A Longitudinal Case Study of the Training of the 2012 European 1500 m Track Champion

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Abstract

The purpose of this study was to present the training of the European 1500 m track champion of 2012. Data from the training diaries were used to describe (a) the average training load (km · week^{-1}), and (b) the distribution of training at different intensities based on his heart rate (HR) as a percentage of maximum heart rate (% HR_{max}) and on lactate measurements. In 2012, 68.5% of the total training load during the period from January to the middle of March was performed with HR between 65 and 75% of HR_{max}, 26.1% was performed as anaerobic threshold training, HR 82-92% of HR_{maks} and 3.8% was performed as aerobic high intensity training, HR 92-97% of HR_{max}. Only 1.5% was performed as anaerobic training. During the track competition season, the percentage of training performed at low intensity increased to 73% as a result of some training loads at anaerobic threshold pace were replaced by some more intensive aerobic and anaerobic training sessions, requiring a lower training load. High proportion of interval training close to the anaerobic threshold might have led to excellent racing performance for this runner.

Keywords: *Training volume, training intensity, anaerobic threshold training*

Introduction

Performance in distance running events is affected by a variety of physiological factors such as maximal oxygen uptake (VO_{2max}) (Billat et al., 2001) , running economy (Jones, 2006), velocity at the anaerobic threshold (vAT) (Maffulli, Capasso, & Lancia, 1991), the velocity at VO_{2max} (Bosquet, Leger, & Legros, 2002; Daniels & Scardina, 1984), anaerobic power, muscular strength and neuromuscular characteristics (Jung, 2003). 1500 m track running demands an energy supply from aerobic as well as anaerobic metabolism. Spencer and Gastin (2001) tested highly trained runners competing at distances from 200 m to 1500 m and calculated the metabolism for the 1500 m race (n = 5) to be 84 ± 3% aerobic and 14.6 ± 2.4% anaerobic.

How to best train for improving aerobic capacity in distance runners is a heavily debated topic among both researchers and coaches (Brandon, 1995; Midgley, McNaughton, & Wilkinson, 2006; Seiler & Tønnessen, 2009). Studies on moderately and well-trained endurance athletes have demonstrated an increased VO_{2max} as a result of replacing training executed at low and moderate intensities with high-intensity interval training (Helgerud et al., 2007; Laursen & Jenkins, 2002; Smith, Coombes, & Geraghty, 2003). However, there is a contrast between these laboratory studies lasting 5–10 weeks and empirical descriptions of how elite runners actually train (Seiler & Tønnessen, 2009). Indeed, there are few descriptions of the distribution of training at different intensities by elite distance runners (Billat, et al., 2001; Robinson et al., 1991). Moreover, these studies analysed training performed at different intensities for only 6–12 weeks' duration.

A 21-year-old Norwegian runner won the men's 1500 m final in the European Championships in Helsinki the 1st of July 2012; one of the most unexpected victories of the championships. One month later, he finished fifth at the same distance in the Olympic Games in London. He was the best European runner in the race and was only 0.3 seconds away from gaining a bronze medal. In December 2012, he won the European Cross Country Championship (8 km) for men < 23 years. The purpose of this article was to describe how this athlete trained from an age of 17 years until the age of 21 years when he became European 1500 m champion.

Methods

Collection of training data

Training data from the seasons 2008, 2009, 2010, 2011 and 2012 were collected from his training diaries. From the start of the 2008 season, the athlete used a heart rate (HR) monitor on all running sessions. From the 2010 season, in addition to recording his HR, blood lactate level was measured on at all interval training sessions by using Lactate Pro LT-1710TM. During an interval training session consisting of e.g. 12 x 1000 m, lactate was typically measured immediately after the third, seventh and the last 1000 m. The athlete or his coach did the measurements.

