From Heart-Rate Data to Training Quantification: A Comparison of 3 Methods of Training-Intensity Analysis

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Purpose: The authors directly compared 3 frequently used methods of heart-rate-based training-intensity-distribution (TID) quantification in a large sample of training sessions performed by elite endurance athletes.

Methods: Twenty-nine elite cross-country skiers (16 male, 13 female; 25 ± 4 y; 70 ± 11 kg; 76 ± 7 mL · min⁻¹ · kg⁻¹ VO₂max) conducted 570 training sessions during a ~14-d altitude-training camp. Three analysis methods were used: time in zone (TIZ), session goal (SG), and a hybrid session-goal/time-in-zone (SG/TIZ) approach. The proportion of training in zone 1, zone 2, and zone 3 was quantified using total training time or frequency of sessions, and simple conversion factors across different methods were calculated.

Results: Comparing the TIZ and SG/TIZ methods, 96.1% and 95.5%, respectively, of total training time was spent in zone 1 (P < .001), with 2.9%/3.6% and 1.1%/0.8% in zones 2/3 (P < .001). Using SG, this corresponded to 86.6% zone 1 and 11.1%/2.4% zone 2/3 sessions. Estimated conversion factors from TIZ or SG/TIZ to SG and vice versa were 0.9/1.1, respectively, in the low-intensity training range (zone 1) and 3.0/0.33 in the high-intensity training range (zones 2 and 3).

Conclusions: This study provides a direct comparison and practical conversion factors across studies employing different methods of TID quantification associated with the most common heart-rate-based analysis methods.

Keywords: XC skiers, endurance training, intensity distribution, time in zone, session goal

The training dose-adaptive response relationship is at the core of sports physiology and performance. However, quantifying training dose remains an area of some confusion. Focusing on endurance athletes, training dose can be measured in terms of external work executed (distance, power, velocity)¹,² or internal physiological responses elicited by that work (heart rate [HR], blood lactate, VO₂).³–¹³ Training dose can also be measured by how the stimulus was perceived (session rating of perceived exertion [RPE]).¹²,¹⁴–¹⁸ Most high-level endurance athletes maintain a training diary where they report their training. In reality, some combination of all 3 of these basic descriptions of the training dose is usually reflected in athlete self-report.¹,³–⁶,⁸,¹⁰–¹²,¹⁹,²⁰

Three basic approaches are described in the literature for quantifying endurance-training sessions based on the HR response. One approach is time in zone (TIZ).⁴,⁵,⁹–¹² Dedicated software allocates HR registration data to intensity zones defined from cutoffs registered in the software by the athlete or coach. A second method is session goal (SG).¹² This categorical approach assigns the entire session into a single intensity zone with the assumption that the “goal portion” of the session primarily determines its impact as an adaptive signal and source of physiological stress. A categorical approach likely gives a realistic picture of the total training-intensity distribution (TID) over the long term and is frequently cited in the literature.¹²,¹⁴–¹⁸

The SG method has also been found to agree well with intensity categorization based on session RPE (sRPE).¹² A third approach is a hybrid combination of SG and TIZ, called the modified SG approach (SG/TIZ) in the literature.⁶–⁸,¹³,¹⁹ The goal of the session is used to aid in allocating training time to intensity zones, based on a combination of actual HR registration and workloads applied.

Figure 1 illustrates the 3 methods by depicting beat-for-beat HR responses to a typical endurance session lasting ~90 minutes. The elite athlete performed interval training organized as 5 × 8-minute work periods with 2-minute recoveries, in addition to a warm-up and cooldown period. Blood lactate concentrations during the first, third, and fourth rest periods were 3.5, 4.2, and 5.6 mmol/L, respectively. The session was prescribed as a zone 3 interval session based on the 3-zone model (Table 1). The athlete’s maximal HR is 200. The TIZ method uses the HR curve (solid line) to allocate time in different zones. Thirty-five minutes are distributed in zone 3, plus 48 minutes in zone 1 and 5 minutes in zone 2. The SG approach categorizes this whole workout as a zone 3 session based on the highest intensity achieved...
and the accumulated duration at that intensity. The dotted line indicates the SG/TIZ method, giving 40 minutes in zone 3 and 48 minutes in zone 1, and is based on the workload actually performed rather than HR alone. Both the SG and SG/TIZ methods use lactate values as additional information to determine correct intensity zones (Table 1). Critically, the validity of all 3 methods for investigating training dose, adaptive response, and performance development depends on consistent and comparable interpretation of training data by coaches and scientists.

