Article

What is the training intensity distribution of recreational-level triathletes when preparing for an Olympic distance triathlon?

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Abstract: Despite the continued growth of the sport, particularly among recreational athletes, very little is known about how triathletes prepare for an event. The aim of this study was to identify the training characteristics of recreational-level triathletes and assess how their preparation for a triathlon influences their health and fatigue. During the 6 weeks prior to an Olympic distance triathlon, and the 2 weeks after the event, ten (5 males, 5 females) recreational athletes completed a daily training log to provide information on every training session. In addition, participants answered the Daily Analysis of Life Demands Questionnaire (DALDA), the Training Distress Scale (TDS), and the Alberta Swim Health Questionnaire weekly. Training loads were calculated using session-based rating of perceived exertion (sRPE) and training impulse (TRIMP). Every week of training was compared to week 1 to determine how athletes' training and health changed throughout the study. In the 6 weeks leading up to the event, training loads, total minutes trained, and time spent in each training zone did not differ significantly. Significant reductions in training duration (Z=2.39, p=0.017, ES = 0.90), training strain (Z=2.59, p=0.009, 0.98), and number of sessions (Z=2.49, p=0.012, ES = 0.94) were seen on week 6. Training intensity distribution favored a threshold approach with athletes spending 56% of their training time at zone 1, 40% at zone 2, and 4% at zone 3. No significant changes were seen in the DALDA or TDS questionnaires. The results show that while the training intensity distribution of recreational-level triathletes does not follow a polarized model, these athletes were able to maintain their health while preparing for an Olympic distance triathlon.

Keywords: training loads; monitoring; illness; fatigue; training intensity distribution; threshold training; polarized training;

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1. Introduction

Triathlon is one of the fastest growing sports among recreational athletes, with most athletes competing in the Olympic distance and Ironman events, with the 35-39 years and 40-44 years age groups comprising most participants[1]. Like other aerobic sports such as road running or cycling, triathlon requires above average aerobic power and muscular endurance, along with well-developed anaerobic capacities for surges in pace and for the final moments of the race [2]. However, triathlon is unique when compared to other endurance sports as it requires athletes to train in three distinct modes of exercise [3]. This leads to higher training hours and total workload for triathletes as training frequency (number of sessions per week) is very high [4,5] with Mujika [6] showing that an elite female triathlete performed 796 sessions in the 50 weeks leading up to the 2012 London Olympics.

Such high training volumes are common at lower levels of the sport as well, where Vleck et al. [1] showed that non-elite triathletes training for the Olympic distance averaged 12 sessions per week. This frequency is greater than what has been reported by recreational endurance athletes in single mode sports, with marathon runners training about 4 times per week [7] while recreational cyclists train on average 2 to 3 times per week [8]. For triathletes preparing for longer distances the load is even higher, with Ironman athletes having higher training volume when compared to competitors training for an Olympic distance triathlon due to an increased duration of long bike and run sessions [5]. However, while overall training volume is a fundamental aspect of a training program aimed at enhancing endurance performance, training intensity distribution (TID) has received much attention recently as a potential factor related to adaptations following endurance training [9].

Endurance training is commonly prescribed based on 5 arbitrary training zones that vary in an intensity range from 50% to 100% of maximal oxygen consumption (VO_{2max}) [10]. However, recent studies examining training intensity distribution have utilized individualized thresholds to demarcate three intensity zones (zone 1 – lower intensity, below lactate threshold (LT), zone 2 – moderate intensity, between LT1 and LT2, and zone 3, high intensity, above LT2) [10,11]. Based on this approach, elite endurance athletes seem to organize their training around a polarized approach that has athletes performing a high volume of training at lower intensities combined with a few sessions at higher intensities [10,12,13]. Specifically, a polarized approach requires athletes to spend about 70 to 80% of their total training time at zone 1, and 10 to 20% at zone 3, while minimizing the amount of zone 2 or threshold training (5 to 10% of total training time) [11]. Such approach to training is supported by retrospective studies of training logs from successful endurance athletes [13,14] and by research that has demonstrated that improvements in endurance performance are related to the time spent at zone 1, as long as the contribution of high-intensity training (zone 3) remains significant [12,15].

While training time at lower intensities seems to be beneficial for performance, spending too much time at zone 2 is often associated with poor performance [9]. In fact, when comparing different TIDs, Stöggl and Sperlich [16] demonstrated that while a polarized approach led to positive results in maximal oxygen consumption (VO_{2peak}), time to exhaustion, peak velocity and power, and velocity and power at 4 mmol. L^{-1}, no improvements were seen in the group that performed threshold training over a period of 9 weeks. Similar results were found in recreational Ironman athletes over a period of 6 months, where the lack of adaptation in swimming and cycling was likely related to a small amount of time spent at zone 1 and too much training time spent at zone 2 [17]. These findings are corroborated by other studies performed in recreational-level athletes [9,12,15] and further emphasize that a polarized TID seems to be the optimal approach for performance improvements in this group. In addition, too much training time at threshold intensities is possibly detrimental to athletes' health as well, with research linking it to overuse injuries [18,19], delayed recovery following training sessions [20], and a greater potential to lead to overreaching and overtraining [17,18]. This is of concern for recreational-level athletes as a polarized approach is not what is commonly employed by athletes at this level. In fact, research has shown that athletes often perform their easy sessions at a higher intensity while not pushing as hard as needed on intense training sessions [18], possibly leading to a constant pattern of threshold training.

As a high training frequency is typical of the sport, with multiple sessions a day a common occurrence and with many triathletes training even when injured by increasing the load in another discipline [4,5], this might put triathletes at a higher risk for negative health outcomes associated with training. In addition to the training related stress that can shift athletes' well-being, the general life stress experienced by recreational athletes can also influence their health status [21,22]. Research has demonstrated that individuals who reported higher levels of mental and life stress had blunted adaptive responses following endurance and resistance training programs [23,24], and general stress also seems to moderate the relationship between fatigue and recovery in athletes [25]. This combination of training and external stressors makes the training process a complex exercise in stress management [26], where an adequate balance between stress (training and competition, other life demands) and recovery is essential for athletes to continue to perform at a high-level [21]. In this context, monitoring athletes' training loads and well-being is a key step to ensure early detection of negative health and performance outcomes [27].

