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ORIGINAL ARTICLE

Polarized training intensity distribution in distance running: A case study of the 2021 Olympic long-distance runner

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ABSTRACT

In this case study, we analysed the online available one-year training diary of a long-distance runner participating in the 2021 Olympic Games in terms of training volume and training intensity distribution during the year and in different phases to track periodization. Based on the literature, we categorized the distances covered in relation to the athlete's race speed into three zones: Z1 <80% RP; Z2 80-95% RP; Z3 >95% RP. The training intensity distribution was calculated using the Polarization Index (PI): PI = $\log_{10}$ (Z1/Z2 x Z3*100). The athlete's average weekly training volume during the 52-week season was 141.77 ± 27.27 km/week (571.94 ± 106 min/week), completed in 10.4 ± 1.24 training sessions. Throughout the season (Z1: 89.95%; Z2: 4.58%; Z3: 5.43%) and also during the different preparation phases, the training intensity distribution showed a polarized pattern (PI >2.00 a.U.). In a typical interval form, the athlete performed intense training (HIT) at and above the anaerobic threshold twice a week (vLT2). Most (>80%) of the high average weekly training volume was sustained running at low intensities. High-intensity interval training (HIIT) twice weekly in the base period typically took the form of long partial distances at and above the anaerobic threshold (~90% vVO_{2max}) and short partial (<800m) distances close to race speed. The polarization rate increased as the racing season approached, and more extended interval training at race speeds was used. In conclusion, in addition to the Pyramid distribution, a Polarized training intensity distribution can also be observed during elite distance runners' training.

Keywords: Technology sport, Innovation sport, Distance running, Training intensity distribution, Polarised training.

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INTRODUCTION

Optimal training to improve endurance performance is a long-researched area. Many physiological factors have been identified over the decades that are related to and determine endurance performance. These include maximum oxygen uptake (VO_{2max}), running economy (RE), and speed associated with maximum oxygen uptake (vVO_{2max}) (Bangsbo, et al., 2001; Casado, et al., 2022). In addition to these factors, the anaerobic threshold and associated running speed (vAt) are the most predictive of distance running performance (Casado, et al., 2021). A consensus has emerged among coaches and researchers that interaction between three main factors plays a role in developing these parameters: training volume (number of kilometres over a given period), training density, and training intensity (Conley, D. L., & Krahenbuhl, G. S, 1980; Enoksen, et al., 2011). However, this combination may vary from one event to another and from one athlete to another (Esteve-Lanao, et al., 2007). There may also be differences in the training tools coaches use to achieve a given physiological adaptation. There are 5 and 9-graded intensity scales for monitoring training intensity in the literature (Haugen, et al., 2021; Haugen, et al., 2022), but the most common is the 3-graded scale (Esteve-Lanao, et al., 2007). In which Zone 1 represents the intensity below the aerobic threshold (vLT1, <2 mmol/L), and Zone 2 represents the intensity between the aerobic and anaerobic threshold (vLT1 and vLT2, or 2 mmol/L and 4 mmol/L). The most intense Zone 3 is above the anaerobic threshold (vLT2, >4mmol/L). Based on the training intensity distribution (TID), elite distance runners' most commonly followed method is the Pyramid Model (Ingham, et al., 2012), in which a decreasing running volume is performed in Zones 1, 2, and 3, respectively. Typically, this has been described as comprising 80% in Zone 1, with the remaining 20% split between Zones 2 and 3, decreasing respectively. The other model used by distance runners is the Polarised Distribution, first described by Stephen Seiler, in which relatively high volumes of training are performed in Zone 1 (~80%) and Zone 3 (20%), with little or none in Zone 2 (Kenneally, et al., 2020). It is also not uncommon for runners to develop a polarized intensity distribution as the season progresses, following the pyramid-like distribution of the base period, with the number of interval training sessions multiplying as the race-specific training intensifies (Kenneally, et al., 2020; Kenneally, et al., 2022). In addition to the traditional subdivision based on physiological factors, many researchers have further developed the use of intensity zones defined concerning race intensity (Kenneally, et al., 2018; Lj, B., 1995).

