NORGE

Olympiatoppen

OLYMPIATOPPEN'S INTENSITY SCALE

Version 2 (2024)

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OLYMPIATOPPENS I-SCALE, 2024

Table 1. Olympiatoppens I-scale.

I-zone	RPE BORG (6–20)	RPE CR10 (0–10)	Description	% av HR_{max}	Lactate*	Ventilation / breathing	Power (Watt)**	Pace/ lap time**
I-1	< 11	1–2	Very light	~55%–72%	< 1.5 mmol/L	Can speak effortlessly.		
I-2	< 13	2–3	Fairly light	~72%–82%	~1.0–2.0 mmol/L	Can speak in longer sentences relatively effortlessly.		
I-3	13–14	4–5	Somewhat hard	~82%–87%	~1.5–3.5 mmol/L	Can speak in short sentences.		
I-4	14–16	6–7	Hard	~87%–92%	-	Can say a few words or very short sentences.		
I-5	16–19	8–10	Very hard	~92%–100%	-	Can say one or two words at a time while breathing heavily.		
I-6	19–20	9–10	Very, very hard		-	Can only say a few, short words while gasping for air.		
I-7	20	10	Very, very hard	-	-	Not applicable.		
I-8	-	-	Maximal mobilization	-	-	Not applicable.		

NB: The intensity scale (I-scale) serves as guidance and is not meant to be applied rigidly. Instead, it should be considered in conjunction with several parameters such as training modality/movement form, fitness level, individual differences, etc. *The lactate values are derived from the Biosen lactate analyzer (there will be larger variations between handheld devices, see Mentzoni et al., 2024 for more information). **Here, each I-scale user can input information based on what is relevant to the user.

INTERPRETATION AND USE OF OLYMPIATOPPEN'S I-SCALE

- It is important to be aware that this is a general intensity scale (I-scale). The I-scale is intended to guide Norwegian athletes and coaches and is not a definitive answer for every situation and individual. Significant variations related to endurance modalities, level, functional impairments, and individual differences will occur. Thus, this should be a guiding and dynamic scale, which each coach and athlete must adapt to their training condition, age, and sport.
- For many athletes, it may also be relevant to use a modified I-scale based on the endurance modality that is practiced. For example, the same athlete may experience varying levels of exertion and lactate at the same heart rate (HR) during different types of movement forms.
- Olympiatoppen recommends that all athletes and coaches develop their own I-scales based on Olympiatoppen's dynamic I-scale. The I-scale should be customized to each individual athlete and training modality/movement form, based on lab/field tests, competitions, and other relevant information. This ensures optimal utilization of intensity monitoring in each training session and for each athlete. The I-scale is an interactive and dynamic model that allows athletes and coaches to "compose" their I-scale based on advisory information.

PARA-ATHLETES
For most para-athletes, it is appropriate to use the standard I-scale with individual adjustments, similar to athletes without functional impairments. However, it is essential to be aware that the standard I-scale is based on values from endurance athletes who compete in sports involving leg and whole-body work (such as running, cycling, cross-country skiing, rowing, etc.). This scale may, therefore, be somewhat misleading for activities/sports performed from a seated position and that primarily utilize upper body musculature.

I-zone 1 (I-1)	
Perceived Exertion (RPE)	Very light/light. Training in I-1 should feel easy/effortless and comfortable, even when performed over a longer duration in most exercise modalities. **Borg (6–20)**: < 11 **CR10 (0–10)**: 1-2
% av HR_{maks}	~55–72% but note that HR will depend on several factors, including exercise modality, training status, mental stress level environmental conditions, and altitude.
% of VO_{2max}	~45–55% but note that the % of VO_{2max} one operates at will depend on several factors, including exercise modality and training status.
Lactate	~0.5–1.0 mmol/L. This is individual and sport-specific. It requires sufficient experience to use blood lactate as a valid measure of intensity.
Ventilation/breathing rate	The number of breaths per minute will typically be < 30, allowing one to utter long sentences effortlessly.
Time to exhaustion	Varies depending on exercise modality and fitness level. For example, an elite cyclist will be able to sustain several hours at this intensity.
Total duration	Depends on the sport, goals, and fitness level. In running, 45 minutes or longer can be appropriate. For cycling, significantly longer sessions are usually required.
Interval duration	In most sports, continuous training in I-1 is both common and beneficial. However, it can also be appropriate to incorporate short breaks during the training session. These breaks serve to maintain good technique and sustain focus, particularly in technically demanding endurance sports.
Rest duration	Not applicable.
Comment	I-1 refers to aerobic training, which is typically performed as continuous work. To ensure a sufficiently long session duration and prevent excessive recovery time, it´s important to replenish fluids and nutrition during training sessions lasting over 90–120 minutes.

I-zone 2 (I-2)	
Perceived Exertion (RPE)	Fairly light. In most exercise modalities, training in I-2 should feel fairly light even when performed continuously for a long duration. **Borg (6–20)**: < 13 **CR10 (0–10)**: 2–3
% av HR_{maks}	~72–82% but note that HR will depend on several factors, including exercise modality, training status, mental stress level, environmental conditions, and altitude.
% of VO_{2max}	~55–72% but note that the % of VO_{2max} one operates at will depend on several factors, including exercise modality and training status.
Lactate	~1.0–2.0 mmol/L. This is individual and sport-specific. It requires sufficient experience to use blood lactate as a valid measure of intensity.
Ventilation/breathing rate	The number of breaths per minute will typically be < 30, and one will be able to utter long sentences relatively effortlessly.
Time to exhaustion	Normally ~3–6 hours but muscularly demanding exercise modalities, such as kayaking/canoeing and skating, may have considerably shorter time to exhaustion. Highly trained endurance athletes can sustain extended durations in I-2. Training level and exercise modality may lead to significant variations.
Total duration	Varies, ranging from 45 min to 3 hours. Sport and training levels will have a great impact. The total duration will additionally typically depend on the goal of the session and the exercise modality performed.
Interval duration	Continuous work is typically performed in most contexts.
Rest duration	Typically, none, except for certain technically and muscularly demanding sports where it's advisable to incorporate microbreaks (10–30 sec) or breaks of up to 2–3 min.
Comment	I-2 is aerobic training that is typically performed as continuous work. It can also be performed as longer segments with shorter breaks. In several endurance sports, training in this zone constitutes a significant portion of the total volume (10–20%). This is to ensure adequate time with high technical quality that is relatively close to the competition pace.