Seiler and Kjerland\textsuperscript{12} provided data comparing SG with TIZ. However, that was not the primary focus of that study, which described the concept of a polarized TID. No study since has systematically quantified TID derived from 3 different methods in highly trained athletes. The TID of endurance athletes has received increased attention in both descriptive\textsuperscript{1–3,6–13,18,20} and experimental studies,\textsuperscript{21–23} as well as recent reviews.\textsuperscript{24,25} Because these 3 methods are used interchangeably there can be confusion regarding interpretation of training data, although the problem has been discussed.\textsuperscript{12}

The purpose of this study was therefore to directly compare 3 methods of TID quantification in a large sample of training sessions performed by elite endurance athletes.

![Figure 1](image)

**Figure 1** — Illustration of intensity distribution using 3 different methods. Three basic intensity zones are exemplified here. The time-in-zone method uses the heart-rate curve (solid line) as the basis for allocating time in different zones. The session-goal/time-in-zone method uses the dotted line in combination with lactate values. The session-goal approach defines this example as a zone 3 session based on the intensity during the core section of the session in combination with lactate values.

<table>
<thead>
<tr>
<th>Intensity zone</th>
<th>Lactate\textsuperscript{a} (mmol/L)</th>
<th>Heart rate (% max)</th>
<th>3-zone model</th>
<th>Binary model</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>6.0–10.0</td>
<td>92–97</td>
<td>Zone 3</td>
<td>high-intensity training</td>
</tr>
<tr>
<td>4</td>
<td>4.0–6.0</td>
<td>87–92</td>
<td>Zone 3</td>
<td>high-intensity training</td>
</tr>
<tr>
<td>3</td>
<td>2.5–4.0</td>
<td>82–87</td>
<td>Zone 2</td>
<td>high-intensity training</td>
</tr>
<tr>
<td>2</td>
<td>1.5–2.5</td>
<td>72–82</td>
<td>Zone 1</td>
<td>low-intensity training</td>
</tr>
<tr>
<td>1</td>
<td>0.8–1.5</td>
<td>55–72</td>
<td>Zone 1</td>
<td>low-intensity training</td>
</tr>
</tbody>
</table>

Note: The reference values in this scale are guidelines only, and individual adjustments are required.

\textsuperscript{a} Measured with lactate pro LT-1710.
Methods

Subjects
Twenty-nine elite cross-country skiers volunteered their informed written consent to participate in the study, which was approved by the Regional Ethics Committee of Southern Norway. Their physical characteristics are shown in Table 2. All subjects were on the Norwegian Cross-Country National Team. Of these, 28 athletes had won medals in senior or junior World or Olympic championships and were experienced in the use of HR watches and training-intensity control.

Training-Data Collection
Data collection was performed during an altitude-training camp in Val Senales (Italy) in October 2012. The average length of the data-collection period for each athlete was 14 days (range 8–18 d). Athletes were instructed to carry out their normal training and use an HR monitor during every session. In total, complete HR data were collected from 570 sessions with accompanying lactate measurements (380 samples).

Intensity-Zone Classification
Norwegian athletes normally use a 5-zone aerobic intensity scale for prescription and reporting of endurance training. This scale is a standardized guideline, with individual test profiles used to identify specific HR and blood lactate cutoffs (Table 1). In the current study, athletes were asked to report their individualized 5-zone scale previously established based on physiological testing and field experience. Laboratory testing includes a standardized incremental submaximal exercise test running at 10.5% inclination on a treadmill. The test consists of four 5-minute stages at increasing velocity (55–90% of VO2max), with VO2 and HR sampled during the last minute of each stage and blood lactate measured in the 30-second recoveries between stages. This lactate-profile test is followed by a VO2max test (described previously26). All athletes were tested regularly (during the last year). The design of intensity zones based on these tests has been previously described.27 Although HR and lactate values differ slightly at different time points, with different sport-specific movements and so on, zones can be expected to remain relatively constant over the course of a training year,28 and athletes therefore only use 1 scale to simplify their daily intensity-control regimen.

To compare the 3 TID methods described, we chose to collapse the 5-zone scale into 3 zones corresponding to physiological anchor points such as first and second ventilatory and lactate thresholds (VT1/2 and LT1/2).24 To calculate conversion factors across different methods, only a binary model was used, low-intensity/high-intensity training (LIT/HIT), to simplify the method and core study outcome (Table 1).