Calculations of the training reported in the training diaries were used to describe (a) the average training load ($km \cdot week^{-1}$) and (b) the distribution of training at different intensities based on the HR in beats $\cdot$ min^{-1} (bpm) as a percentage of his HR_{max} and on lactate measurements. The athlete under study has given his informed consent for data regarding his training to be used in a scientific publication. This study has been accepted by the Norwegian Social Science Data Services.

Intensity zones and training load

Training intensity was based on an distribution of training into three aerobic- and two anaerobic specific intensity zones. A distribution of aerobic training in three zones has been used in studies where intensity has been related to ventilation and lactate. Training at an intensity below first lactate- (LT_1) and ventilatory turnpoint (VT_1) (zone 1 in Table 1) is defined as low intensity training. Zone 2 is classified between VT_1/LT_1 and VT_2/LT_2. Zone 3 is training performed at intensities between VT_2/LT_2 and VO_{2max} (Lucia, et al., 1999; Lucia et al., 2003; Seiler & Kjerland, 2006). In Table 1 are these three aerobic zones adjusted to this athlete's training regime. In addition, Table 1 contains two anaerobic zones. Zone 4 training is anaerobic lactacid training. The athlete in this study classify all intensive training sessions, except sprint training, where lactate is measured to be > 6.0 $mmol/L^{-1}$ in this zone. Zone 5 is alactacid anerobic training. Sprint training and strides over distances from 60- to 100 m are listed in zone 5.

The frequency of training (units $\cdot$ $week^{-1}$) and the average weekly running distance (km $\cdot$ $week^{-1}$) were recorded. The training loads (km $\cdot$ $week^{-1}$) were also classified according to the prescribed intensity zones in Table 1.

Table 1: Standardized intensity zones (HR as % of HR_{max}), running pace and type of training. Blood lactate concentration, and physiological adaptation in the prescribed intensity zones

	Training Zone/ Kind of training	**Lactate (mmol/L)**	**HR as % of HR_{max}**	**Physiological adaptation**
1	Easy and moderate continuous running	0.7-2.0	62-82%	Restitution and running economy
2	Threshold intervals	2.0-4.0	82-92%	Anaerobic threshold pace
3	Harder aerobic intervals	4.0-6.0	92-97%	VO_{2max} / aerobic capacity
4	Fast repetitions over shorter distances. Hills or track training at 800m and 1500m pace	> 6.0	> 97%	Anaerobic capacity (Anaerobic lactacid)
5	Sprint and strides			Speed training (anaerobic alactacid)

Instruments

A HR monitor (Polar Sports Tester, Polar Electro Oy, Kempele Finland) was used in all running sessions between 2008 and 2012. Training intensity was also measured during interval training sessions by sampling lactate using a Lactate Pro LT–1710™ analyser (ARKRAY Inc., Kyoto, Japan). Training performed at intensities around 90% of HR_{max} is referred to as the anaerobic threshold intensity. Measurements of this athlete's individual anaerobic threshold show that his HR at vAT was in this area (Tjelta, Tjelta, & Dyrstad, 2012). A HR between 82 - 92% of HR_{max} and a lactate level between 2.0 and 4 mmol · L^{-1} were classified as anaerobic threshold training (zone 2 in Table 1).

Results

Training from age 17 to 21 years

The average training volume (km· week^{-1}) and the distribution of training at different intensities per week during the 10 weeks from January to middle of March from age 17 to 21 years in the period 2008-2012 is shown in Fig 1. Further training such as strength training, drills and stability training was performed once or twice a week, but is not recorded in Fig 1. His progression as a runner is shown in Table 2 as the best results at different ages for the 800, 1500 and 3000 m distances.