I-zone 3 (I-3)	
Perceived Exertion (RPE)	Somewhat hard. **Borg (6–20)**: < 13 **CR10 (0–10)**: 2–3
% av HR_{maks}	~82–87% but note that HR will depend on several factors, including exercise modality, work duration, training status, mental stress level, environmental conditions, and altitude.
% of VO_{2max}	~70–80% but note that the % of VO_{2max} one operates at will depend on several factors, including exercise modality and training status.
Lactate	~1.5–3.5 mmol/L. This is individual and sport-specific. It requires sufficient experience to use blood lactate as a valid measure of intensity.
Ventilation/breathing rate	The number of breaths per minute will typically be 30 – 50, and one will be able to utter short sentences.
Time to exhaustion	~1–2 hours. There will be significant individual differences depending on training level and sport.
Total duration	Great variations depending on training status and session modality. Anything from 20 min during low-load sessions to 90 min during high-load sessions can be beneficial, depending on the aim of the session.
Interval duration	8–20 minutes is the typical repetition duration for sessions in this I-zone. In some cases, intervals as short as 1 minute can be appropriate. Variations may be attributed, among other factors, to the session model, period goal, the nature of the sport, and the level of the athlete.
Rest duration	Depends on the interval length and the goal of the session and/or training period. However, 25% of the interval duration or 1–3 minutes is common practice.
Comment	Typically conducted as interval training but can also be performed as continuous work in the form of fast-paced long-duration sessions.

I-zone 4 (I-4)	
Perceived Exertion (RPE)	Hard. **Borg (6-20)**: 15–16 **CR10 (0-10)**: 6–7
% av HR_{maks}	~87–92% but note that HR will depend on several factors, including exercise modality, work duration, training status, mental stress level, environmental conditions, and altitude.
% of VO_{2max}	~75–85% but note that the % of VO_{2max} one operates at will depend on several factors, including exercise modality and training status.
Lactate	Requires a high level of experience regarding session design among other factors. Therefore, specific guidelines are not provided here.
Ventilation/breathing rate	The number of breaths per minute will typically be > 40, and one will be able to utter short sentences or single words.
Time to exhaustion	~45 min but this will vary greatly from person to person.
Total duration	Based on the session's/period's objectives, exercise modality, and the athlete's level, it is often common with a duration of 20–50 min. In certain cases, shorter durations may be appropriate.
Interval duration	3–10 min depending on the goal of the session, but the interval duration may be considerably shorter with the inclusion of microbreaks.
Rest duration	Great variation depending on the objectives and exercise modality. Often around 50% of the interval duration.
Comment	Generally performed as interval work to ensure a longer total duration accumulated in this I-zone. Can also be performed as continuous work.

I-zone 5 (I-5)	
Perceived Exertion (RPE)	Very hard. **Borg (6-20):** 17–19 **CR10 (0-10):** 8–10
% av HR_{maks}	~ 92% but note that the HR will depend on several factors, including exercise modality, work duration, training status, mental stress level, environmental conditions, and altitude.
% of VO_{2max}	~ 85–100% but note that the % of VO_{2max} one operates at will depend on several factors, including exercise modality and training status.
Lactate	Requires extensive experience and largely depends on the session model. Specific values are therefore not provided.
Ventilation/breathing rate	The number of breaths per minute will typically be > 40, and one will be able to utter short sentences or single words.
Time to exhaustion	~20 min if the external load is held relatively constant. This will vary depending on the training status and exercise modality. It may be considerably longer in sports with frequent changes in external load, such as mountain biking.
Total duration	I-5 session will often have a total duration of 15–30 min. However, it can also be appropriate with considerably shorter duration in low-load sessions and periods.
Interval duration	Interval duration can vary greatly but 30 sec (with microbreaks) up to 5 min is common practice.
Rest duration	Large variations depending on objectives and exercise modality. Often around 50–75% of interval duration to ensure high intensity during the repetitions. In some cases, for example prior to competitions, it may be beneficial with longer rest periods.
Comment	Generally performed as interval work to ensure a longer total duration accumulated in this I-zone. Can also be performed as continuous work, such as in a test race.

I-zone 6 (I-6)	
Perceived Exertion (RPE)	Very, very hard. **Borg (6-20):** 19–20 **CR10 (0-10):** 9–10
% av HR_{maks}	Not applicable.
% of VO_{2max}	Not applicable.
Lactate	Not applicable.
Ventilation/breathing rate	During training in I-6, one will have difficulty speaking due to very frequent ventilation. One will therefore typically only be able to utter short words while gasping for air.
Time to exhaustion	~ 4 min depending on anaerobic capacity and training status.
Total duration	Total duration will typically only be a few minutes due to the extremely demanding intensity.
Interval duration	Interval duration normally varies from around 30 sec up to 2 min.
Rest duration	I-6 training requires long rest periods that are at least 100–200% of interval duration and in some cases up to 10 min.
Comment	Anaerobic training primarily stimulates anaerobic capacity and requires extensive recovery time compared to aerobic training.

I-zone 7 (I-7)	
Perceived Exertion (RPE)	Very, very hard. **Borg (6-20)**: 20 **CR10 (0-10)**: 10
% av HR_{maks}	Not applicable.
% of VO_{2max}	Not applicable.
Lactate	Maximal. Be aware that it takes time before blood lactate concentration increases and that the value can continue to rise after the completed interval. Therefore, Olympiatoppen does not recommend lactate as a suitable measure for controlling intensity during this type of training.
Ventilation/breathing rate	Not applicable.
Time to exhaustion	~ 1 min depending on anaerobic capacity and training status.
Total duration	Total duration will typically only be a few minutes due to the extremely demanding intensity.
Interval duration	Interval duration is typically 15-60 sec depending on the goal and session design.
Rest duration	5–15 min.
Comment	Anaerobic training that primarily stimulates anaerobic capacity and that requires extensive recovery time if many repetitions are performed.