Data Analyses
All training sessions were analyzed using 3 methods; TIZ, SG, and SG/TIZ (Figure 2).

• **TIZ:** HR was recorded continuously during sessions and divided into HR-zone cutoffs to allocate exact time in zone 1, 2, or 3 (Figure 1 and Table 1). Individual HR cutoffs between zones were provided by each athlete as described. All athletes used a Garmin HR watch Forerunner 910XT or 610 (Garmin, Olathe, KS, US) with a sampling frequency of 1 Hz. HR data were subsequently uploaded to the Garmin Training Center (version 3.6.5) and further analyzed in Microsoft Excel (2010).

• **SG:** In the SG approach, the primary goal of the session was used as a basis for categorical allocation of each whole training session to zone 1, 2, or 3 (Figure 1 and Table 1). Interval sessions where the intended intensity during the core portion was in zone 2/3 were categorized as zone 2/3 sessions if

Table 2  Physical Characteristics of the Subjects (Mean ± SD)

<table>
<thead>
<tr>
<th></th>
<th>Men, n = 16</th>
<th>Women, n = 13</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (y)</td>
<td>26 ± 3.0</td>
<td>24 ± 4.0</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>181 ± 5.0</td>
<td>168 ± 5.0</td>
</tr>
<tr>
<td>Body mass (kg)</td>
<td>77.6 ± 6.5</td>
<td>61.2 ± 6.6</td>
</tr>
<tr>
<td>Heart rate max (beats/min)</td>
<td>194 ± 8.0</td>
<td>195 ± 8.0</td>
</tr>
<tr>
<td>VO2max (mL · kg⁻¹ · min⁻¹)</td>
<td>79.8 ± 5.0</td>
<td>70.3 ± 5.0</td>
</tr>
<tr>
<td>VO2max (L/min)</td>
<td>6.2 ± 0.5</td>
<td>4.3 ± 0.3</td>
</tr>
</tbody>
</table>

Figure 2 — Training sessions executed by 29 elite athletes during 8- to 18-day training camp, along with accompanying heart-rate (HR data), lactate measurements, and lactate profile test data, were distributed into 3 intensity zones via 3 different methods: HR-derived time in zone, a categorical session-goal allocation, and a hybrid session-goal/time-in-zone distribution.
HR and lactate measurements confirmed that they were executed as planned (Table 2). All of these sessions were planned and executed such that the accumulated high-intensity work time exceeded 25 minutes. For continuous sessions, an accumulation of >15 minutes was set as a threshold for categorizing the entire session as zone 2/3.

• SG/TIZ: The SG/TIZ approach combines the SG and TIZ approaches. For continuous sessions, TIZ was defined using HR curves as a visual starting point (Figure 1 and Table 1). Periods that were clearly in zone 2/3 for several minutes were distributed there appropriately. Interval sessions used the primary goal of the session’s core section, alongside HR and lactate values, to distribute training time into zone 2/3. Recovery phases in interval sessions were categorized as zone 1 only if active rest was used.

Data from each method were further analyzed and compared. Proportions (ratios) of zones 1, 2, and 3 were calculated using total training time in the TIZ and SG/TIZ methods and frequency of sessions in the SG method.

Conversion-Factor Calculation

Assuming that the overall session structure used by elite or recreational athletes is reasonably comparable, we calculated simple conversion factors to facilitate converting TID estimates based on one method to another. For simplicity only a binary model was used in these calculations, 1 conversion factor for TID ratio in the LIT (zone 1) range and 1 conversion factor in the HIT (zones 2 and 3 combined) range. The following formulas were used:

Conversion factor for TIZ to SG = ratio SG%/ratio TIZ%
Conversion factor for SG to TIZ = ratio TIZ%/ratio SG%

Statistical Analyses

Total training time is reported as mean ± SD, both as group values from 29 athletes and total values from 570 training sessions. A paired-samples t test was used to identify differences between training time in the TIZ and SG/TIZ methods, and 95% confidence intervals bounding the difference were calculated. Conversion factors between different methods were calculated based on total training ratios.

All statistical analyses were performed using SPSS 18.0 (SPSS Inc, Chicago, IL, USA), with statistical significance accepted as $P < .05$.