Despite the increased participation in the sport, and the potential issues associated with training and health in recreational-level triathletes, very little is known about how these individuals train, with studies failing to report characteristics such as training loads and risk of injury and illness [1]. Thus, the main purpose of this study was to understand the TID of recreational-level triathletes preparing for an Olympic distance triathlon. Secondly, we aimed to understand if the training pattern employed by these triathletes influenced self-reported measures of health, stress, and fatigue. It was hypothesized that these participants would perform a higher volume of training in Zone 2 than what is recommended for optimizing endurance performance. It was also hypothesized that fatigue would be increased with increased training volume and that high levels of fatigue would be associated with illness and musculoskeletal complaints.

2. Materials and Methods

The study was approved by a Research Ethics Board (Pro00082267) and participants were informed of the risks and benefits of the investigation prior to signing an institutionally approved informed consent document. Recruitment occurred online via social media, e-mail communication, and the website of each of the events (WTS Edmonton, WTS Montreal, or Vancouver Triathlon). Participants were eligible if they were between 18 and 50 years of age, had been competing in triathlon for 3 or more years, and regularly trained using a heart rate monitor. Eleven (6 males, 5 females) recreational-level triathletes volunteered to participate in the study. Participants were characterized as recreational athletes as they were competing in the amateur category, were not part of a regional or national development center and trained and competed in their leisure time, as none of them reported training as their main occupation. Participants agreed to record their training programs in the 6 weeks leading to an Olympic distance triathlon that was a major event of their season and the 2 weeks that followed the event. As only two of the 11 participants reported training with a coach at the time of the event through participation in a local triathlon club, the data is representative of the athletes' self-prescribed training strategies.

2.1. Training monitoring

Participants' training was monitored via a custom online training log developed for monitoring training volume for the purposes of this study. Ten of the eleven participants of the study recorded their training throughout the 8 weeks. One participant responded to every weekly questionnaire but only recorded training sessions for the first 2 weeks, and thus, this training data was not included in the study. Participants were instructed to maintain their regular training programs while tracking every session with the use of their own heart rate monitors utilizing a 5-zone approach [10], as this is common practice for many endurance athletes. At the end of the study the 5 zones were transformed into three to provide researchers with information on the training intensity distribution of the participants according to a polarized model. Using the 5-zone model, zones 1 and 2, and zones 3 and 4 were grouped together, to represent zones 1 and 2 in the 3-zone model, respectively, while time at zone 5 in the 5-zone model was considered as zone 3 in the polarized model. This allowed athletes to perform their training at heart rate zones that were very similar to what has been reported in studies on polarized training in recreational athletes (zone 1, heart rate below 77 ± 3%, zone 2, between 77 ± 3% and 91 ± 3%, and zone 3, above 91 ± 3%) [12]. In addition, even though zone 4 is represented as exercise that is performed above the second lactate threshold (4 mmol. L^{-1}) and therefore should be considered as zone 3 in a polarized model [10], zone 4 was considered race pace in this group of athletes since this was the intensity that the Olympic distance triathlon was completed. To calculate their training zones, participants were asked to use the maximal heart rate obtained from a recent (within 6 months) maximal test (VO_{2max}), or to estimate it according to the formula HR_{max} = 208 – 0.7 * age [28]. The training log required participants to report their session goal, activity type and mode, time spent at each training zone, average heart rate, and session rating of perceive exertion (sRPE) [29].

2.2. Training load calculations

External training loads were calculated as the total duration of each session (in minutes) across each week and were later separated by the time spent at each of the three training zones, according to a polarized model [11]. The participants' internal loads were calculated using the session rating of perceived exertion method (sRPE) developed by Foster [29], with the duration of each session multiplied by the rate of perceived exertion (1 – 10) assigned by the athlete for that session. Training monotony, an index of training variability defined as the daily mean load divided by the standard deviation of the load calculated over a week, and strain (the product of training load and monotony) were also calculated for each week [29]. In addition, training impulse (TRIMP) was quantified with the time spent at each of the five training zones being multiplied by a weighting factor (1, 2, 3, 4, and 5, respectively, for each of the five training zones), as utilized with Edward's TRIMP [30]. The total training load for a specific session was then calculated as the sum of the training loads across all training zones.

2.3. Questionnaires

At the end of every training week, participants were asked to complete online versions of three different questionnaires. These questionnaires were sent to participants via a digital link every Sunday morning with participants having until Monday night to complete them. The Daily Analysis of Life Demands for Athletes (DALDA) [31] consists of 9 questions to assess general stress levels and their source (part A) and another 25 questions to determine symptoms of health and fatigue (part B). Participants were required to rate each variable as either "worse than normal", "normal" or "better than normal", with the changes in the numbers of "worse than normal" scores utilized to assess participants' health across the 8 weeks.

The Training Distress Scale Questionnaire (TDS) [32] was used to monitor the athlete's psychobiological response to training and to identify athletes at risk of training-induced distress. The questionnaire consists of 7 items with participants rating their mood responses using a 5-point Likert-scale ranging from "0 – not at all" to "4 – extremely". The sum of the scores was calculated for participants every week, with lower scores meaning the athletes displayed a better mood state. Lastly, the Alberta Swim Fatigue questionnaire [33], a custom online questionnaire used to determine health and fatigue status as well as general attributes associated with good health was used on a weekly basis (Appendix A).

At the beginning of the data collection, 48 hours prior to the event and 2 weeks post-event, athletes were also instructed to complete the Recovery Stress Questionnaire for Athletes (REST-Q). The REST-Q measures the frequency of current stress along with the frequency of recovery associated activities [34]. It consists of 77 items (19 scales with four items each, plus a warm-up item), with a Likert-type scale used with values ranging from 0 (never) to 6 (always), indicating how often the athlete has participated in various activities over the past 3 days and nights [34]. Total stress was calculated as the sum of scores from the 10 stress subscales, while total recovery was calculated as the sum of the 9 recovery subscales. A general indicator of the athletes' recovery-stress balance was calculated as the total stress score minus the total recovery score [35]. High scores in stress-associated scales reflect intense subjective strain, while high scores in the recovery associated scales reflect adequate recovery [34,35].