I-zone 8 (I-8)	
Perceived Exertion (RPE)	Maximum mobilization.
% av HR_{maks}	Not applicable.
% of VO_{2max}	Not applicable.
Lactate	Not applicable.
Ventilation/breathing rate	Not applicable.
Time to exhaustion	~15 sec.
Total duration	Total duration for the intervals can range from < 1 min to 3 min. This is to maintain maximum quality and effort during each interval.
Interval duration	Normal interval duration is typically 3–15 sec depending on the goal and session design.
Rest duration	I-8 training requires long rest periods, but the duration varies greatly depending on the goal and interval duration. Anything from 3–15 min is normal.
Comment	Anaerobic training that is performed with maximal or near-maximal mobilization.

Table 2. Overview of the relevant parameters in each intensity zone (I-zone) for monitoring intensity during training sessions.

INTENSITY ZONE	RPE	RESPIRATION	HEART RATE	LACTATE	POWER	SPEED
I-ZONE 1		+	+	+	+	+
I-ZONE 2		+	+	+	+	+
I-ZONE 3	+	+	+	+	+	+
I-ZONE 4	+	+	(+)	(+)	+	+
I-ZONE 5	+	+	(+)	(+)	+	+
I-ZONE 6	+	+			+	+
I-ZONE 7	+	+			+	+
I-ZONE 8					+	+

NB: It is important to evaluate and regulate training intensity by considering various parameters, as relying on any single variable will not offer a comprehensive assessment on its own.
+ This parameter is appropriate for monitoring intensity within this I-zone;

(+) This parameter can be useful for monitoring intensity within this I-zone, depending on the session model and experience level.

Abbreviations: RPE; Rating of Perceived Exertion.

PLANNING, EXECUTION, AND EVALUATION OF SESSIONS

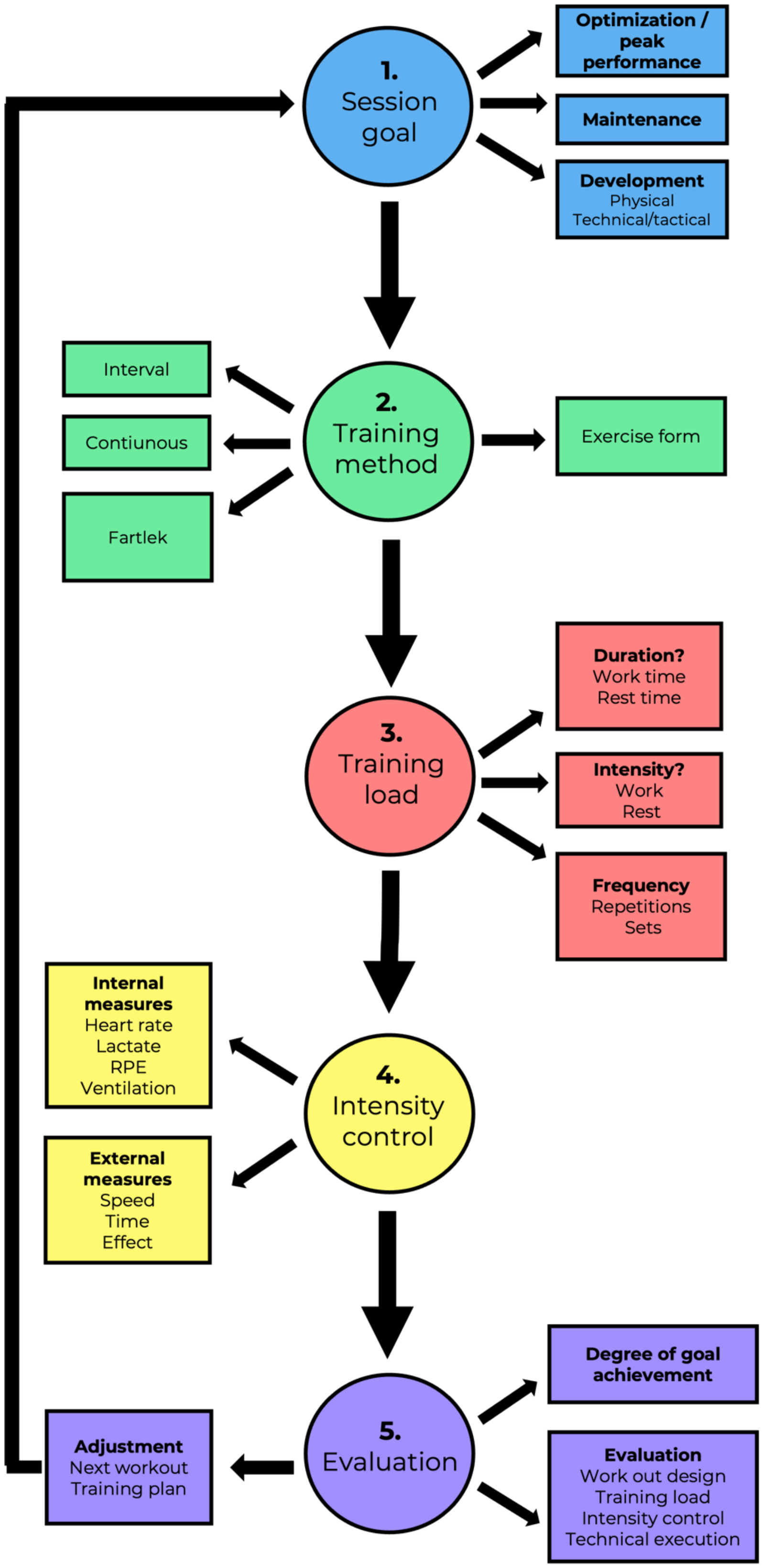

Figure 1. The figure shows the process that should form the basis for planning, conducting, and evaluating training sessions. Abbreviations: RPE; Rating of Perceived Exertion.

The purpose of the I-scale is to provide coaches and athletes with a "toolbox" for **planning and setting training goals** (Phase 1), selecting an appropriate **training method** (Phase 2), determining desired **training load** (Phase 3), **managing intensity** during the session (Phase 4), **and evaluating** the training while making necessary adjustments for the next session (Phase 5).