Results

Time Distribution Versus Session Distribution

Comparing TIZ and SG/TIZ methods, $96.1\% \pm 1.4\%$ and $95.5\% \pm 1.5\%$ of total training time, respectively, was in zone 1 ($P < .001$). Training in zone 2 accounted for $2.9\% \pm 1.3\%$ and $3.6\% \pm 1.5\%$ ($P < .001$), and zone 3 $1.1\% \pm 0.9\%$ and $0.8\% \pm 0.7\%$ ($P < .001$), of total training time based on the 2 methods. The relative underestimation of HIT time (zones 2 and 3 combined) was $16.6\% \pm 19.0\%$ (confidence interval: 9.2–24.0, $P < .001$) when using TIZ versus SG/TIZ (Table 3 and Figure 3).

When these same training sessions were allocated categorically using the SG method and verified by HR and lactate data, $86.6\% \pm 4.8\%$ (492 of 570) of training sessions were performed primarily as zone 1, $11.1\% \pm 5.0\%$ (64 of 570) as zone 2, and $2.4\% \pm 2.8\%$ (14 of 570) as zone 3 (Table 3 and Figure 3).

The conversion factor from the ratio of TIZ or SG/TIZ to SG was ~0.9 in the LIT range and 3.0 in the HIT range. The conversion factor from SG to TIZ or SG/TIZ was estimated to be 1.1 in the LIT range and 0.33 (1/3) in the HIT range (Figure 4).

Table 3  Training Time in TIZ and SG/TIZ Methods and Frequency of Sessions in SG Method Based on Mean and Total Training Data From 29 athletes During 8–18 Training Days (1107.6 h, 570 Sessions)

<table>
<thead>
<tr>
<th></th>
<th>TIZ (h)</th>
<th>TIZ (%)</th>
<th>SG/TIZ (h)</th>
<th>SG/TIZ (%)</th>
<th>SG (no. of sessions)</th>
<th>SG (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean ± SD (N = 29) Zone 1</td>
<td>36.7 ± 8.4</td>
<td>96.1 ± 1.4</td>
<td>36.5 ± 8.3</td>
<td>95.5 ± 1.5</td>
<td>17.0 ± 2.8</td>
<td>86.6 ± 4.8</td>
</tr>
<tr>
<td>Zone 2</td>
<td>1.1 ± 0.5</td>
<td>2.9 ± 1.3</td>
<td>1.4 ± 0.6</td>
<td>3.6 ± 1.5</td>
<td>2.2 ± 1.0</td>
<td>11.1 ± 5.0</td>
</tr>
<tr>
<td>Zone 3</td>
<td>0.4 ± 0.4</td>
<td>1.1 ± 0.9</td>
<td>0.3 ± 0.3</td>
<td>0.8 ± 0.7</td>
<td>0.5 ± 0.6</td>
<td>2.4 ± 2.8</td>
</tr>
<tr>
<td>Total (570 sessions) Zone 1</td>
<td>1063.8</td>
<td>1057.7</td>
<td>492</td>
<td>Zone 2</td>
<td>31.6</td>
<td>40.6</td>
</tr>
<tr>
<td>Zone 3</td>
<td>12.2</td>
<td>9.3</td>
<td>14</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>1107.6</td>
<td>1107.6</td>
<td>570</td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

Abbreviations: TIZ, time in zone; SG, session goal.
Time in HIT Sessions

Mean duration of HIT periods was significantly lower in TIZ than in SG/TIZ, 32.5 ± 8.6 versus 38.2 ± 6.5 minutes, \( P < .001 \). TIZ underestimated time spent working in the HIT range by 27.5% ± 43.7%.

Discussion

This study provides directly comparable data demonstrating differences in quantification of TID using 3 analysis methods frequently reported in the literature.4–13,19

Data from numerous studies1–13,18 report athletes’ TID using a 3-zone model. Critically, the distribution ratio is often based on different methods (time-based allocation vs categorical allocation) and on athletes at different levels, making comparisons across studies difficult. While our sample athletes employed a nationally standardized 5-zone aerobic intensity scale, we chose to convert their training data to the same 3-zone intensity scale, anchored around VT1/LT1 and VT2/LT2, that has been most frequently used in research on TID10–12,21–24 as well as intensity distribution during long single-day13 and multiday events.4,5