2.4. Statistical Analyses

Data are presented as means ± standard deviation, unless otherwise stated. Statistical analysis was performed using IBM SPSS® Statistics V.24, with significance level set at $p \leq 0.05$. Data distribution was checked with the Shapiro-Wilk test and a repeated-measures analysis of variance (ANOVA) was used to compare changes between week 1 and every subsequent week to analyze how training progressed leading up to the competition, and in the 2 weeks following the event. Health and fatigue symptoms during the 8 weeks of the study were also analyzed in relation to week 1. Partial eta square effect sizes are reported (η^2), and when a main effect of time was found, post-hoc comparisons were performed using Bonferroni correction, with Cohen's *d* calculated to report effect sizes of pairwise comparisons between weeks (0 – 0.2 = trivial, 0.2 – 0.6 = small, 0.6 – 1.2 = moderate, 1.2 – 2.0 = large, and > 2 = very large) [36]. Only pairwise comparisons between week 1 and every subsequent week were performed. When Mauchly's test was significant, a Greenhouse-Geiser adjustment was used to determine the significance level of the test. If the assumption of normality was violated, Friedman's Test was utilized to assess the main effect of time, with Kendall's W used to report effect sizes. When the main effect of time was significant, the Wilcoxon-Signed Rank test was used to determine differences between weeks, with effect sizes calculated for each comparison ($r = Z / \sqrt{N}$) and interpreted as 0.10 (small), 0.30 (moderate), and 0.50 (large) effect [37]. Correlation analyses between weekly training characteristics (training loads, monotony, and strain) and the "worse than normal" scores on the DALDA questionnaire or the scores on the Training Distress Scale were performed using Spearman's Rank Test.

3. Results

Participants characteristics and descriptive information are presented on table 1.

Table 1. Participants' characteristics. Data presented as mean ± standard deviation (range).

Age at baseline (years)	39 ± 5.5 (30 – 47)
Age when started triathlon training (years)	31.5 (11 – 42)
Triathlon Experience (years)[#]	5 (3 – 12)
Swimming Experience (years)[#]	8 (3 – 30)

Cycling Experience (years)[#]	7 (3 – 26)
Running Experience (years)	15.7 (3 – 31)
Number of races performed last season	3.75 (2 – 5)
Hours of training in the previous year (hours)	341.9 ± 185.1 (150 – 674)
Self-reported number of sessions per week	7.6 ± 1.6 (5 – 10)
Swimming	2.2 ± 1.0 (1 – 4)
Cycling[#]	3 (2 – 3.5)
Running	2.7 ± 0.6 (2 – 4)
Self-reported training volume per week (hours)	8.7 ± 3.5 (3.5 – 13.5)
Swimming	2.4 ± 1.6 (0.5 – 5)
Cycling	3.8 ± 1.5 (1.25 – 6)
Running[#]	2 (1 – 6)
Longest self-reported session (min)	
Swimming	76.6 ± 22.3 (50 – 120)
Cycling	198.4 ± 104.3 (90 – 420)
Running	112.3 ± 45.8 (60 – 180)
Best time in Olympic Distance (min)	150.6 ± 16.2 (122 – 180)
Best swim time	27.7 ± 6.6 (17.6 – 42.0)
Best bike time	71.1 ± 8.4 (61.0 – 85.0)
Best run time	48.1 ± 7.5 (38.8 – 60.0)

[#] data presented as median (range).

3.1 Training characteristics

A summary of training characteristics can be found in table 2.

3.1.1. Training duration (min)

A main effect of time was reported (χ^2 (7) = 19.86, p = 0.006, ES = 0.28), and when compared to week 1 training volume was significantly lower on week 6 (Z = 2.39, p = 0.017, ES = 0.90, median = 331.5 vs 490.6), week 7 (Z = 2.59, p = 0.009, ES = 0.98, median = 191.0 vs 490.6), and week 8 (Z = 2.19, p = 0.028, ES = 0.83, median = 295.1 vs 490.6).

3.1.2. Training time at zone 1

Training time spent at zone 1 significantly changed across the 8 weeks of training ($F(7, 63) = 3.57$, $p = 0.003$, $\eta^2 = 0.28$), with post-hoc analysis showing a significant difference between week 1 and week 6 ($p = 0.048$, 95% CI = 1.40, 371.62, ES = 1.60), with time spent at zone 1 being significantly lower on week 6 (294.1 ± 144.2 vs 107.6 ± 79.9 minutes).

3.1.3. Training time at zone 2

A main effect of time was reported for the time spent training at threshold intensities (χ^2 (7) = 19.11, $p = 0.008$, ES = 0.27), with higher volumes of zone 2 training on week 3 (Z = 2.09, $p = 0.037$, ES = 0.79, median = 188.2 vs 115.3 minutes), and on week 6 (Z = 2.39, $p = 0.017$, ES = 0.90, median = 172.7 vs 115.3 minutes) when compared to week 1.

3.1.4. Training time at zone 3

Training at high intensities for this group of athletes did not change across the 8 weeks (χ^2 (7) = 7.69, $p = 0.361$, ES = 0.11), with most athletes reporting very little training at zone 3, with a median of 14 minutes on week 6 being the highest reported value throughout the study.

3.1.4. Number of sessions per week

While there was a main effect of time reported (χ^2 (7) = 22.97, $p = 0.002$, ES = 0.32), other than a reduction in training sessions on week 2 (Z = 1.99, $p = 0.046$, ES = 0.72, median = 7.0 vs 8.5), participants mainly maintained their training frequency until the week of the event (week 6), where a significant reduction (Z = 2.49, $p = 0.012$, ES = 0.94, median = 5.5 vs 8.5) was reported, with the number of sessions being further reduced following the event on week 7 (Z = 2.49, $p = 0.013$, ES = 0.94, median = 4.5 vs 8.5), when compared to week 1.

