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A Study on the Relationship Between Objective and Subjective Methods in Quantifying Training Load Among Middle-Distance Runners

دراسة العلاقة بين الطرق الموضوعية والطرق الذاتية في تكميم حمولة التدريب لدى عدائي المسافات النصف طويلة

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Abstract:

This study aimed to determine the relationship between objective methods based on heart rate (HR) and subjective methods (RPE) in quantifying training load among middle-distance runners. A purposive sample of 14 athletes from the OML Athletics Team was selected (age: 21.14 ± 2.62 years, height: 172.07 ± 3.38 cm, weight: 62.42 ± 3.83 kg). We used a descriptive correlational approach, and as study tools, we relied on Foster's RPE scale and the TRIMP and SHRZ methods to measure training load. The data were processed using the SPSS statistical program. In conclusion, the results revealed a high positive relationship with correlations reaching 0.837 for TRIMP-RPE methods and 0.732 for SHRZ-RPE methods.

Keywords: Training Impulse (TRIMP); Summated Heart Rate Zones (SHRZ); Rating of Perceived Exertion (RPE); training load; Quantification of Training Load.

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Introduction:

Sports training is one of the fields that has undergone many changes and developments. These changes and progress were driven by academics' and researchers' work to elevate performance, improve the training conditions of athletes, and focus on preparing them well. Despite this scientific progress in the field of sports training, more research and studies are needed to uncover many scientific facts and create integration in athletes' performance to reach the highest levels of athletic achievement. What we see today in terms of record-breaking in athletics, especially in running events, is not a coincidence but the result of the development of training programs based on sound scientific principles, which requires studying and monitoring the development of physical attributes, maintaining their peak performance, and searching for everything that unleashes the athlete's latent energy throughout the competition.

Middle-distance running (800 m and 1500 m) is particularly complex in terms of performance (Stellingwerff et al., 2018), which is influenced by a range of physiological factors (Tjelta, 2013) such as maximum oxygen consumption (Billat et al., 2001), lactate threshold (Casado et al, 2022), running economy, and neuromuscular abilities (Tjelta, 2013). They place high demands on energy production (ATP) through both aerobic and anaerobic systems (Storen et al, 2021). This contribution between aerobic and anaerobic capacities also allows the athlete to maintain high speeds throughout the race (Brandon, 1995). Scientific studies have confirmed that middle-distance races are a major challenge for coaches (Sandford et al, 2019) due to the overlap between aerobic and anaerobic physiological capacities (Tanji et al, 2018). Therefore, planning training programs for middle-distance races is very complex, as they need to develop their aerobic capacity similar to that of long-distance runners (marathoners), along with some of the mechanical characteristics of sprinters, while also possessing high-level anaerobic capacity (Hanley & Hettinga, 2018).

On the other hand, when we talk about training planning, the first step we take is to determine the training load and its components and how to regulate training for regular periods using the principle of progression and variation in training loads, which leads to anatomical, physiological, biochemical, and functional adaptations (Impellizzeri et al., 2004), taking into account that monitoring training load is extremely important (Foster et al., 2001), because physical development and improvement are significantly related to the methods and principles used in regulating training load.

Training load is quantified during training programs with the aim of improving training response, achieving the desired adaptation, and reducing the incidence of injuries and illness (Arney et al, 2018). Good management of athletic form, determining the optimal training load according to the athlete's capabilities, is a continuous process that requires individual monitoring of internal and external loads (often duration and distance) and analysis and use of these indicators to modify training and improve recovery processes (Kadem & Derouiche, 2023).

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Among the components that comprise sports performance analysis, determining the intensity of the training is often the most challenging component. Scholars resort to various aspects based on the sport being analyzed (Hourcade, 2017). The intensity of the training is normally measured using the heart rate (HR), the level of lactate in the blood (La^{-}), as well as the rating of the level of exertion (RPE) (Hill-Haas, 2011). This therefore implies that trainers use different techniques to measure the intensity of the training through a combination of technology as well as manual techniques that require adept trainers with the ability to analyze the information available (Arney et al., 2018).

One of the common objective methods of sports training is to monitor internal physiological values, which include heart rate (HR) (Bellinger et al., 2019). Although the method is quite popular, it also comes with its demerits. The equipment is quite expensive, it needs technical know-how, and analyzing the results takes time (Dellal, 2008). Moreover, using heart rate to determine the training intensity may fail, especially when it comes to intense or interval training (Foster et al., 2001), in addition to the fact that emotions can increase the rate of the heart, thus overestimating the actual training intensity (Hill-Haas et al., 2011).