- **Phase 1: Planning and goal-setting** of the training session is based on the purpose of the training period and should consider the athlete's total load (both training load and other physical and/or mental load). The purpose of the training session can be to develop one or more attributes, maintain one or more attributes, or "peak" fitness/optimize performance. To determine which attribute(s) should be developed or maintained, one should consider the athlete's profile in relation to the demands of the sports performance. This assessment will guide the athlete's choice of endurance modality, session model, and appropriate training intensity.
- **Phase 2: Choice of training method.** The purpose of the session determines which training method is favorable for achieving the desired effect. During this phase, one evaluates whether the session should involve continuous work or interval work, as well as which movement modality one should perform.
- **Phase 3: Training load** is primarily determined by **intensity**, **duration**, and **frequency** (number of repetitions/sets) and should be prescribed according to the session's goal. For example, the training load will be high in a session composed of low intensity and long duration, as well as very high intensity and short duration. A good session model with the right balance between workload and rest interval duration is generally the best way to guide the athlete toward the desired intensity.
- **Phase 4:** The most relevant variables for **intensity monitoring** will depend on movement modality, session model, and intensity. The purpose of intensity monitoring is to achieve the desired training load. Because there are significant limitations to only relying on one variable when controlling intensity during training sessions (such as *only* HR, *only* lactate, or *only* pace), we recommend combining information from several different variables. Therefore, athletes and coaches should have sufficient knowledge and experience with different parameters and how they can be used together to optimize training outcomes.
- **Phase 5: Evaluation** of the session is based on the session´s objectives, adherence to the planned session, and whether adjustments should be made to the training plan based on experiences from the session.

PHYSIOLOGICAL STIMULI FROM TRAINING IN DIFFERENT I-ZONES

Importantly, you never train only one specific attribute in one I-zone and a completely different attribute in another I-zone. The transitions between I-zones are fluid, and the various physiological systems will be stimulated to a greater or lesser extent depending on the intensity level. That is, the systems are not turned "on or off" as you move from one I-zone to another. Furthermore, whether the athlete trains in the lower or upper part of an I-zone will also influence the type of stimuli and load applied. Remember that the training duration affects the physiological stimulus and training effect. The duration becomes more important the lower the intensity used. Thus, comparing I-zones based on the same duration is not meaningful, as the duration must be adapted to each I-zone.

The figure below shows the primary systems stimulated by training in each I-zone. If the goal of the session is to improve VO_{2max} and central aerobic factors, such as stroke volume, training in I-3, I-4, or I-5 is likely most beneficial. If the goal is to develop peripheral aerobic qualities, such as capillarization or mitochondrial density in sport-specific muscles, it might be more appropriate to have a long-duration session in I-1, I-2, or I-3. If the goal is to develop the ability to process glucose, metabolize lactate, and increase buffering capacity in the muscles, training in I-6 and I-7 is probably most suitable. If the goal is to improve speed and anaerobic capacity, training in I-7 and I-8 is likely most relevant.

The neuromuscular system determines the muscles' ability to generate force and power. Enhancements of the neuromuscular system can be achieved by training the nervous system to activate muscles more effectively. Simultaneously, changes can happen in muscle size (hypertrophy) and muscle architecture (the organization of muscle fibers). This is typically achieved through training at high and maximal intensity (I-7 and I-8), which closely aligns with strength, plyometric, or speed training. This type of anaerobic training develops endurance at high and maximal intensity. Training of the neuromuscular system also occurs at lower I-zones but is then related to neural strategies that improve the degree of muscular utilization and work economy at submaximal intensity. Here, neural adaptations can occur alongside improvements in the muscles' aerobic energy metabolism. Depending on the sport, these neural strategies may also be associated with improved technique (e.g., for a cross-country skier).

If the goal is to specifically develop a technique or a component of the technique, it is most appropriate to train in the I-zone that corresponds to competition speed in the given sport. Alternatively, the athlete may perform a large volume of training in I-1 and I-2 to accumulate an adequate repetition volume in the relevant movement form.

In endurance sports, the work intensity often varies, such as when participating in a mass start and/or competing on varying terrain. Performance will then depend on tactics. Tactics can include:

- Pacing.
- How to position oneself in the field (e.g., to reduce air resistance).
- Intake of nutrition and fluids.

Tactical skills can be developed across all I-zones. However, in sports with long competition durations, most training will occur in the lower I-zones for extended periods (several hours).