3.1.5. Number of swimming, cycling, running, and other sessions

Throughout the 8 weeks of the study, participants had no significant changes in the number of swimming (χ^2 (7) = 8.29, $p = 0.308$, ES = 0.11), and cycling (χ^2 (7) = 10.74, $p = 0.150$, ES = 0.15) sessions that were performed. However, a significant change in the number of running sessions was found (χ^2 (7) = 20.35, $p = 0.005$, ES = 0.29), with a higher number of sessions on week 1 when compared to week 6 (Z = 2.16, $p = 0.03$, ES = 0.82, median = 1.5 vs 3.0 sessions) and week 7 (Z = 2.20, $p = 0.02$, ES = 0.83, median = 0.0 vs 3.0 sessions). A significant main effect of time was reported for other types of sessions performed throughout the 8 weeks (χ^2 (7) = 15.24, $p = 0.033$, ES = 0.21), with a higher number of sessions on week 1 when compared to week 2 (Z = 2.26, $p = 0.024$, ES = 0.85, median = 0.0 vs 1.0 sessions) and week 6 (Z = 2.41, $p = 0.016$, ES = 0.91, median = 0.0 vs 1.0 sessions).

3.2. Training Loads

3.2.1. Session-based RPE (sRPE)

There was a significant main effect of time in relation to training loads performed by the athletes ($F(7,63) = 22.07$, $p = 0.00$, $\eta^2 = 0.33$). However, the only difference occurred between the loads performed during week 1 and week 7 ($p = 0.46$, 95% CI = 17.93, 2.619.42, ES = 1.62, 2248.5 ± 1007.5 vs 930.1 ± 557.6 a.u), indicating that a significant reduction in training load was only seen in the week after the event.

3.2.2. Training impulse (TRIMP)

Throughout the 8 weeks of training no significant changes in training load were seen when the loads were calculated using training impulse (χ^2 (7) = 13.36, p = 0.064, ES = 0.19). Interestingly, utilizing this method the training load during the week of the competition was higher when compared to week 1 (median = 930.8 vs 886.1 a.u), and while there was still a sharp reduction in load after the competition when compared to week 1 (median = 394.0 vs 886.1 a.u), such changes did not reach statistical significance.

3.2.3. Training Monotony

A main effect of time was reported for training monotony (χ^2 (7) = 21.43, p = 0.003, ES = 0.30), with pairwise comparisons showing a significantly lower value for week 6 when compared to week 1 (Z = 2.70, p = 0.007, ES = 1.02, median = 1.0 vs 0.6). No other differences were reported.

3.2.4. Training Strain

A significant main effect of time was reported for training strain (χ^2 (7) = 19.66, p = 0.006, ES = 0.28), with pairwise comparisons showing a significantly higher training strain during week 1 when compared to week 6 (Z = 2.59, p = 0.009, ES = 0.98, median = 2302.9 vs 1319.6), and week 7 (Z = 2.19, p = 0.028, ES = 0.83, median = 2302.9 vs 583.0).

3.3. Questionnaires

3.3.1. DALDA part B

No significant changes were reported in “worse than normal” answers in the DALDA questionnaire throughout the 8 weeks (χ^2 (7) = 12.54, p = 0.084, ES = 0.22). Despite not reaching statistical significance, week 6 presented the best scores when compared to week 1 (median = 1 vs 5).

3.3.2. Training distress questionnaire

No significant changes were found across the 8 weeks (χ^2 (7) = 12.82, p = 0.07, ES = 0.22). Despite the results not reaching statistical significance, similar to what was reported with DALDA, the best scores were reported on week 6 (median = 2 vs 6).

3.3.3. Recovery Stress Questionnaire (REST-Q)

No significant differences were found in participants’ responses at the beginning of data collection, 48 hours prior to the event, or two weeks after it (F(2,16) = 1.31, p = 0. 29, η^2 = 0.14). While not statistically significant, the results collected 48 hours prior to the event saw a decrease in the athletes’ recovery balance when compared to the data from baseline (mean = 61.5 vs 40.3) and to what was reported two weeks later (mean = 71.4 vs 40.3), when the athletes presented the best recovery status.

Table 2. Training characteristics of recreational-level triathletes for 8 weeks (data presented as mean ± SD

Variable	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8	p value	Effect size
Training Loads										
sRPE (a.u)	2248.5 ± 1007. 5	1792.3 ± 941.4	2390.7 ± 698.3	1991.7 ± 986.6	1854.6 ± 868.5	1993.2 ± 615.5	930.1 ± 557.6[a]	1511.7 ± 761.9	0.000	0.337
TRIMP (a.u)[#]	886.1 (593.1, 1329.3)	873.4 (513.6, 1259.0)	1054.0 (940.3, 1320.9)	926.2 (554.7, 1244.2)	837.7 (645.7, 1033.4)	930.8 (774.2, 1173.4)	394.0 (303.5, 781.7)	772.0 (404.1, 1090.0)	0.641	0.191
Training Duration (min)[#]	490.6 (235.2, 546.1)	390.5 (182.3, 526.5)	409.0 (228.3, 523.1)	381.5 (228.3, 523.1)	256.2 (238.8, 419.5)	331.5 (245.5, 370.5)[a]	191.0 (146.4, 303.6)[b]	295.1 (125.8, 363.1)[a]	0.006	0.284
Time at Zone 1 (min)	294.1 ± 144.2	237.8 ± 150.2	209.5 ± 101.5	223.0 ± 111.5	174.9 ± 118.2	107.6 ± 79.9[a]	150.8 ± 103.9	158.3 ± 131.6	0.003	0.284
Time at Zone 2 (min)[#]	115.3 (31.5, 174.9)	109.8 (63.3, 204.7)	188.2 (141.2, 289.5)[a]	124.2 (39.3, 233.9)	124.2 (73.6, 170.7)	172.7 (124.2, 268.6)[a]	57.7 (29.5, 130.1)	116.0 (44.7, 195.0)	0.008	0.273
Time at Zone 3 (min)[#]	3.1 (0.0, 22.5)	3.5 (0.9, 17.5)	6.4 (0.0, 26.5)	9.6 (0.0, 30.1)	13.6 (0.7, 33.4)	14.0 (0.0, 27.0)	3.6 (0.0, 17.3)	0.0 (0.0, 11.2)	0.361	0.110