Because of these shortcomings, reliance on coach's subjective evaluation or the application of Rating of Perceived Exertion scale (RPE) (Bellinger et al., 2019) in particular, which is founded on a normative rating scale (Hourcade, 2017) to assess effort, have been adopted by a number of coaches. While more accessible and cost-effective than objective methods, the information derived by RPE can track the training load in a broad range of sports (Arney et al., 2018). The use of heart rate (HR) information in conjunction with RPE provides a more accurate depiction of the training intensity than HR analysis conducted separately (Hill-Haas et al., 2011).

Hence, the focus of this research is to analyze the objective methods designed on HR, as opposed to subjective methods that depend on perception. Two new methods that will be presented to quantify the intensity of training related to HR would be TRIMP, developed by Banister & Calvert (1980), as well as SHRZ, which is based on Summated Heart Rate Zones, as described by Edwards (1993). For the subjective approach, the Foster RPE scale developed by Foster et al. (2001) will be used.

2. General Framework of the Study

2.1 General question:

Is there a relationship between objective and subjective methods in quantifying training load in middle-distance runners?

2.2 Sub-questions:

- Is there a relationship between the Training Impulse (TRIMP) method and the Rating of Perceived Exertion (RPE) method in quantifying training load in middle-distance runners?
- In measuring training load in middle-distance runners, does a relationship exist between Summated Heart Rate Zone and Rate of Perceived Exertion methods?

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2.3 General hypothesis:

There is a relationship between objective and subjective methods in estimating training load in middle-distance runners.

2.4 Sub-hypotheses:

- A positive correlation exists between the TRIMP and the RPE methods in quantifying training load in middle-distance runners.
- A positive correlation exists between the SHRZ and RPE methods in quantifying training load in middle-distance runners.

2.5 Study objectives:

- To identify the nature of the relationship between objective methods based on heart rate (TRIMP and SHRZ) and the self-perceived exertion (RPE) method in quantifying training load in middle-distance runners.
- To enable the monitoring and quantification of training load by applying the TRIMP and the SHRZ methods.
- To be able to monitor and quantify training load using the Rating of Perceived Exertion (RPE) method.

2.6 Significance of the Study:

- Identifying the methods that help for making an effective determination, measurement, and follow-up would result in accurate training load monitoring during an athletic season.
- This research is considered important because, once it is published, it will be a source of scientific reference for track and field coaches, particularly those involved with long- and middle-distance events. It points out using objective heart-rate–based techniques such as TRIMP and SHRZ with subjective RPE.

2.7 Key Terminology of the Study:

2.7.1 Training Impulse (TRIMP):

TRIMP stands as a method suggested to determine the effort an individual puts in their training based on the heart rate data recorded during exercise (Hourcade, 2017). It involves exactly three components: the actual percentage of heart rate reserve you exercise, the time spent exercising, and your heart rate max value (HRmax) (Arney et al., 2018). The result obtained is obtained using the following formula:

Men: duration (min) x (HRex – HRrest)/(HRmax – HRrest) x $0.64e^{1.92X}$

X: (HRex – HRrest)/(HRmax – HRrest).

HRrest: Average Heart Rate while resting.

HRex: Average Heart Rate while exercising. (Banister, 1991).

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2.7.2 Summated Heart Rate Zone (SHRZ):

Edwards' SHRZ training model breaks a workout routine into five zones based on heart rate, each of which has its corresponding importance coefficient beginning from 1 to 5. The training load is computed by summing the products of the time spent in each zone and its corresponding zone coefficient, as explained by Hourcade (2017): training load is calculated by multiplying the time accumulated in each heart rate zone by its corresponding weighting factor, and then summing the products: (time in zone 1 × 1) + (time in zone 2 × 2) + (time in zone 3 × 3) + (time in zone 4 × 4) + (time in zone 5 × 5), as proposed by Edwards (1993).

