run (Zone 1) PM Strenght and core *Weekly total: 140 km* *(Z1: 70%; Z2 26%; Z3 4%)*

* Workouts done at higher intensities (Zone 2 and Zone 3) are highlighted with bold text.

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Conclusions and Practical Applications

The integrative literature review resulted in the following key findings: the two internality zone models that best characterize the training of elite distance runners are largely identical. The main differences lie in the number and use of high-intensity aerobic training sessions. Whereas in the polarised method, the anaerobic threshold is „pulled up" by a high volume of high intensity (30-40 minutes of intensive training) once a week at a slightly higher intensity than the anaerobic threshold (vLT2). In the pyramidal distribution, the same speed is „pushed up" by more frequent (2-4) intervals or tempo training below the anaerobic threshold (between aerobic/ vLT1 and anaerobic/ vLT2 thresholds). The observations that have been successfully used in both methods and that can be put into practice by coaches are summarised below:

- To achieve an international level of distance running performance, a high level of weekly training (120-180 km/week) is required.
- Most runners have 5-10 years of systematic training of high quality and quantity before achieving an outstanding result.
- A high percentage of the weekly training (70-80%) should be low intensity, below the aerobic threshold (marathon pace).
- During the base period, focus on developing speed at the anaerobic threshold (vLT2) with high-intensity aerobic tempo or interval training 1-4 times per week, using paces between Marathon and 10 km race speeds, with 20-40 minutes worth of intensive work per session.
- Maintain race speed-related coordination and anaerobic capacity with short interval running (>800 m) on flat or uphill terrain, on average 1 time per week, with controlled lactate accumulation (>8 mmol/L) during the base period.
- Development and maintenance of maximal running speed using short sub-maximal sprint runs with full rest (> 15 seconds) and using conditioning and plyometric exercises.
- Use of longer race-specific anaerobic (< 8 mmol/l) intervals 1-2 times per week in a 4-8 week pre-competition period, before racing season.
- Maintain the endurance level acquired during the race period with high volumes of low-intensity running and level-maintaining anaerobic threshold training.
- To avoid overtraining, close monitoring of intensity zones and training paces, especially during low-intensity (Zone 1) and near anaerobic threshold (Zone 2) training, using heart rate monitoring, pace charts, and lactate measurement.

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