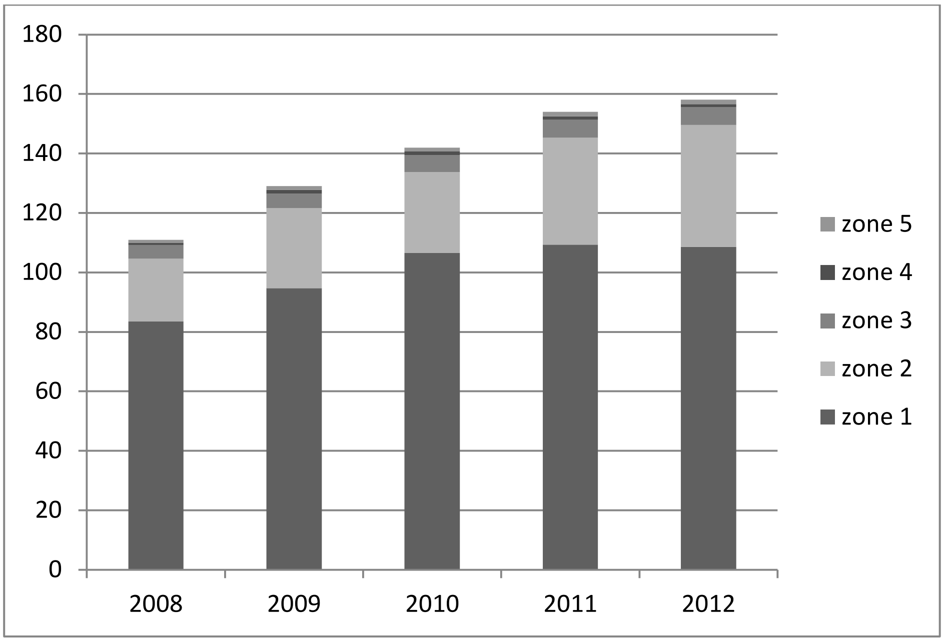

Fig 1. *Average total running volume (km· week^{-1}) and average running volume in different intensity zones during 10 weeks from January to middle of March in the years 2008-2012*

Table 2: Time at different ages on the distances 800 m, 1500 m and 3000 m

Age	17	18	19	20	21
800 m	1:52.51	1:51.34	1:50.84		1:48.60
1500 m	3:50.63	3:44.53	3:38.61	3:39.50	3:35.43
3000 m	8:17.96	8:08.69	7:58.15		

In 2008, at the age of 17 he won the youngest class in the Norwegian junior cross-country skiing championship in freestyle. At this age he was also one of four Norwegian junior runners who finished second in the team competition in the European Cross Country Championships (Tjelta & Enoksen, 2010). During the winter season, at the age of 17 years, his average training load differed from one week to another depending on to what extent he was doing cross-country ski training and competing in ski competitions. The ski training sessions were normally longer than the running sessions. In a “typical running week” in February and at the beginning of March, he ran an average of 111 km. A standard training week in this period at the age of 17 years typically involved a session of 10 × 1000 m with 1 min recovery and with a HR from 85–90% of HR_{max} and a lactate level from 2.5–4 mmol · L^{-1}. In addition to running and skiing sessions, he did general strength training twice a week. At the age of 17 years, he trained 8–10 sessions per week and took part in 38 races including 11 cross-country skiing competitions. During the track competition season in 2008, the frequency of interval sessions at an anaerobic threshold pace decreased and the number of sessions at 800 m and 1500 m racing pace (zone 4 sessions) increased. However, the total training load performed in a single training session in zone 4 was rather small, resulting in the percentage of total training performed in zone 1 becoming greater than in the winter season.

Table 3 shows eight days of training leading up to an important race at the age of 17 years. During seven days prior to the race day, he ran a total of 113.7 km. 99 km (87%) were executed below his anaerobic threshold (zone 1) with a HR ranging from 131 to 144 bpm. Having a HR_{max} of 195 bpm at this age, the athlete performed his zone 1 training at a HR from 67–74% of HR_{max}. During the same seven days, a distance of 8 km (7%) was performed in zone 2 , 4.3 km (3.8%) in zone 4 and 2.4 km (2%) as strides in zone 5

Table 3: Eight training days in July leading up to an important1500m competition at the age of 17 in 2008