Table 1: Heart Rate Zones and Corresponding Coefficients

	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5
% HRmax	50-60	60-70	70-80	80-90	90-10
Coeff	1	2	3	4	5

Source: Hourcade (2017)

2.7.3 Rating of Perceived Exertion (RPE):

Carl Foster, an American researcher, developed the RPE. It is, to-date, the best way to assess the training level in any form of exercise, such as sustained, effort-based, competitive, bodybuilding, or acceleration-based. Athletes are requested to rate their workout session's intensity after approximately 30 minutes following the completion of the training session. This is done in accordance with the RPE, that is, the intensity level, on a subjective scale of 0 to 10. The current training level is computed using the formula:**TL = Session duration × RPE (UA)**(Hourcade, 2017)

2.7.4 Training Load:

Training load is described as the actual workload that is done, expressing both the volume completed and its intensity (Zouaghi et al., 2024). It encompasses all manner of reactions that occur in relation to exercising, be it physiological, technical, tactical, psychological, or social (Soligard et al., 2016). Training load can also be considered as having internal and external facets (Soligard et al., 2016).

2.7.5 Quantification of Training Load:

Quantification is a strategic component of training that aims to gauge the level of training based on volume and intensity. The intention is to enhance performance through the reduction of fatigue and improved recovery (Mansouri et al., 2024).

2.8 Previous and Related Studies

2.8.1 Carl Foster et al. Research in 2001

It was entitled: A New Approach to Monitoring Exercise Training

Its objectives:

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To monitor and assess the exertion level perceived by the athletes during training, using the RPE scale, and to compare the values with an objective heart-rate-based measure. The comparison was made for both continuous and intermittent workouts, including even basketball practice sessions.

Sample:

This study had 12 cyclists and 14 basketball players.

Findings:

- The conclusion drawn from the research is that Rating of Perceived Exertion (RPE) is an effective means of quantifying training loads for differing exercise modalities.
- A positive associations: among RPE, heart rate (SHRZ), and levels of blood lactate, both during continuous and intermittent exercise.

2.8.2 Coutts et al. Research in 2003

It was entitled: Validity of the Session-RPE Method for Determining Load in Team Sport Athletes

Its Objectives:

this study sought to assess how effectively the RPE method can be used to estimate training load. This study aimed to investigate the use of RPE, which has been developed and quantified by Foster, and compared with other training load estimation models based on heart rates, such as Banister's TRIM method.

Sample:

Participants were 18 rugby players.

Findings:

- All correlations between Foster's RPE scale and various heart rate-based methods were statistically significant.
- The results demonstrated that Foster's RPE is a valid and appropriate method for assessing training load in team sports.

2.8.3 Impellizzeri et al. Research in 2004

It was entitled: Use of RPE-Based Training Load in Soccer

Its Objectives:

The aim of this study is to apply Foster's RPE method in soccer and determine internal training load using RPE, evaluating its relationship with other heart rate-based methods.

Sample:

The sample consisted of 19 soccer players (mean age: 17.6 ± 0.6 years, weight: 70.02 ± 4.7 kg, height: 178.5 ± 4.8 cm).

Findings:

- Correlations between Rating of Perceived Exertion (RPE) and heart rate-based methods (SHRZ) were significant, ranging from about 0.50 to 0.85. These are slightly below the level that has been assumed in previous studies, from about 0.75 to 0.90, explained due to the anaerobic component of soccer.

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- Thus, RPE serves as a legitimate measure to gauge the individual's training load. The use of RPE in relation to heart rate lactate values will result in a more accurate measure.

2.8.4 Alexiou& Coutts' Research in 2008

It was entitled: A Comparison of Methods Used for Quantifying Internal Training Load in Women Soccer Players

Its Objectives:

This study aimed to compare the RPE method for internal training load assessment with heart rate-based methods.

Sample:

The sample included 15 female soccer players (mean age: 19.3 ± 2.0 years).

Findings:

- Statistically significant correlations were found between RPE and TRIMP. Correlation coefficients ranged from 0.68 to 0.82 during technical sessions, 0.60 to 0.79 during fitness sessions, and 0.61 to 0.79 during speed-focused sessions.

2.8.5 Rodriguez et al. Research in 2012

It was entitled: Comparison of Heart Rate and Session Rating of Perceived Exertion Methods of Defining Exercise Load in Cyclists

Its Objectives:

To compare heart rate and RPE in determining training load during exercise in cyclists.

Sample:

The sample included 12 professional cyclists (mean age: 25 ± 1 years, height: 175 ± 3 cm, weight: 65.9 ± 2 kg).