Training Monotony (a.u)[#]	1.0 (0.8, 1.3)	1.1 (0.8, 1.3)	0.9 (0.6, 1.6)	1.0 (0.7, 1.4)	0.8 (0.7, 1.4)	0.6 (0.5, 0.7)	0.7 (0.6, 1.2)	0.9 (0.8, 1.1)	0.003	0.306
Training Strain (a.u)[#]	2302.9 (1575.2, 2726.6)	2199.9 (918.0, 3232.1)	2347.1 (1394.4, 3492.9)	2518.9 (1017.7, 3557.8)	1646.7 (1111.1, 3099.6)	583.0 (298.3, 1423.9)[b]	1441.3 (910.8, 2518.9)[a]	1319.6 (1062.7, 1652.8)	0.006	0.281
Number of Sessions per week[#]	8.5 (5.7, 10.2)	7.0 (5.7, 8.0)[a]	7.5 (5.7, 9.2)	6.5 (5.7, 8.5)	6.0 (4.7, 7.5)	5.5 (4.0, 6.25)[a]	4.5 (3.7, 7.0)[a]	7.0 (5.2, 8.2)	0.002	0.328
Swimming sessions per week[#]	2.0 (1.0, 3.0)	2.0 (1.0, 3.0)	2.5 (1.7, 3.0)	1.0 (1.0, 3.0)	2.0 (1.0, 3.0)	1.0 (1.0, 2.2)	1.0 (1.0, 2.2)	1.0 (0.0, 3.0)	0.308	0.118
Cycling sessions per week[#]	2.0 (1.75, 3.2)	2.5 (1.5, 3.0)	3.0 (2.0, 3.2)	2.0 (1.7, 3.0)	2.5 (1.0, 4.0)	1.5 (1.0, 3.0)	1.0 (1.0, 2.2)	1.0 (0.0, 3.2)	0.150	0.153
Running sessions per week[#]	3.0 (2.0, 4.0)	2.5 (1.7, 3.0)	2.0 (0.7, 3.0)	2.0 (0.0, 3.2)	2.0 (0.7, 3.0)	1.5 (0.0, 2.0)[a]	1.0 (0,0, 1.5)[a]	2.5 (1.7, 3.0)	0.005	0.291
Number of other sessions per week[#]	1.0 (0.0, 2.2)[a]	0.0 (0.0, 1.0)	1.0 (0.0, 1.0)	1.0 (0.0, 2.0)	0.0 (0.0, 1.2)	0.0 (0.0, 0.2)[a]	0.0 (1.0, 2.0)	0.0 (0.0, 3.0)	0.033	0.218

[a] denotes a significant difference from week 1 ($p < 0.05$)

[b] denotes a significant difference from week 1 ($p < 0.001$)

[#] data presented as median (25th percentile, 75th percentile)

3.3.4. Correlational analysis between training loads and questionnaires

There was a positive correlation between the training loads based on training impulse (TRIMP) and the "worse than normal" DALDA responses on week 4 (ρ (8) = 0.687, p = 0.028). No other significant correlations between training loads based on sRPE and TRIMP, monotony, or strain and the DALDA and the Training Distress Scale responses were found.

3.3.5. Alberta Swim Health Questionnaire

Throughout the 8 weeks of training, the number of athletes who reportedly had enough sleep was lower on weeks 1 and 2, with most athletes reporting enough sleep in the subsequent weeks. Weeks 6 and 7 presented some of the lowest reports of negative health symptoms (cold, flu, upset stomach, not feeling good overall), muscular aches and soreness, and niggles. Still, such symptoms were reported every week by at least 40% of the athletes, with 20% of them having to modify their training on a weekly basis. Results from the Alberta Swim Health Questionnaire are presented in table 3.

Table 3. Descriptive data regarding athletes' health status according to the Alberta Swim Health Questionnaire.

Title 1	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8
Number of athletes who reported enough sleep	3	5	10	9	8	8	9	7
Number of athletes who reported general symptoms	5	4	2	3	5	1	3	3
Number of athletes who reported aches and soreness	6	7	5	9	7	5	9	6
Number of athletes who reported niggles	8	7	7	7	6	5	7	6
Number of athletes who modified training	3	5	2	5	3	3	2	3

4. Discussion

This study addressed a gap in the literature by providing information on how recreational-level triathletes prepare for a major event. Considering that only 2 participants reported training with a coach, corroborating what had been stated by Vleck et al. [1] that most age-groupers do not have any assistance during training, the results presented in this study provide a clearer picture of how recreational triathletes program their training in the weeks leading up to competition. Training frequency in this group of athletes was lower when compared to what was reported by competitive, but non-elite athletes [5], with the recreational-level triathletes in this study averaging close to 7 sessions per week throughout the 8 weeks compared to 12 by competitive athletes. While training volume was also lower compared to what has been reported by recreational-level triathletes in the 6 months of preparation for an Ironman event [17], it was still higher than what has been reported in other recreational endurance athletes, such as road cyclists [8] and marathoners [7], corroborating the fact that a high training frequency is typical of triathlon [4,5].

One key finding in this group is that progressive overload, a key training principle for improvements in performance [38], was not seen in the weeks leading up to the event. In fact, there seems to be no discernible pattern among the training loads performed by these athletes, as shown in figures 1 and 2. In addition, despite the fact that athletes belonged to a similar age group and had comparable training experience, training characteristics and TID were remarkably different for each athlete, as can be seen in figure 2. Based on what was reported by the participants, it seems that training for a competitive event in this group was a balancing act between the hours of training and general life. Indeed, 4 participants highlighted the fact that at some point, they used their commutes to and from work as “training sessions”, and 3 participants reported difficulties in maintaining their training programs due to other commitments, such as work or family life taking precedence over training.