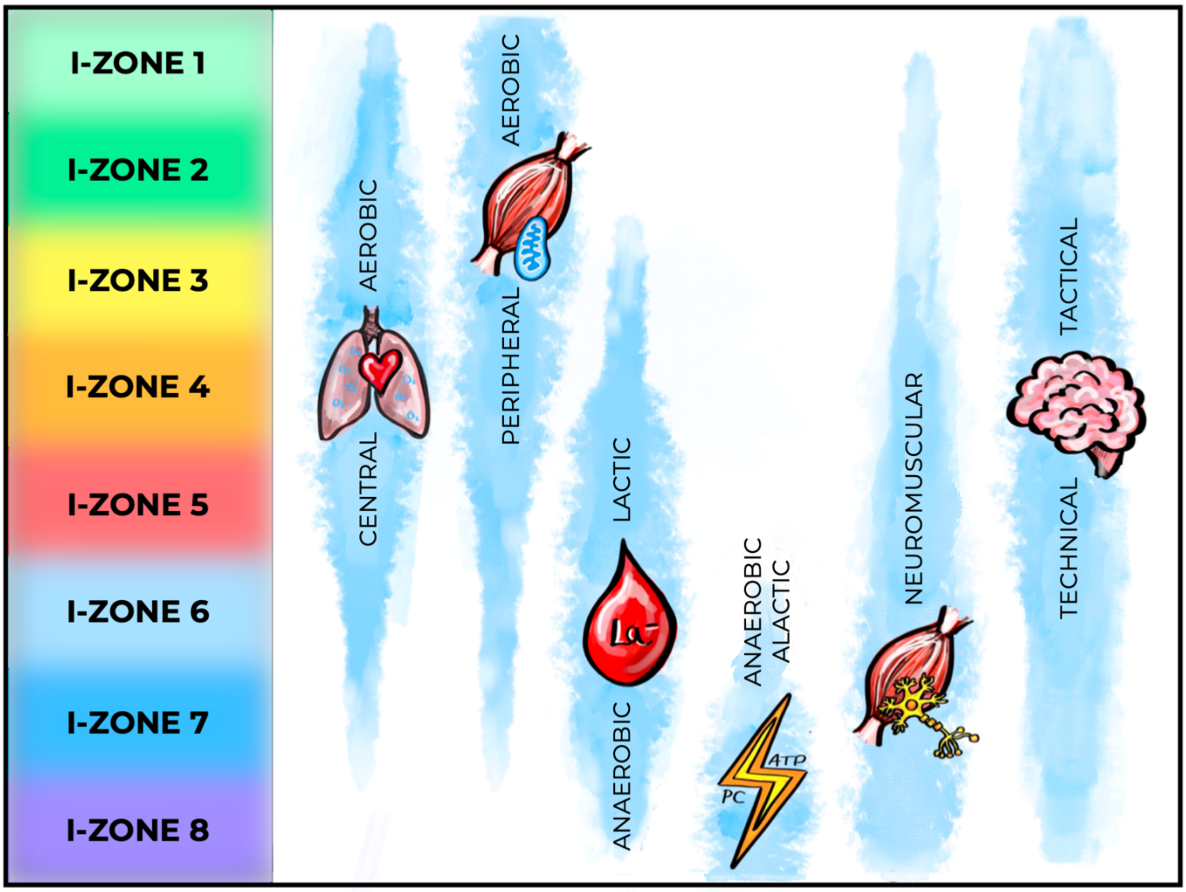

Figure 2. Overview of the physiological stimuli during training in the various I-zones. The figure highlights that each I-zone induces multiple physiological stimuli, rather than just one. There are fluid transitions and parallel impacts on many physiological systems across several I-zones.

The I-scale can be divided into four categories:

1. **Internal subjective measures**. *RPE, perceived ventilation.*
   These parameters reflect how the athlete subjectively perceives the external load.
2. **Internal objective measures**. *HR, lactate, ventilation frequency*.
   These parameters reflect the actual physiological load.
3. **External measures**. *Watt, speed, lap time*.
   These parameters reflect the external load inflicted upon the athlete.
4. **Session planning**. *Total duration, typical interval duration, rest duration, time to exhaustion*.
   These parameters give information on how to design and structure effective training sessions in the various I-zones.

INTERNAL MEASURES

This chapter deals with relevant tools, both objective and subjective measures, that reflect the internal load the athlete is subjected to during activity.

RPE (RATING OF PERCEIVED EXERTION)

Perceived exertion can be assessed using the Borg 6-20 scale or the CR10 scale, depending on which scale the athlete is accustomed to. There is a good correlation between these methods (Arney et al., 2019).

BENEFITS OF RPE FOR MONITORING INTENSITY:

- There is a strong correlation between RPE and HR/lactate, and it appears to be a reliable measure of intensity regardless of level and training status (Scherr et al., 2013).
- It accounts for daily fluctuations in daily form and helps detect progress in fitness, insufficient recovery, excessive total load, or early signs of overtraining when considered alongside other variables such as HR and speed/wattage.

DISADVANTAGES OF RPE FOR MONITORING INTENSITY:

- It is important to recognize that the duration an athlete sustains an effort impacts how hard it feels. For instance, what may feel manageable after a brief duration can become considerably more challenging if the athlete is required to sustain the effort for an extended period. The same applies when performing multiple intervals. It is natural for the RPE score to increase as the training session progresses, even if all intervals are performed at the same external load (speed/wattage).
- Although RPE is a good measure of intensity within an individual athlete, it is often not as accurate when comparing RPE scores between different athletes.
- Greater uncertainty/variation in RPE at low intensity suggests that it might not be as reliable a measure during training in I-1 and I-2.
- In certain endurance modalities, there can be a difference in RPE between cardiovascular load and muscular load. For example, running downhill may feel easy, even though it imposes a significant muscular load.
- Limited experience with reporting RPE, particularly among young athletes, can also result in greater variation and uncertainty.
- Different timings of reported RPE values can affect measurement reliability.

HEART RATE

HR is arguably the most commonly used tool for assessing and controlling intensity during endurance training.

BENEFITS OF HR FOR MONITORING INTENSITY:

- A good measure of intensity during continuous work, or during interval training where the interval duration is long enough for HR to stabilize (> 4 min).
- Easy to measure with an HR monitor and a watch, and comparable across different measurement units if chest strap belts are used (unlike, for example, lactate or wattage).
- The athlete can receive continuous feedback throughout the entire session.
- A lower HR at the same external load is usually a sign of improved fitness in an athlete. However, a lower HR, especially at very high intensity, can also be a sign of too high total load over time and/or insufficient recovery (Bosquet et al., 2008). Therefore, it can be an important variable to monitor both for tracking fitness progress and for preventing overtraining (Meeusen et al., 2013).

DISADVANTAGES OF HR FOR MONITORING INTENSITY:

- The delay in HR at the onset of exercise means that it is often a less useful measure of intensity during interval training at short, high-intensity intervals, or in cases where the external work constantly shifts between low and very high intensity, such as in ball sports, skiing, or mountain biking.
- The daily variation in HR can be approximately 6–12 beats (Bagger et al., 2003; Lambert et al., 1998) and will be influenced by several factors such as altitude, climate, hydration, glycogen levels, and mental stress levels (Borresen & Lambert, 2009).
- It is common to see a drift in HR as the session progresses if the duration is long enough, even if the external load remains the same. This is especially true when training in a hot climate and/or when dehydrated.
- There is a considerable margin of error in HR measurements taken from the wrist. Therefore, athletes should opt for a chest strap to ensure precise measurements.
- The athlete must have an accurate and updated measure of HR_{max}. Because HR_{max} typically declines with age, it should be regularly updated to avoid under- or overestimation of intensity.

LACTATE

Lactate has become a common tool in recent years for controlling and evaluating intensity during endurance training.

BENEFITS OF LACTATE FOR MONITORING INTENSITY:

- A good measure of intensity when training in I-1, I-2, and I-3.
- A good tool for tracking an athlete's progress over time by comparing performances under identical session models.

- Useful for "re-calibrating" the athlete's perception of intensity when training in, for example, altitude or heat, where the relationship between power/speed, the athlete's perception, HR, and ventilation may deviate from normal conditions.