July	Morning session	Afternoon session
1st	40 min easy continuous running (HR =138)	17 min jog + drills + 4 x 100 m strides +8 x1000m (average time: 3:12, recovery = 1 min.) + 6 x100m strides + 12 min easy running
2nd	40 min easy continuous running (HR =140)	50 min easy continuous running (10.5km) (HR =138)
3rd	40 min easy continuous running (HR =144)	20 min jog + drills + 4 x 100m strides + 4 x 300m (46.2, 47.3, 45.8, 46.5) + 5 x200m (29.5, 29.5, 29.4, 28.9, 28.7 + 2 x 150m (19.8, 18.8) + 11 min easy running
4th	40 min easy continuous running (HR =142)	53 min easy running (HR = 143). + drills +4 x 90m strides
5th	40 min easy continuous running (HR =138)	20 min easy running, drills + 4 x 90m strides + 3 x 400m (61.1, 63.1, 60.4) + 3 x 200m (29.5, 29.5, 29.4) + 11min easy running
6th	30 min easy continuous running (HR =136)	30 min. easy continuous running (HR =138) + 4 x 90m strides
7th	30 min easy running (HR=131)	30 min easy running (HR =134) + 4 x 90 m strides
8th	3 km easy running + 2 x 100m strides	1500m race: 3:51.56 (personal record). Warm up: 25 min jog + drills + strides. 20 min jog after the race.

From the age of 18 years, he decided to focus on distance running for the coming years. During 2009 and 2010, he gradually increased his total weekly training load from an average of 100–110 km · week^{-1} in 2008 to an average of 140 km · week^{-1} in 2010 (Fig 1). He also increased the number of training sessions performed at an anaerobic threshold pace from two to three times per week during the winter season in 2008, to four in 2010. In 2010, he set a Norwegian junior record for the 1500 m, running 3:38.61 min. In January 2010, he tested VO_{2max} and velocity at anaerobic threshold (vAT) at the Norwegian Olympic Training Centre. VO_{2max} and vAT were 84.4 ml · kg^{-1} · min^{-1} and 18.2 km · h^{-1}, respectively. The vAT- test was carried out as 5 × 5 min increments at increasing velocities with a treadmill gradient of 1.7% (Tjelta, Tjelta & Dyrstad, 2012). When testing vAT and VO_{2max} in 2010, he used VO_2 = 0.190 ml · kg^{-1} · km^{-1}, running at a pace of 16 km · h^{-1} with a 1.7% gradient. This is the lowest use of energy (the best running economy) at this pace recorded among 34 runners who have been participants in different distance projects under the supervision of the Norwegian Athletic Federation during the last 25 years (Tjelta, Tjelta & Dyrstad, 2012).

Most of the subject's 2011 season was spoiled because of a stress fracture. After recovering from injury, he started training for the 2012 season at the beginning of November 2011. The average training load in November and December (build-up period 1) was 146 km · $week^{-1}$; from January to the middle of March (build-up period 2), it was 156 km · $week^{-1}$; and from the middle of March to the end of May, it was 150 km · $week^{-1}$ (pre-competition period). The average training load and the distribution of training at different intensities during 10 weeks from January to the middle of March in the years from 2008 to 2012 are shown in Fig 1.

In the week of June 18–24, 2012 (the week before the European Championships), he ran a total of 145.5 km. Of the weekly training load, 27.9% (40.2 km) was performed at intensities at or above the anaerobic threshold pace (30 km in zone 2, 8 km in zone 3, 1.2 km in zone 4 and 1 km in zone 5). In the training week leading up to the European Championships, the amount of training at an anaerobic threshold pace was reduced as well as the total amount of training. This week is listed in Table 4.