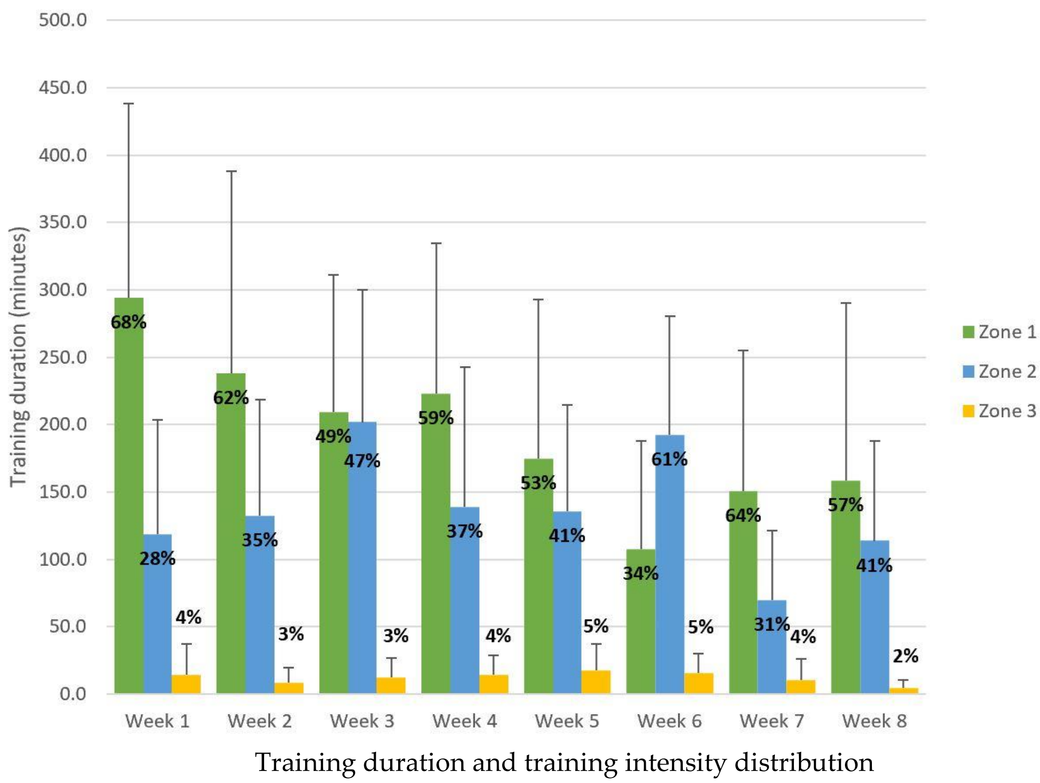
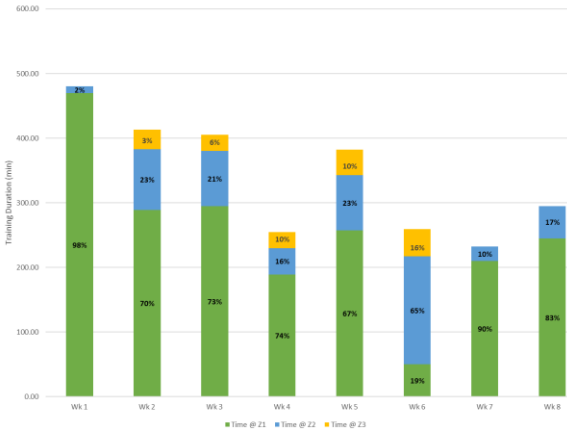
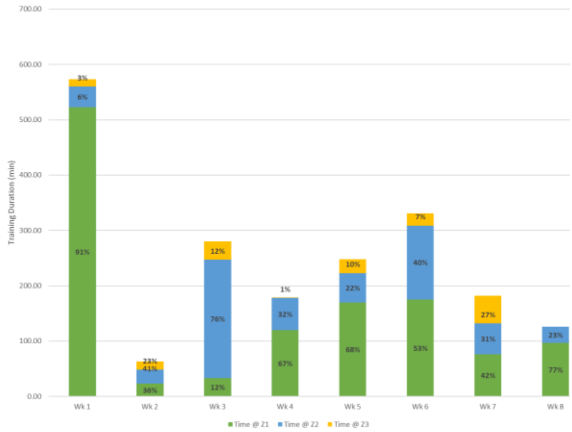


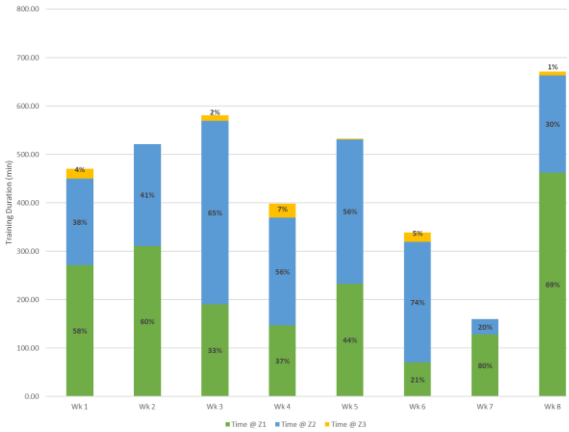
Figure 1. Average training duration and intensity distribution in recreational-level triathletes throughout the 8 weeks of training. The numbers represent the percentage of total time spent at each training zone.



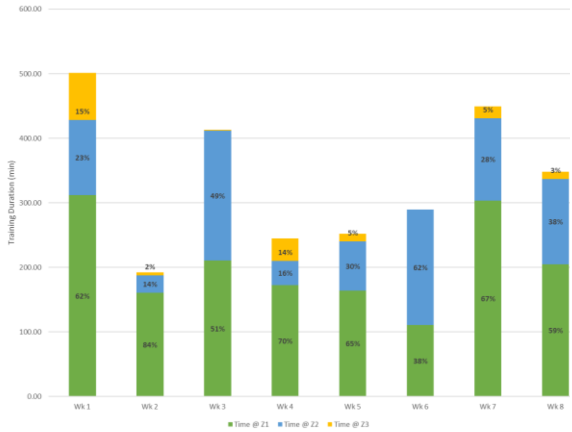
(a) Training duration and training intensity distribution for participant 1.



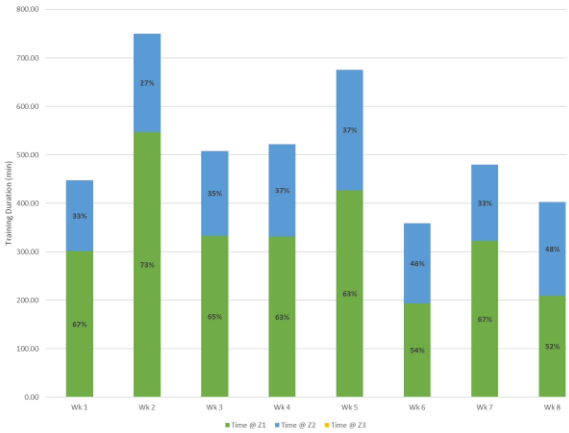
(b) Training duration and training intensity distribution for participant 2.