DISADVANTAGES OF LACTATE FOR MONITORING INTENSITY:

- Utilizing lactate testing demands extensive knowledge and experience from both the athletes and coaches to ensure that the benefits outweigh the costs. Large measurement variations can arise depending on the analyzer used.
- There are significant individual differences in blood lactate values (Jones et al., 2019), and both maximal and submaximal values will depend on factors such as genetics, sport, and training status.
- Even within the same athlete, lactate values across different I-zones can vary between endurance modalities. For example, the relationship between HR/RPE and lactate will differ between running and cycling.
- At high intensity (I-4 and above), lactate levels may not consistently reflect intensity unless an individual has extensive experience or has conducted repeated measurements using the same session model. Since lactate is measured in capillary blood rather than directly in the working muscles, its levels can be influenced by measurement timing and the duration of intervals.
- Requires specialized equipment and a good technique to obtain reliable measurements. There is a significant risk of inaccurate readings when employing handheld analyzers with small blood sample volumes, such as due to sweat contamination. Additionally, one should be cautious when comparing lactate values measured with different handheld lactate analyzers, as these analyzers do not provide comparable values (Mentzoni et al., 2024). If one is to measure lactate in the field, it is, therefore, crucial to be very meticulous with the technique for taking the measurement and to ensure that the same handheld meter is used over time if the values are to be used for intensity control of the session.
- If the athlete has low glycogen stores, it may result in artificially low lactate values, thereby underestimating the actual intensity.

VENTILATION / BREATHING

How frequently and/or how heavily one breathes, and how difficult it is to speak short or longer sentences, can provide simple yet valuable information about the intensity level. There are also technological solutions available that measure the ventilation rate.

BENEFITS OF VENTILATION FOR MONITORING INTENSITY:

- Easy to use for both athletes and coaches.
- Several studies have shown a very high correlation between ventilation rate and perceived exertion (Nicolo et al., 2016; Nicolo et al., 2017).

- During short interval bouts or frequent changes in external load, ventilation may be a better measure of intensity than traditional tools like HR and lactate levels, as it provides more immediate feedback.

DISADVANTAGES OF VENTILATION FOR MONITORING INTENSITY:

- Not a particularly good measure of intensity during training at altitude, where ventilation is elevated compared to HR and lactate.
- Currently, none of the most commonly used sports watches/bike computers on the market provide reliable measurements of ventilation rate.

PARA-ATHLETES

Less muscle mass is activated during upper-body work compared to leg and whole-body work. The upper body also exhibits a different composition of muscle fibers, with a higher proportion of fast-twitch muscle fibers (type II vs. type I) compared to the legs (Saltin et al., 1977). This can cause the relationship between internal physiological load (HR and lactate) and internal subjective load (RPE) to differ from that observed during leg and whole-body work. One should also be aware that athletes who have not previously engaged in isolated upper body work, may experience it very muscularly challenging, even though both HR and ventilation rates are low. In such instances, RPE will provide a better indication of the appropriate intensity for completing a training session. As the athlete becomes fitter and more experienced, RPE, HR, and ventilation will align more closely.

The physical disability itself can also affect the physiological response to exercise. For example, higher HR has been observed during upper body work at the same external load in athletes with spinal cord injuries compared to athletes without disabilities (Hopman et al., 1992; Hopman et al., 1993). This occurs because a larger portion of the blood volume is pooled around the internal organs in these athletes. Consequently, less blood is pumped back to, and out of, the heart. This is compensated for by an increased HR to maintain the heart's pumping capacity.

The general recommendation for para-athletes competing in a seated position, primarily using their upper-body muscles, is to use RPE combined with HR to define and monitor training intensity. Lactate measurements are less recommended, but elite-level para-athletes in certain sports may benefit from measuring blood lactate. However, this requires systematic use over time to develop familiarity with one’s individual values and fluctuations.

EXTERNAL MEASURES

This chapter deals with relevant tools, both objective and subjective measures, that reflect the external load the athlete is subjected to during activity.

POWER (Wattage)

The use of power meters has increased considerably over recent years in several sports. Power can provide valuable information and make it easier to monitor intensity during fluctuating external conditions (and therefore varying intensity). However, there are many sports where it is difficult and impractical to use power as an intensity parameter. It should also be noted that at the same power, intensity can vary, e.g., when cycling uphill versus on flat terrain or indoors versus outdoors.

BENEFITS OF POWER FOR MONITORING INTENSITY:

- Reflects the external load on the athlete, thus offering valuable objective information alongside internal feedback.
- Effective in measuring rapid intensity shifts during varying terrain or loads.

DISADVANTAGES OF POWER FOR MONITORING INTENSITY:

- Large variations between different measurement units.
- Does not provide a measure of internal load and should be considered alongside internal feedback such as RPE, HR, blood lactate levels, and/or ventilation.

SPEED / LAP TIME

In many sports, speed is often used as the main parameter for monitoring intensity. It is user-friendly, practical, and offers a good overview of intensity. However, its applicability heavily depends on external conditions.

BENEFITS OF PACE FOR MONITORING INTENSITY:

- Easy to use for both athletes and coaches.
- Allows comparison with competition speed, as many sports take place in arenas with standardized tracks.

DISADVANTAGES OF PACE FOR MONITORING INTENSITY:

- Speed does not reflect the external load as accurately as a power meter, as it is influenced by factors such as equipment, terrain/gradient, temperature, humidity, wind, and air resistance.
- Does not provide a measure of internal load and should be considered alongside internal feedback such as RPE, HR, blood lactate levels, and/or ventilation.

PLANNING INFORMATION

Below, we will provide current information related to session planning and workload.

TOTAL DURATION

The total duration of a training session and accumulated time in an I-zone are primarily determined by the session's goal, the athlete's level, the training period, and the endurance modality. In some modalities, manageable work duration in a given I-zone may be limited by mechanical or muscular stress rather than metabolic stress.

In some sports, it is common to have two intense training sessions in one day, each with a slightly reduced volume. This approach helps maintain optimal technique and quality throughout all efforts. In such cases, the total workload and volume are high, even though the individual sessions do not meet the physiological “requirements” of a physical developmental session.

Given the aforementioned factors, it is not practical to give specific instructions as to how much time should be spent in each I-zone to achieve the desired training effect. Nevertheless, tracking the duration in an I-zone can be a valuable tool for coaches and athletes. It aids in tracking training progression and provides a clear understanding of what different session models should entail in terms of intensity.

Table 3. Suggested duration in each I-zone per session to develop and maintain physical capacity for a high-level cyclist.

I-zone	DEVELOPMENTAL SESSION	MAINTENANCE SESSION
I-1	~180–420 min	~120–240 min
I-2	~120–240 min	~60–120 min
I-3	~60–90 min	~45 min
I-4	~40–60 min	~30 min
I-5	~30 min	~15 min
I-6	~15 min	~6–8 min
I-7	~5 min	~2–3 min
I-8	~1–3 min	~0.5–1 min

*Total duration for the intervals.