Table 4: The training in the week 26th of June to 1st of July 2012, 100.5

	Morning session	Afternoon session
Monday	30 min (6.5 km) easy continuous running (HR =136)	20 min jog + drills + 4 x 100m strides +10 x 400m (recovery = 1 min). Lactate 4.5 mmol/L^{-1} (after no. no. 10) + 12 min easy running
Tuesday	36 min (8 km) easy continuous running (HR =144)	34.30 min easy continuous running (8 km) (HR =146)
Wednesday	10 min easy continuous running + 4 x 6min increasing speed on treadmill: 18.5, 19, 19.5 and 20 km/hour (recovery = 1 min, lactate from 1.5 - 2.9mmol/L) +10 min easy running	20 min jog + drills + 4 x 100m strides + 5 x 200m (average 28.28) + 10 min easy running
Thursday	31 min jog (6 km) (HR =132)	28 min jog (6km) (HR = 143)
Friday	18 min easy continuous running (4km) +200m, + 150m, +2 x120m + 5 min jog + 2 x 90 m strides	
Saturday	1500m heats European Championship, Helsinki. No. 4 in the heat (3:46.16) + warm up and jog + strides after the race	20 min easy continuous running (HR =134) + 4 x 90m strides
Sunday	15 min easy running (HR=135) + 2 x 80m strides	European Championship 1500m final: no. 1 (3.46:20) + warm up + strides (before race) and jog after the race

During the week listed in Table 4, he ran a total of 100 km. Of this distance, a session of 4 × 6 min (7.8km = 7.8%) on Wednesday morning was training in zone 2, and 10 × 400 m on Monday afternoon (4%) was training in zone 3. The distances of two 1500 m competitions, the 5 × 200 m on Wednesday afternoon and 200 m, 150 m and 2 × 120 m on Friday made a total of 4.6 km (4.6%) performed as running in zone 4; of this distance, 1.8 km (1.8%) was run as strides (zone 5). This gives a total of 18.2 km (18.2%) of the total weekly training load performed at intensities at or above his anaerobic threshold with the remaining 81.8% at rather low intensity (zone 1).

During the season of 2012 the athlete in this study took part in 25 races including four cross country competitions.

Discussion

Training loads

From running an average of 100–110 km · week^{-1} at the age of 17 in 2008, his training load increased to an average of around 130 km · week^{-1} at the age of 18 in 2009 and 140 km · week^{-1} in 2010. In addition to setting a Norwegian 1500 m junior record in 2010 (3:38.61), he won the junior team competition in the European Cross Country Championships. In 2012, his average training load in November and December was 146 km · week^{-1}, 156 km · week^{-1} during the 10 weeks from January to the middle of March, and 150 km · week^{-1} from the middle of March to the end of May. This is close to the training load reported for three of the best Norwegian long-distance track runners in the period 2000 to 2010 (Enoksen, Tjelta, & Tjelta, 2011). It has to be emphasized that the runner in this study performed a weekly training load at the age of 17 to 19 years that was higher than those observed in previous studies of elite young cross-country skiers (Seiler & Kjerland, 2006) and middle- and long- distance runners (Esteve-Lanao et al., 2005; Esteve-Lanao et al., 2007). During the competition season in 2012, his training load ranged from 100 km · week^{-1} to 155 km · week^{-1}. His lowest total training load (100 km · week^{-1}) was during the weeks leading up to the European Championships (see Table 4) and the Olympic Games.

The reduction of the training volume combined with high-intensity training the week before the European Championship and the Olympic Games is in accordance with recommendation given by Shepley at al. (1992) who examined the effect of three different tapers in highly trained middle distance runners.