METHODS

Training and Competition data

Data from the athlete's online available training log (Strava.com) were used to analyse the average training volume (in kilometres), duration (in minutes), training frequency (sessions/ week), training intensity, and its distribution during the Olympics years 52-week long season (September 2020 to September 2021). The season was then divided into 4 periods to account for periodization. These periods were the following: Preparational Phase 1. (weeks 1-12), Competition Phase 1. (weeks 12- 25), Preparational Phase 2. (weeks 26-34), and Competition Phase 2. (weeks 35-52). Individual sessions were analysed and categorized (easy runs under 20 kilometres, long runs between 20 and 32 kilometres, tempo runs or fartlek, interval training, and competition/time trials). The volume in each intensity zone was then calculated. The average pace was used during continuous sessions, while individual repetitions were analysed in fartlek and interval sessions.

Intensity zones and Polarization index

Based on the literature (Kenneally, et al., 2018; Lj, B., 1995), we categorized the training sessions based on the percentage of the athlete's race speed (RP = 22.9 km/hr, race speed 5000 m) into three zones: Z1 <80% RP (18.3 km/hr), Z2 80-95% RP (18.3-21.8 km/hr), and Z3 (>95% RP). The training intensity distribution was calculated using the Polarization Index (PI): PI = $\log_{10}$ (Z1/Z2 x Z3*100) based on Treff and his colleagues

(Midgley, et al., 2007) work. If PI >2.00 a.U., the TID was defined as "*polarized*", with increasing values indicating a higher level of polarization. If PI is ≤ 2.00 a.U., the TID was defined as non-polarized.

RESULTS

Training volume and Frequency

Over the 52 weeks analysed, he ran 7371.9 kilometres in 29741 minutes. This average weekly volume is 141.77 ± 27.27 km// week (571.94 ± 106 min/week), which he completed in 10.4 ± 1.24 training sessions. This training volume and density remained consistently high throughout the different periods (Prep. Phase 1.: 152.04 ± 23.37 km/week; Comp. Phase 1.: 149.05 ± 24.61 km/week; Prep. Phase 2.: 158.88 ± 13.53 km/week; Comp. Phase 2.: 121.27 ± 23.88 km/week), decreasing significantly only during the week of the races: 103.07 ± 19.62 km/week. The total number of kilometres covered during the training weeks and kilometres in the different zones is shown in Figure 1.

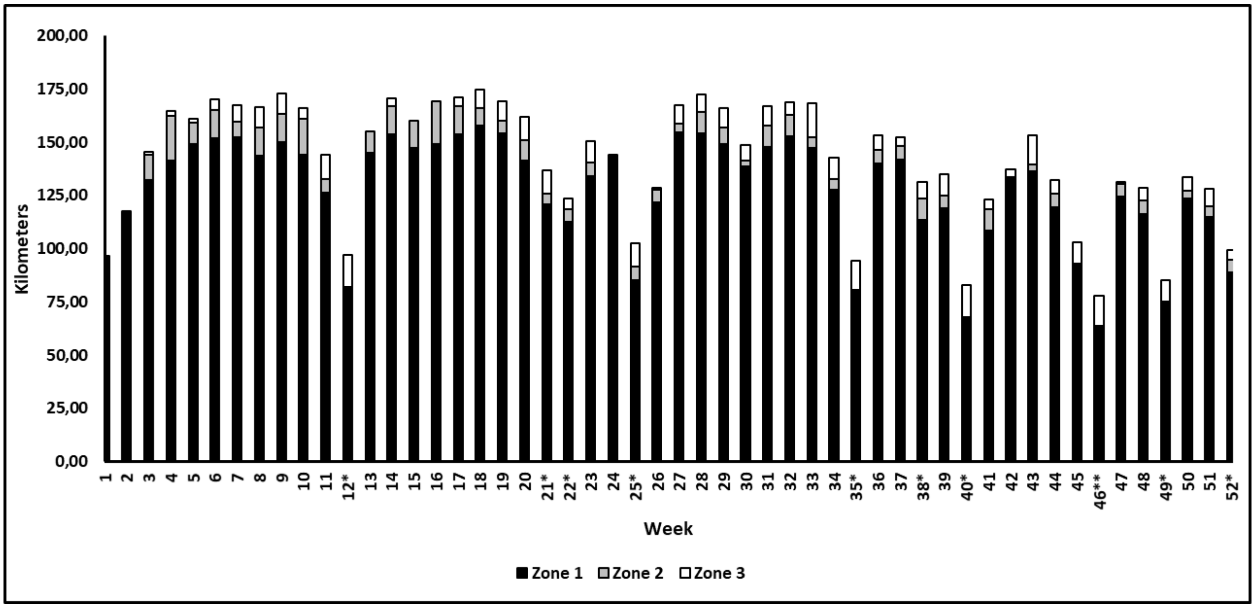

Figure 1. The quantity and intensity of training weeks over the 52-week season.