INTERVAL DURATION

The recommended interval duration within the various I-zones will vary significantly between session models. There is no clear-cut answer as to what is ideal because the session design should always be built according to the goals of the training period and session, the athlete's training status, and the endurance modality the session is intended for. The relationship between interval duration and rest periods will largely dictate the intensity during the session. The appropriate choice of session model will help "guide" the athlete into the desired intensity zone.

Endurance sports that require high levels of technical execution often perform shorter intervals compared to those that are less technically demanding. This is done to optimize work economy and technique and to maintain focus throughout the interval/session. Sports with shorter competition durations typically use shorter intervals compared to those with longer competition durations.

Examples of current session models can be found by clicking on the icons on the intensity scale’s web page. Here, we have compiled session models used by national team athletes in various endurance sports.

REST PERIOD DURATION

Rest period duration can be used as a tool to control the intensity of the activity. With shorter breaks, athletes are compelled to maintain a slightly lower intensity during the intervals compared to when rest periods are longer. However, too short breaks may lead to inadequate recovery between intervals, resulting in deterioration of technical execution as the session progresses. In general, when the load on the muscular system outweighs that on the cardiovascular system, athletes require longer rest periods between intervals. The need for longer rest periods also increases with higher interval intensity.

During training in I-1 and I-2, rest periods are generally unnecessary, except for certain modalities where micro-pauses may be warranted due to high muscular strain or to offer athletes brief mental breaks to enhance technical execution. Rest period durations typically increase gradually from 2 min and beyond during training in I-3, reaching 3-5 min during training in I-5. During training in I-6 to I-8, it is common to have rest periods ranging from 5 min to 15 min.

TIME TO EXHAUSTION DURING CONTINUOUS WORK

Time to exhaustion in the various I-zones is sport-specific, as it is largely influenced by the varying muscular loads imposed by different endurance modalities.

For example, a cyclist will find it much easier and more practical to spend many hours in I-2 compared to a rower or canoeist. A marathon runner can run just below its threshold pace for two hours, while a speed skater will experience significant muscular issues in the back due to the seated position, forcing them to stop much earlier. This occurs even though HR, lactate, ventilation, and other indicators suggest that the intensity is no higher than what the I-zone would indicate.

Table 4. Approximate time to exhaustion in running. Illustrated to provide a better understanding of how long a well-trained endurance runner can sustain continuous work in the different I-zones.

I-ZONE	TIME TO EXHAUSTION	RUNNING SPEED
I-1	-	-
I-2	~3 hours	-
I-3	~60 min	~Half marathon speed
I-4	~30 min	~10 000 m speed
I-5	~15 min	~3000/5000 m speed
I-6	~4 min	~800–1500 m speed
I-7	~1 min	~200–400 m speed
I-8	~15 sec	~60–100 m speed

PARA-ATHLETES
The session models are central for both planning and monitoring intensity for para-athletes. It is particularly important to ensure that the choice of terrain supports the planned intensity. For example, sitting athletes in cross-country skiing will have a narrower speed range in uphill sections compared to standing athletes, making it impossible to keep the intensity low on steep or long climbs.

TESTING OF MAXIMAL HEART RATE

One can achieve HR_{max} in various ways, but for those who are unsure, Olympiatoppen recommends a test that involves 3x3 min with 2 min of active rest between each interval. The intensity should progressively increase with each interval, culminating in maximum effort during the final interval. Athletes should test their HR_{max} at least once every three years, as HR_{max} normally declines with age.

For those engaging in high-volume endurance training across various exercise modalities, it is advisable to test HR_{max} in each relevant modality, as it will vary depending on the type of activity. For example, the same athlete can have ~5% higher HR_{max} in running compared to cycling (Millet et al., 2009).

Below is an example of a HR_{max} test in running. A similar protocol can advantageously be implemented in other endurance modalities as well.

The test is performed as running on a treadmill or uphill with a ~6% to 10% incline (depending on the athlete's endurance level). After 15 minutes of warm-up with a HR of approximately 75% of the estimated max, the intensity is gradually increased over the next 10 minutes. The HR after the warm-up should be about 20 beats below the athlete's expected maximum HR.

The test starts with a 3-minute interval at a pace that the athlete could maintain for a maximum of 10 to 15 minutes. After 2 minutes of easy jogging, the athlete completes the next 3 minutes at 1 km/h faster than the first interval. After another 2 minutes of easy jogging, the athlete starts the final 3 minutes at a pace 1 km/h faster than the second interval and increases the speed from there by 0.5 km/h every minute until exhaustion.

HR is continuously measured throughout the test (using a heart rate monitor), and the highest value is defined as the HR_{max}.

The figure below illustrates the wide variation in HR_{max} based on age. This highlights the importance of knowing your own HR_{max} rather than estimating it based on age.