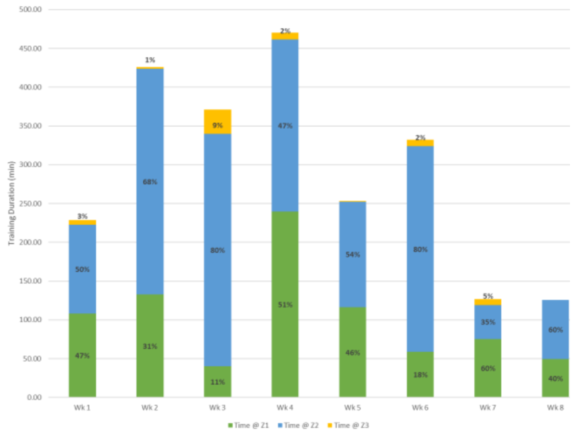
(c) Training duration and training intensity distribution for participant 3.



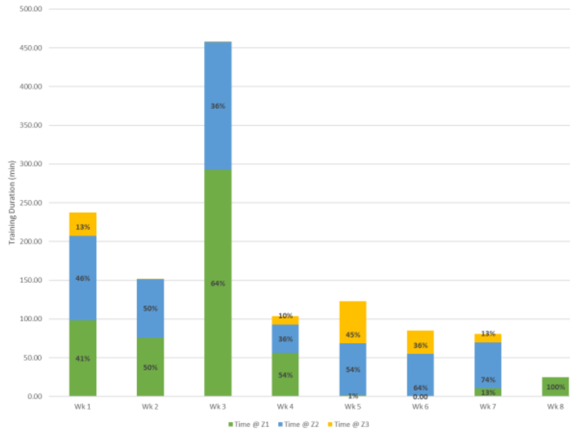
(**d**) Training duration and training intensity distribution for participant 4.



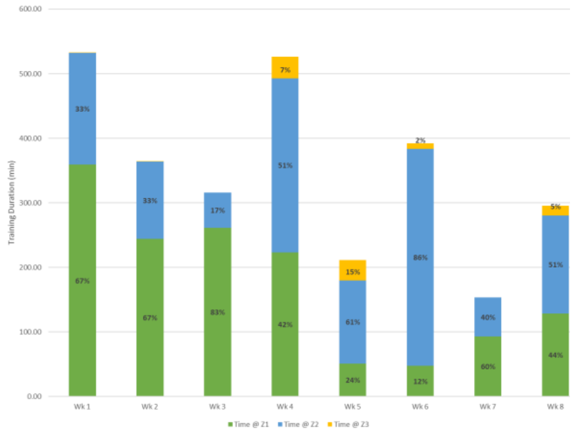
(**e**) Training duration and training intensity distribution for participant 5.



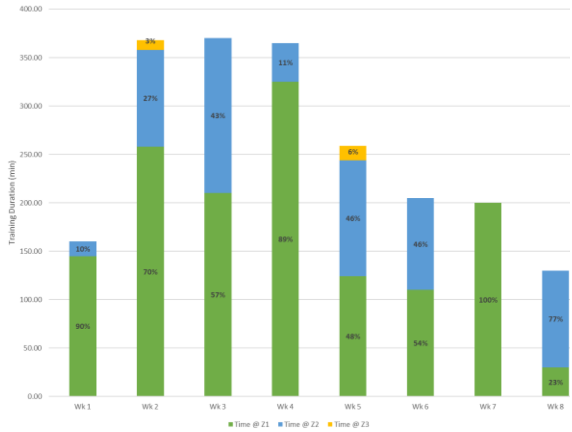
(**f**) Training duration and training intensity distribution for participant 6.



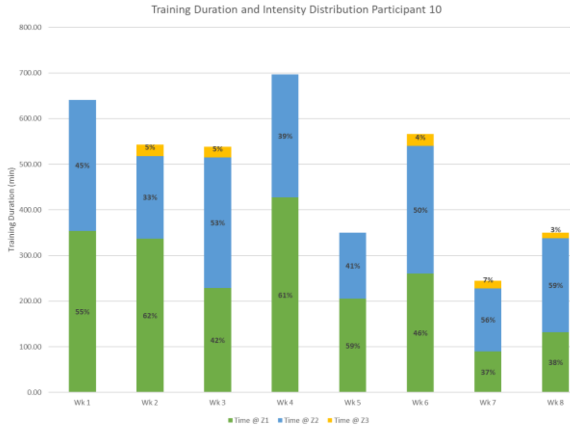
(**g**) Training duration and training intensity distribution for participant 7.



(**h**) Training duration and training intensity distribution for participant 8.



(**i**) Training duration and training intensity distribution for participant 9.



(h) Training duration and training intensity distribution for participant 10.

Figure 2. Training duration and training intensity distribution for each participant throughout the 8 weeks. The numbers in the bars indicate the percentage of time spent at each training zone.

Concurrently with the lack of progression in training loads across weeks, little to no changes were found in the amount of time spent at each training zone, with an increase in training at zone 2 on week 3 being the only significant progression that occurred in the 6 weeks leading up to the competition. Common guidelines for endurance athletes have demonstrated that as the competition approaches, the amount of time spent at zone 1 is reduced, while training time spent at higher intensities is increased [14,39]. While the taper period prior to competition can be as short as four days, best practices to enhance performance suggest a period of 7 to 21 days of gradual decrease in training volume (up to 40 to 60%), achieved by a reduction in training duration with a concomitant increase in training intensity [40]. Thus, regardless of the athletes' approach to training and tapering, at least during the initial 4 weeks of the study, a progression in training loads was expected.

In addition, the lack of time spent at higher intensities is certainly detrimental to athletes' performance, as research has demonstrated that the combination of time spent at zone 1 and zone 3 is the best approach for improvements in endurance performance [12,15,16]. Particularly, it seems that training at lower intensities even with longer durations might provide a stimulus for adaptations to occur without inducing a significant level of systemic stress [20], corroborating studies that related improvements in endurance performance to a higher volume of training at zone 1 [9,12,15]. Training at higher intensities is also key to enhancing performance in recreational athletes via increases in maximal oxygen uptake and running economy [39,41]. Research has demonstrated that recreationally-trained athletes can accumulate a significant amount of work at higher intensities at manageable levels of exertion, and that these athletes can tolerate two intense sessions a week when these are combined with lower intensity sessions [42]. Furthermore, as recreational-level athletes may struggle to stick to their training routines, as seen in athletes' logs in this study, it is interesting to note that training at zone 3 using high-intensity interval training sessions can elicit performance improvements even when training volume is reduced up to 54% [43].