A useful conversion factor between a time-based and a categorical TID approach emerges from these data using a binary model (zone 1 = LIT, zones 2 and 3 = HIT). Assuming that the basic content and structure of HIT sessions is reasonably consistent across athlete groups and sport disciplines, we suggest that HR-based TIZ estimates for HIT sessions can be multiplied by ~3 (Figure 4) to give an equivalent distribution based on categorical allocation of HIT sessions. In elite athletes training ≥800 h/y, or 500 training sessions/y, where HR analysis using TIZ shows 93%/7% in LIT/HIT, the categorical SG distribution of endurance sessions will approximate 81%/21% LIT/HIT. This difference is largely explained by the fact that LIT sessions are often longer than HIT sessions and HIT sessions generally include considerable warm-up and cooldown time and recovery time between high-intensity bouts. For example, a 6 × 4-minute HIT session at 95% HR_{max}, lactate values >6 mmol/L, with 2 minutes recovery, a 20-minute warm-up, and a 15-minute cooldown would result in a TIZ distribution of ~20 minutes HIT and 45 minutes LIT. As such, even this high-intensity session would be quantified as ~70% LIT, despite blood lactate values clearly indicating that the session was very demanding. By extension, SG-based TID can be converted to estimates of TIZ using a conversion factor of ~0.33 in the HIT range (Figure 4). Because these 2 TID-calculation

![Figure 3](image3.png)

**Figure 3** — Training-intensity distribution in 570 sessions analyzed with 3 different methods: time in zone (TIZ), session goal/time in zone (SG/TIZ), and session goal (SG).

![Figure 4](image4.png)

**Figure 4** — The figure illustrates how to convert reported training distribution from a time-based-ratio method (time in zone [TIZ] or session goal/time in zone [SG/TIZ]) to a method of categorical allocation of each training session (SG), or vice versa. Panel A: low-intensity-training range; Panel B: high-intensity-training range.
methods are frequently reported in the literature.\textsuperscript{4,5,10–12} This conversion factor can facilitate more informed comparisons of studies concerning elite athletes, as well as less confusion regarding interpretation of TID data. In addition, the conversion factors appear reasonable when used in subelite/recreational athletes. Converting TID data from TIZ to SG in junior athletes training \textasciitilde500 h/y with 91%/99% LIT/HIT (TIZ method) provides \textasciitilde27% HIT when converted to the SG method, which is comparable to the reported 25%.\textsuperscript{12} Recreational athletes training 5 sessions/wk or 5 h/wk, including 2 HIT sessions, give \textasciitilde15% of training time, or 40% HIT sessions, in TIZ or SG, respectively. These examples suggest that the conversion factor identified from elite athletes’ training is transferable across different training levels.

In 78 HIT sessions quantified in this study, the average time difference between SG/TIZ and TIZ calculation of HIT time was 27.5% (38.8 min vs 32.5 min), due to HR “lag time” in the TIZ method (Figure 1). Over a season, this can account for 10 to 12 hours of additional zone 2/3 training in an athlete training 800 h/y. In addition, interval sessions include rest and recovery time. How these rest intervals are treated in TID can be a significant source of inconsistency across studies when employing the SG/TIZ approach.\textsuperscript{19} We argue that recovery time should not be included as zone 2/3 time. Rest duration varies across different interval session types and can be modified during a mesocycle as part of a periodization plan. Therefore, this portion of the interval session should be assigned as zone 1 or to the specific zone in which it is performed if conducted as active recovery.

Several studies have reported using the TIZ\textsuperscript{5,9–12} or SG/TIZ method\textsuperscript{5,6–8,13} in studies of athletes. More important, these methods are frequently used among athletes as self-report in diaries. We have previously shown that when self-reporting training, elite athletes used a “conceptual” routine close to the SG/TIZ method.\textsuperscript{19} In the Norwegian national cross-country team, 24 of 29 athletes used the SG/TIZ method, while the remainder analyzed their HR data directly using TIZ. Use of the TIZ method is straightforward due to easy accessibility to HR watches and accompanying analysis programs. In the Norwegian cross-country junior national team, TIZ is even more common than the SG/TIZ method (personal communication). This pinpoints the importance of being able to analyze and compare these methods. TIZ and SG/TIZ methods are attractive since they are easy to analyze, individualized, and noninvasive. However, TIZ methods have in some cases been shown to poorly match perceived effort for a given workout\textsuperscript{12} and may underestimate the actual stress load,\textsuperscript{29} so we highly recommend that athletes using a time-based method also self-report sRPE and SG in diaries to give a realistic picture of the long-term TID.