Training intensity

The optimal distribution of training at different intensities that should be recommended for elite athletes in endurance events is debatable. According to Seiler & Tønnessen (2009), 80% of low-intensity training (below the anaerobic threshold) and 20% of high-intensity training (at and above the anaerobic threshold) give excellent long-term results. An 80:20 ratio between low- and high-intensity training was also found among successful Norwegian junior and senior runners (Enoksen; Tjelta & Tjelta, 2011; Tjelta & Enoksen, 2010). This same ratio also characterized the training of the runner in this study at the ages of 17 and 18 years. From the age of 19**,** his amount of training at and above the anaerobic threshold pace increased to 33% during the 2012 build-up periods (from November 2011 until the middle of March 2012). This came from an increasing number of anaerobic threshold sessions. In January and February 2012, he usually performed two threshold sessions (zone 2 training) on the same day, for example, 5 × 6 min in the morning session and 12 × 1000 m or 25 × 400 m in the evening session. This he typically performed two days per week. In addition to these four zone 2 sessions he normally did one weekly session in zone 3 (i.e. 20 x 200m hill running).

During the competition season in 2012, the distribution of his training at different intensities differed more from week to week than during the build-up periods. In competition-free weeks, the distribution between low- and high-intensity training could be 75:25 and in an important competition week it was 80:20. A higher percentage of low-intensity training was performed in the competition season because some high-load anaerobic threshold sessions were replaced by sessions in zones 3 and 4, which incorporate a lower training load.

The high proportion of interval training close to the anaerobic threshold, might have led to: 1) the improvements in his racing performance (from 3:50.63 in 2008 to 3:35.43 in 2012 for the 1500 m), 2) excellent aerobic capacity (VO_{2max}, 84.4 $ml \cdot kg^{-1} \cdot min^{-1}$ in 2010), 3) high vAT (18.2 $km \cdot h^{-1}$ in 2010) and 4) good running economy (the best result among 34 Norwegian elite distance runners (Tjelta, Tjelta & Dyrstad, 2012)).

Both the athlete and his coach stressed that the advantage of anaerobic threshold training compared with more intensive interval training was that the athlete could tolerate a high load on each work-out. They claimed that it would have resulted in overtraining if the intensities of these sessions had been higher. This is in agreement with the study by Billat et al. (1999) who found increased subjective stress and symptoms of overtraining in middle-distance runners who performed three high-intensity sessions during a training period, one lactate threshold session and two continuous running sessions per week.

Conclusion

This paper has analysed the training performed by the 2012 European 1500 m track Champion from an age of 17 in 2008 until an age of 21 in 2012. During this period, he gradually increased his average weekly training volume from 100–110 km · week^{-1} in 2008 to 145-160 km · week^{-1} in 2012. During the build-up periods in 2012, 33% of his training volume was performed as interval training at and above his anaerobic threshold. This high volume of interval training typically performed in 5 weekly sessions in 2012 might have given an advantageous contribution to his VO_{2max}, vAT, running economy and to his progression as a runner.

References

Billat, V. L., Demarle, A., Slawinski, J., Paiva, M., & Koralsztein, J. P. (2001). Physical and training characteristics of top-class marathon runners. *Medicine & Science in Sports & Exercise,* **33**, 2089-2097.

Billat, V. L., Flechet, B., Petit, B., Muriaux, G., & Koralsztein, J. P. (1999). Interval training at VO2max: effects on aerobic performance and overtraining markers. *Medicine & Science in Sports & Exercise,* **31**, 156-163.

Bosquet, L., Leger, L., & Legros, P. (2002). Methods to determine aerobic endurance. *Sports Medicine,* **32**, 675-700.

Brandon, L. J. (1995). Physiological factors associated with middle distance running performance. *Sports Medicine*, **19**, 268-277.

Daniels, J., & Scardina, N. (1984). Interval training and performance. *Sports Medicine*, **1**, 327-334.

Enoksen, E., Tjelta, A. R., & Tjelta, L. I. (2011). Distribution of Training Volume and Intensity of Elite Male and Female Track and Marathon Runners. *International Journal of Sports Science & Coaching,* **6**, 273-293.

Esteve-Lanao, J., Foster, C., Seiler, S., & Lucia, A. (2007). Impact of training intensity distribution on performance in endurance athletes. *Journal of Strength & Conditioning Research*, **21**, 943-949.