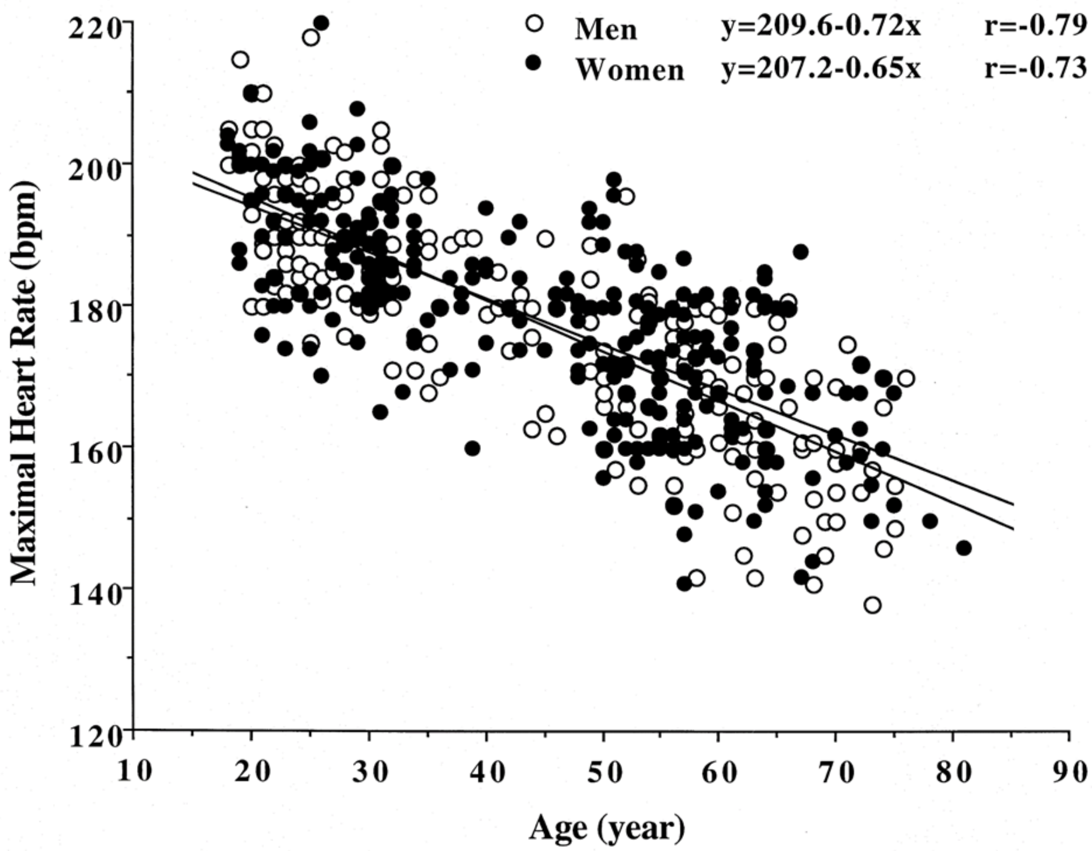

Figure 3. Spread in maximal heart rate for women and men, respectively, in different age groups (Tanaka et al., 2001).

RECOVERY TIME AND TOTAL LOAD

Recovery is a complex process where both physiological and psychological factors play a role (Halson, 2014). The recovery time from a workout is primarily a product of the duration and intensity of the session, as well as the type of exercise modality (Skorski et al., 2019).

There can also be differences in recovery with respect to central and peripheral factors. Central factors refer to processes that occur in the central nervous system, while peripheral factors refer to processes that occur in muscles and other tissues in the body. This can be exemplified by a run with a lot of downhill segments. The recovery time for the muscles may potentially be several days due to the high eccentric load, while the rest of the body will be recovered within a few hours. Recovery time is also significantly influenced by factors such as nutrition, sleep, rest, training status, and other variables.

Therefore, it is highly impractical and almost impossible to define recovery time based solely on the time spent in the various I-zones without also considering the specific training session, the training period, and the athlete's overall training status. Athletes can exhibit significant individual differences in their ability to recover after training and competition. It is therefore important to tailor recovery time to each individual athlete.

Factors in the athlete's overall life situation can also lead to increased recovery time after training. These can include factors such as poor sleep, poor nutrition, mental factors, or injuries/illnesses.

Continuous monitoring of the athlete's total workload and recovery state is essential for making timely adjustments to prevent overloading and/or overtraining.

We recommend that all endurance athletes record their training daily in Olympiatoppen's training diary. You can find more information about this below.

PARA-ATHLETES
For some para-athletes, increased energy expenditure during daily movement can also lead to longer recovery times after training. It is also important to recognize the cumulative load on the upper body muscles for athletes who utilize them in training and everyday transportation.

QUANTIFICATION OF INTENSITY

Reporting training session intensity can be done in several ways. For example, some choose to include the entire interval session, including rests, in the same I-zone, while others record the rest periods in I-1. Some track the accumulated duration in each I-zone based on "time in zone" from the HR monitor, while others use a combination of perceived effort, pace/wattage, and HR to define the intensity of each interval. The most important thing is to be consistent with your approach so that you can compare your training effort, execution, and progress with yourself over time. It is also highly advantageous for coaches if all athletes report in the same way, making it possible to compare athletes and develop knowledge about what training best improves performance.

Olympiatoppen recommends considering several intensity-monitoring tools, including both internal measures (e.g., subjective feeling, heart rate, lactate) and external measures (e.g., pace, power). We want to emphasize the importance of comparing various parameters against each other rather than using them in isolation to quantify the intensity of sessions. Relying solely on one parameter, such as HR, to record intensity will likely lead to an underestimation of intensity. This is especially evident in sessions with short intervals or rapid load changes, as the delay in HR response can lead to less time being recorded in the high I-zones than what was actually experienced.

An example could be 15 x 1 min intervals with rest periods of 1 min. Both speed and subjective feeling may indicate that this is a typical I-5 session. However, because it takes time for HR to rise during each interval, the HR monitor might only show 7–8 min in I-5, thereby underestimating how tough the session actually was. It is recommended to record all 15 working minutes as I-5 in the training diary, rather than relying solely on the data from the HR monitor.

At lower intensities, steady pace, and longer intervals or endurance runs, HR is a much better measure to report compared to interval sessions with short interval durations.

During training in I-8, it is common practice to include the rest periods as part of the total accumulated work time. An example would be 10 x 10 sec sprints with 2 min recovery between intervals. In this example, it would be appropriate to log the session as 20 min of I-8 training. This practice is also commonly utilized during training in I-6 and I-7.

TRAINING DIARY

Olympiatoppen recommends that all athletes log the intensity of their training sessions, as described above, in a training diary. Olympiatoppen has developed a training diary that is free for everyone to use, and we recommend using Olympiatoppen's training diary daily to record your workouts. The training diary serves as a valuable tool for planning and assessing your workouts. It contributes to managing the total workload, tracking progression, and implementing effective periodization strategies to optimize training benefits while minimizing the risk of overtraining. In the diary, you can also access statistics displaying the distribution of your training across various I-zones per session, week, month, and season.

The training diary enables athletes to monitor their progress consistently throughout their entire careers, utilizing the same platform from youth to elite levels. In Olympiatoppen's training diary, athletes have ample opportunities for reporting their training, accessing daily parameter statistics, conducting analyses, planning future sessions, and communicating with coaches and other support personnel.

Olympiatoppen recommends that all sports federations develop their own guidelines for quantifying training intensity and reporting it in the training diary. This approach ensures uniformity within the sport, allowing for athlete comparisons, and ultimately foster a shared understanding of training intensity.

Figure 4: The picture shows the front page of Olympiatoppen's training diary. Athletes, coaches, or staff can create an account.

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