Intensity distribution and Periodization

Throughout the season (Z1 89.95%; Z2 4.58%; Z3 5.43%) and during different periods (Prep. Phase 1.: Z1 90.52%; Z2 6.28%; Z3:3.20%; Comp. Phase 1.: Z1 89.87 %; Z2 5.30 %; Z3 4.83 %; Prep. Phase 2.: Z1 90.61 %; Z2 4.23 %; Z3 5.15 %; Comp. Phase 2.: Z1 89.33 %; Z2 3.17 %; Z3 7.49 %;), the training intensity distribution showed a polarized pattern (PI >2.00 a.U.), with large proportions (~90%) of work done at low-moderate aerobic intensities (Z1). The degree of polarization increased as the racing season progressed (shown in Figure 2.), achieving the highest value in the summer racing season (Comp. Phase 2.: PI = 4.32 a. U.). Example training weeks during the preparation and competition season are shown in Table 1.

Training session types

The athlete performed 541 sessions over the 52 weeks, including races and a time trial. Figure 3 represents the proportion of session types performed. Most of the training (404 training sessions, 74.67%) consisted of low-intensity aerobic runs of less than 20 kilometres in volume. Long runs at a medium intensity were done weekly, covering distances between 20 and 32 kilometres (43 training runs, 7.94 %). Anaerobic threshold development was mainly in the form of tempo and fartlek (13 sessions, 2.4%) at the beginning of the preparation periods and then took a longer interval form (intervals between 1km and 4.8 km with an overall volume of 10- 15 kilometres) as the season progressed. The athlete completed 70 interval training sessions during the season (12.92%).

Table 1. Training week examples in preparation and competitive phase.

Day	**Early Season (2021.03.29- 2021.04.04)**	**Competitive phase (2021.06.07- 2021.06.13)**
Monday	AM: 16.13 km, average pace 4:06 min/km (Zone 1)	AM: 11.29 km, average pace 4:00 min/km (Zone 1) PM: 6.49 km, average pace 4:13 min/km (Zone 1) 6x100m (14 sec) (Zone 3)
Tuesday	AM: 29.02 km, average pace 3:43 min/km (Zone 1)	AM: 4.8 km warm-up (Zone 1) 2km-1.6km-1.2km-1km-800m-600m-400m (5:40; 4:27; 3:17; 2:36; 2:03; 1:27; 56) (Zone 3) 4 km warm-down (Zone 1) PM: 6.47 km, average pace 4:05 min/km (Zone 1)
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	AM: 16.11 km, average pace 3:59 min/km (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: 12.9 km, average pace 3:54 min/km (Zone 1) PM: 6.46 km, average pace 4:00 min/km (Zone 1) + 6x100 m (13 sec) (Zone 3)
Friday	AM: 14.52 km, average pace 3:59 min/km (Zone 1) + weight training	AM: 6.46 km, average pace 4:05 min/km (Zone 1) PM: 4.8 km warm-up (Zone 1) 2km-1km-2km-1km+4x400m (5:47;2:35;5;46;2:34/ 62.7; 58.8; 61.0; 57.4) 4 km warm-down (Zone 1)
Saturday	AM: 16.13 km, average pace 4:04 min/km (Zone 1)	AM: 9.69 km, average pace 4:04 min/km (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) 4 km warm-down (Zone 1) *Weekly total: 166.1 km* *(Z1: 89,7%, Z2: 4,81 %, Z3: 5,41 %)*	AM: 20.94 km, average pace 3:57 min/km (Zone 1) *Weekly total: 135.0 km* *(Z1: 88,1%, Z2: 4,44 %, Z3: 7,4%)*