We previously argued in a review\textsuperscript{24} that a “typical” TID between LIT and HIT in elite endurance athletes approximates 80% LIT and 20% HIT based on a categorical approach allocating entire training sessions into intensity categories. In the current study, subjects only performed 13% to 14% of training sessions as HIT (zone 2–3) using the SG method. However, this was a training camp where athletes resided and performed LIT at \textasciitilde3000 m and HIT at \textasciitilde1800 m. Consequently, the TID consisted of a lower proportion of HIT, consistent with the greater stress of altitude training. HR responses at altitude differ from those at sea level,\textsuperscript{30} but due to individualized downward adjustment of external load, athletes trained using their normal intensity scale after initial acclimatization. Of 29 athletes, 24 used the same intensity reference values at sea level and altitude. The remaining athletes reported <5-beats/min lower values in each zone at altitude. Collecting data at high altitude could influence the results, and their reproducibility at sea level remains unclear.

It is also worth noting that these elite athletes use a polarized\textsuperscript{24} training model. LIT sessions are typically very easy, and HIT sessions considerably harder. Although the reference scale (Table 1) suggests 82% or 2.5 mmol/L as the lower limit, sessions in zone 2 are, due to very high aerobic capacity and lactate threshold, normally conducted with HR \textasciitilde90% and lactate 1.5 to 4.0. The high-intensity zone is therefore narrower in elite than recreational athletes, and comparison of data across different performance levels must be conducted with caution.

A limitation of this study is that standardized perceptual measures of training intensity were not included in the athletes’ self-report. sRPE has been frequently employed in recent studies. This categorical method is appropriate for estimating long-term TID patterns\textsuperscript{12,14–18} and likely provides an accurate representation of the training load over time.\textsuperscript{12,14,20} Foster et al\textsuperscript{15,16} introduced the sRPE method to provide a measure of the global perception of intensity during an entire training session. Using sRPE as a basis for session intensity classification, Stellingwerff\textsuperscript{18} found that TID in 3 male elite marathon runners during 1 year was 74%/11%/15% in zones 1/2/3. Norwegian endurance athletes are unfortunately not accustomed to the sRPE method, and as a compromise we agreed with their coaches not to influence their normal intensity scale after initial acclimatization. However, we suggest that sRPE and SG data correspond well and are reasonably interchangeable. Seiler and Kjerland\textsuperscript{12} found 92% agreement between a 3-zone categorization of sRPE and the 3-zone SG method in junior cross-country skiers. Nevertheless, the disadvantage of the SG method is that elite athletes and coaches may not be familiar with this categorical method of analyzing training data. However, it seems that athletes do informally think of sessions in terms of some form of binary intensity classification. For example, the Norwegian national cross-country ski team has formulated as a “success rule” that \textasciitilde100 to 140 sessions in zones 2 to 3 should be integrated into the annual training load of >800 hours (personal communication).

**Practical Applications**

In this study we objectively compared 3 conceptually different methods of quantifying TID. In recent years, TID has been extensively explored and several studies have described training characteristics in elite athletes via these 3
methods. In additional, self-report among athletes in training diaries normally uses methods close to the SG/TIZ or TIZ method. The current study shows that due to dissimilarities in the methods used, it is inappropriate to compare TID both across different self-report methods from athletes and between studies without taking into account the discrepancies between methods. Therefore, the results from the current study may help athletes, coaches, and scientists when interpreting studies of TID and endurance performance. We suggest the following guidelines:

- Normal methods of self-report in diaries, such as TIZ or SG/TIZ, underestimate the ratio of total training in the HIT range compared with the SG method. We suggest a conversion factor of 3 when converting total training ratio from TIZ or SG/TIZ to SG and 0.33 from SG to TIZ or SG/TIZ in the HIT range.
- TIZ underestimates time in the HIT work-intensity range compared with the SG/TIZ method due to HR “lag time.” The magnitude of this distortion may depend on how sessions are composed (HR “fast component,” recovery duration, etc.). In elite athletes this difference can account for 10 to 12 h/y and must be taken into account when evaluating self-report training diaries using different methods.
- The SG/TIZ approach should be generally recommended for athletes, coaches, and scientists to standardize TID. In addition, we highly recommend that athletes self-report SRPE and SG to give a better picture of total training load.
- In interval sessions, recovery time should be subtracted from zone 2 to 3 training time to ensure consistent and comparable TID.

Conclusions

This study provides a quantitative comparison of TID differences associated with the most common HR-based analysis methods. These data provide defensible conversion factors for comparisons of studies employing different methods of TID quantification that will hopefully contribute to greater clarity on this topic.

References