Thus, the lack of training at higher intensities (Zone 3) led to an average training intensity distribution that heavily favored a threshold approach in this group (56% at zone1, 40% at zone 2, and 4% at zone 3), corroborating our main hypothesis. This distribution is very similar to what was used in a recent study (57%, 43%, and 0%, at zones 1, 2, and 3, respectively) that compared the effects of 6 weeks of threshold or polarized training in trained cyclists with improvements favoring the polarized group in peak power output, lactate threshold and high-intensity exercise capacity [44]. While the threshold group still showed improvements following 6 weeks of training, other research studies show this is not always the case. Stöggl and Sperlich [16] demonstrated that a threshold training group had no improvements in performance following 9 weeks of endurance training, while Esteve-Lanao et al. [45] and Neal et al. [17] showed that the lack of improvements in sub-elite and recreational endurance athletes' performance was related to a higher training volume at zone 2. Considering that in this study the first two training zones from the 5-zone model were considered as zone 1 when transformed to 3 zones, it is likely that the total amount of threshold training was even higher, as the first two zones in a 5-zone model encompass training that is possibly performed slightly above the first lactate threshold (1.5 – 2.5 mmol. L^{-1}) [10]. Thus, some of the time at zone 1 determined in this study could be considered threshold training, increasing the total amount of zone 2 from what has been reported.

Too much time spent at threshold intensities is limiting not only to athletes' performance [16,44] but also possibly detrimental to their health as well [17,18]. Training at such intensities has been shown to delay the recovery of the autonomic nervous system when compared to training at a lower intensity [20], with such delay being larger in athletes who are not highly trained. As described by the authors [20], this is critical for athletes performing two sessions a day, a common practice for triathletes and something that was often reported by the participants in this study. In addition, a high volume of training at threshold intensities might be a factor leading to symptoms associated with overreaching and overtraining. Foster [29] showed that a program consisting of 6 days of more or less equivalent hard training led to a higher training strain when compared to a program focused on 4 hard training sessions with the addition of two recovery days (30 minutes at an RPE of 3), despite both programs having the same total workload. Thus, it seems that recreational-level triathletes might benefit from a reduction in the training time spent at threshold intensities in two ways. First, a reduction in threshold training likely enhances preparedness for zone 3 sessions as such reduction would lead to higher amounts of training at zone 1, which does not induce a significant level of stress [20], and is directly related to improvements in endurance performance [9,15,45]. Second, because triathletes often perform multiple sessions in the same day, recovery between sessions would not be compromised by the greater systemic stress induced by threshold training [20], and thus performing a lower intensity (zone 1) session in the morning would reduce recovery time, allowing athletes to perform at a high level on the second session of the day.

However, even though the training patterns in these athletes are suboptimal to their health, no significant changes in athletes' health status were seen according to their answers to the DALDA questionnaire, the Training Distress Scale, or the REST-Q. It is likely that the small number of participants, the different training loads between athletes, and the randomness of the training programs could explain such results. In multiple weeks, some of the athletes with the heaviest workloads also had the fewest number of "worse than average" scores on the DALDA and the lowest scores on the Training Distress Scale, while reporting very little, if any, negative health symptoms or musculoskeletal issues according to the Alberta Swim Health Questionnaire. This corroborates the idea that a high training load does not necessarily pose a health or injury risk as long as these workloads were achieved safely [46]. Furthermore, given that every athlete in the study had multiple years of experience in triathlon and even more experience in training for other endurance sports, it is possible that athletes had an intrinsic knowledge of what a tolerable load is per week for them, thereby avoiding such threshold and keeping them, on average, healthy and injury free.

Still, despite the fact that these athletes were apparently healthy according to the DALDA, the TDS, and the REST-Q, signs and symptoms associated with excessive training and not enough recovery were reported. Specifically, muscle soreness, aches, and niggles were reported every week by at least 40% of the athletes, with 20% of them having to modify their training on a weekly basis. This modification to training is similar to what has been previously reported in the literature, with athletes often increasing the load in another discipline when necessary [1,4]. In addition, these reports might indicate a lack of recovery during training, which could eventually lead to overuse injuries, the most frequently cited occurrence in triathletes [5]. Lastly, an increased recovery might also be needed as research has demonstrated that recreational athletes possibly experience a significant amount of life stress [47], a factor that has also been linked to increased injury rates and negative performance [48].

5. Conclusions

This study examined the training characteristics of recreational-level triathletes in the 6 weeks leading up to a major competition, and the 2 weeks after the event. Training frequency is lower than what has been previously reported in higher levels of the sport [5] or for recreational-level triathletes focusing on longer distances [17], but still higher than what is seen for recreational athletes in other endurance sports [7,8]. Despite an overall reduction in training volume and loads in the weeks leading up to a major event, there seems to be no discernible training pattern in the athletes' preparation, with the number of sessions, training minutes, and time spent at each training zone remaining mostly constant. Thus, similar to what has been previously reported [18,19], this study shows that this group of triathletes do not follow optimal guidelines in terms of TID, progressive overload, or tapering. This highlights an obvious gap in the knowledge translation from what is published in scientific literature and what is employed in the real world by recreational endurance athletes. Therefore, it is essential that current information on best training practices for endurance performance be made available to participants competing in endurance sports.

Particularly, recreational-level triathletes should track their training in a manner that allows them to visualize how much training is being performed at each zone (zones 1, 2 and 3), improving their ability to use a polarized approach to their training. In addition, athletes' training program should allow for a progressive increase in training load throughout the season, with a taper performed in the days or weeks leading up to the main competition. Lastly, while a high training frequency is typical of the sport and might be necessary given the need to excel in three distinct modes of exercise, recreational athletes would benefit from having a practical tool, such as the questionnaires used in this study, to assess their health and fatigue on a weekly basis, providing enough recovery when necessary, so that athletes do not have to modify their training programs on a regular basis due to excessive fatigue or negative health symptoms. Further investigations into current training practices of recreational-level triathletes are required to verify the findings in this study, while assisting to reduce the gap that exists between the best practices that have been established in research and what is currently performed by this group of athletes.

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