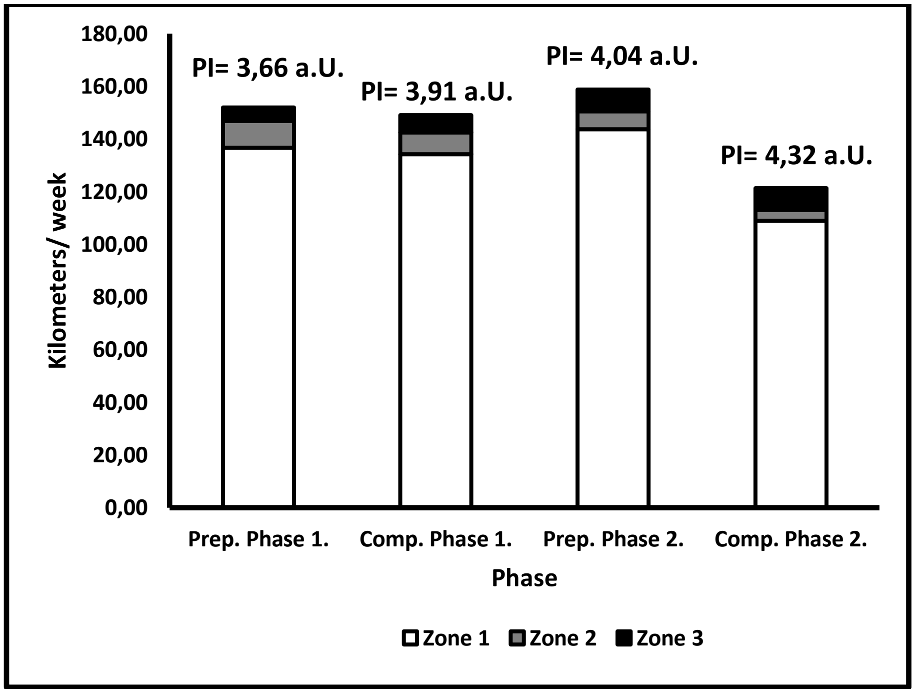

Figure 2. The evolution of the degree of polarisation during the preparation periods.

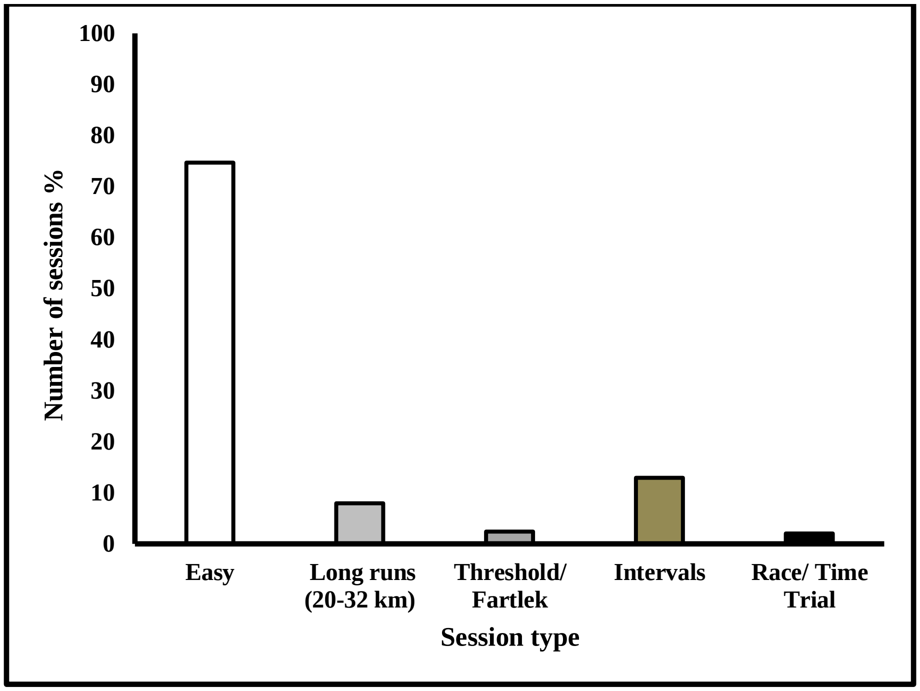

Figure 3. Session type by percentage over the year.