Esteve-Lanao, J., San Juan, A. F., Earnest, C. P., Foster, C., & Lucia, A. (2005). How Do Endurance Runners Actually Train? Relationship with Competition Performance. *Medicine & Science in Sports & Exercise*, **37**, 496-504.

Helgerud, J., Høydal, K., Wang, E., Karlsen, T., Berg, P., Bjerkaas, M., Hoff, J. (2007). Aerobic High-Intensity Intervals Improve VO2max More Than Moderate Training. *Medicine & Science in Sports & Exercise,* **39**, 665-671.

Jones, A. M. (2006). The Physiology of the World Record Holder for the Women's Marathon. *International Journal of Sports Science & Coaching,* **1**, 101-116.

Jung, A. P. (2003). The impact of resistance training on distance running performance. *Sports Medicine (Auckland, N.Z.),* **33**, 539-552.

Laursen, P. B., & Jenkins, D. G. (2002). The Scientific Basis for High-Intensity Interval Training: Optimising Training Programmes and Maximising Performance in Highly Trained Endurance Athletes. *Sports Medicine,* **32**, 53-73.

Lucia, A., Hoyos, J., Carvajal, A., & Chicharro, J.L. (1999). Heart rate response to professional road cycling: the Tour de France. International Journal of Sports Medicine, **20**:167-172.

Lucia, A., Hoyos, J., Santalla, A., Earnest, C., & Chicharro J.L. (2003). Tour de France versus Vuelta a Espana: which is harder? *Medicine & Science in Sports & Exercise,* **35**:872-878.

Maffulli, N., Capasso, G., & Lancia, A. (1991). Anaerobic threshold and performance in middle and long distance running. *The Journal Of Sports Medicine And Physical Fitness,* **31**, 332-338.

Midgley, A. W., McNaughton, L. R., & Wilkinson, M. (2006). Is there an Optimal Training Intensity for Enhancing the Maximal Oxygen Uptake of Distance Runners?: Empirical Research Findings, Current Opinions, Physiological Rationale and Practical Recommendations. *Sports Medicine,* **36**, 117-132.

Robinson, D. M., Robinson, S. M., Hume, P. A., & Hopkins, W. G. (1991). Training intensity of elite male distance runners. *Medicine & Science in Sports & Exercise,* **23**, 1078-1082.

Seiler, S., & Kjerland, G. Ø. (2006). Quantifying training intensity distribution in elite endurance athletes: is there evidence for an optimal distribution? *Scandinavian Journal of Medicine & Science in Sports,* **16**, 49-56.

Seiler, S., & Tønnessen, E. (2009). Intervals, Thresholds and Long Slow Distance: The Role of Intensity and Duration in Endurance Training. *Sportscience,* **24**, 1340-1345.

Shepley, B., Macdougall, J.D., Cipriano, N., Sutton, J.R., Tarnopolsky, M.A., & Coates, G. (1992). Physiological-effects of tapering in highly trained athletes. Journal of Applied Physiology 1992, **72**:706-711.

Smith, T. P., Coombes, J. S., & Geraghty, D. P. (2003). Optimising high-intensity treadmill training using the running speed at maximal O2 uptake and the time for which this can be maintained. *European Journal of Applied Physiology,* ***89***, 337-343.

Spencer, M. R., & Gastin, P. B. (2001). Energy system contribution during 200- to 1500-m running in highly trained athletes. *Medicine & Science in Sports & Exercise,* **33**, 157-162.

Tjelta, L. I., & Enoksen, E. (2010). Training Characteristics of Male Junior Cross Country and Track Runners on Eoropean Top Level. *International Journal of Sports Science & Coaching,* **5**, 193-203.

Tjelta, L. I., Tjelta, A. R., & Dyrstad, S. M. (2012). Relationship between Velocity at Anaerobic Threshold and Factors Affecting Velocity at Anaerobic Threshold in Elite Distance Runners. *International Journal of Applied Sports Sciences*, **24**, 8-17.