Competitions and performance

During the season, he participated in 10 races (4 times in Comp. Phase 1. and 6 times in Comp. Phase 2.) and achieved personal best times across all distances (1500m-3:37.00; 3000m-7:39.18; 2-mile-8:11.55; 5000m-13:06.67; 10,000m-27:23.44). The athlete finished 16th in the 10.000m at the Olympic Games.

DISCUSSION

This case study followed the year-long training of an Olympic-level distance runner, setting personal bests in all distances between 1500 and 10,000 meters. The data on training volume and training density are consistent with those reported previously in the literature, namely that elite 1500-10.000 m track runners train an average of 120-180 km per week over 11-13 training sessions, 80% of which are done at low intensity (Z 1/ below aerobic threshold) (Noakes, et al., 1990; Seiler, K. S., & Kjerland, G. Ø., 2006; Seiler, S., 2010). In this respect, the present runner's intensity distribution during training is similar to that of the outstanding Norwegian runner of the 1980s, Ingrid Kristiansen, who set world records in the 5000 m, 10,000 m, and marathon distances. During her training in 1985, she completed 87.9% of her average weekly 155 km running volume at low intensity (Z1), 4.7% at anaerobic threshold intensity (Z2), and the remainder at high intensity (Seiler, K. S., & Kjerland, G. Ø., 2006; Seiler, S., 2010). Similarly, the competitor analysed in the present paper performed 89-90% of his work at low intensity throughout the year and during the different preparation phases, which is more pronounced than the 80% rate described by Stephen Seiler (Seiler, S., & Tønnessen, E., 2009; Seiler, et al., 2011). A systematic review of the literature by Casado et al. found that at the elite level, most athletes' training workloads have a pyramidal distribution (Ingham, et al., 2012). However, there are examples in the literature of some athletes' year-round training being polarized (Tjelta, L. I., 2013) and the pyramidal distribution being replaced by a polarised one as the season approaches (Kenneally, et al., 2022). However, the present case study adds to the body of research that suggests that a polarised training intensity distribution is appropriate for achieving world-class endurance performance (Esteve-Lanao, et al., 2007; Kenneally, et al., 2018; Tjelta, L. I., 2013).

As the competitive season approaches, the increasing use of intense, competition-specific interval training and the resulting increasing degree of polarization is consistent with the trend in the preparation of two other world-level competitors (Kenneally, et al., 2022; Tjelta, L. I., 2016). Researching the use of training tools, Casado and colleagues' article shows that the training of world-class distance runners is best characterized by anaerobic threshold training (tempo runs and cruise intervals) and short intervals near race speed (Tjelta, L. I., 2016). The present participant performed above low-intensity training twice a week and a near marathon-paced long run of 90-120 min. In addition, he performed short (100 m) acceleration runs above the race pace every week. At the beginning of the training period, he mainly did tempo and fartlek training at an anaerobic threshold speed once a week. In addition, he also did short intervals (<800m) at near race speed on hilly or flat terrain once a week. As the season progressed, the sustained methods (tempo/fartlek) were replaced by longer intervals (1-3.2km) above the anaerobic threshold. These were close to 90% of the VO_{2max} recommended by Seiler and Joranson (Tjelta, L. I., & Tjelta, A. R., 2012; Treff, et al., 2019). The latter is close to the speed of the competitor's main event (10.000 m), which parallels the observation that race speed is more important than physiological factors in training planning for elite athletes (Kenneally, et al., 2020; Lj, B., 1995).

CONCLUSIONS

In addition to the Pyramid distribution, a Polarized training intensity distribution can also be observed during the training of elite distance runners. The majority (>80%) of the high average weekly training volume (~140 km/week) is made up of sustained running at low intensities. High-intensity interval training (HIIT) twice weekly in the preparation period typically takes the form of long intervals at and above the anaerobic threshold (~90% vVO_{2max}) and short intervals (<800m) close to race speed. As the competition season approaches, the rate of polarisation increases, and longer, more specific interval training at race speeds is typically introduced.

AUTHOR CONTRIBUTIONS

Bence Kelemen developed the theoretical formalism, collected, evaluated and summarised the data. Authors Bence Kelemen, Ottó Benczenleitner and Zsolt Gyimes contributed to the final version of the manuscript. The project was supervised by László Tóth.

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DISCLOSURE STATEMENT

No potential conflict of interest was reported by the authors.

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