Findings:

- A correlation of 0.75 was found between RPE and the TRIMP method, indicating no significant differences between the two methods in determining training load.

3. Methodological Procedures

3.1 Pilot Study

The pilot study represents the initial step that helps the researcher gain a general understanding of the field aspects of the main study. It has become a fundamental stage for many researchers, whether to uncover certain scientific facts, test the reliability and validity of their research tools, identify challenges and limitations in conducting the primary study, or train support staff on practical implementation.

Accordingly, prior to launching the main study, a pilot study was conducted to assess the research setting, organize logistical procedures for measurement and fieldwork, inspect the training venue, coordinate with the club administration (training schedule, training days), clarify how to use the research tools, assess the participants' responsiveness, determine the time needed to complete measurements of training load, and identify potential difficulties researchers might face.

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3.2 Pilot study Results

- Secured approval from the club's administration to conduct the field study.
- Identified the specific characteristics of the sample to be studied.
- Discovered the main challenges and obstacles researchers might face during testing.
- Ensured that the support team fully understood how to implement measurements, record results, and process data.

3.3 Research Method

Methods of research refer to the systematic order of steps that a researcher adopts to accomplish the research objectives. In this study, a descriptive correlational research method was employed as it will best fit the nature of the research problem.

3.4 Research Population and Sample

3.4.1 Study Population:

The population of the research covers all individuals who are associated with the phenomena under scrutiny (Kadem &Derouiche, 2023). In the specific research in question, the population includes all mid-distance runners who belong to the Bouira provincial athletic leagues.

3.4.2 Study Sample:

The sample is defined as a subset of the population selected in a specific manner for study purposes (Kadem &Derouiche, 2023). The study sample included **14 athletes** from the OML Lakhdaria team (Age: 21.14 ± 2.62 years; Height: 172.07 ± 3.38 cm; Weight: 62.42 ± 3.83 kg; Training Age: 6.07 ± 1.14 years; HRmax: 197.85 ± 1.7 bpm; HRrest: 60.92 ± 1.43 bpm). The sample was selected intentionally (purposive sampling).

3.4.3 Sample Homogeneity:

Homogeneity is the idea that the sample remains as similar as possible and that large variability among the subjects should not significantly affect the results. To test whether homogeneity is achieved, we employed the coefficient of variation (CV).

Table 2: Coefficient of Variation (CV) for Sample Characteristics

Variable	Mean	Std. Deviation	CV (%)
Age	21.14	2.62	12.39%
Height	172.07	3.38	1.96%
Weight	62.42	3.83	6.13%
Training Age	6.07	1.14	18.78%
HRmax	198.36	1.78	0.90%
HRrest	61.79	1.72	2.78%

Source: Researcher

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Per Table 2, the statistical measures illustrate the absolute homogeneity of the sample data for all the measured factors since all the coefficients of variation are below 30%.

3.5 Study Procedures

The objective of this study was to investigate the nature of relationship between objective and subjective methods of training load quantification when conducting middle-distance training sessions. The participants were followed for 12 training sessions using the identified methods for quantification. The training load was measured by TRIMP and SHRZ methods by recording heart rate via the Polar V800 when undertaking training sessions. The training also involved completing an RPE test by Foster for subjective measures.

3.6 Research Tools

3.6.1 Training Impulse (TRIMP) Method:

This method quantifies internal training load based on heart rate analysis (Hourcade, 2017).

Table 3: Example of Training Load Calculation Using TRIMP Method

	HRmax	HRrest	HRex	X	Duration of the exercise session (min)
Player 1	197	61	158	0.71	80
Total Load Training (u.a)	duration (min) x (HRex – HRrest)/(HRmax – HRrest) x $0.64e^{1.92X}$				141.62

Source: Researcher

3.6.2 Summated Heart Rate Zone (SHRZ) Method:

An objective method that quantifies internal training load via heart rate zones (Hourcade, 2017).

Table 4: Example of Load Calculation Using SHRZ Method

	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5
% HRmax	50-60	60-70	70-80	80-90	90-100
Coeff	1	2	3	4	5
Duration (S)	45	130	2.70	245	195
Duration (min)	0.75	2.17	4.5	4.08	3.25
Load Training	0.75	4.34	13.5	16.32	16.25
Total Load Training (u.a)	(T in zone 1 x 1) + (T in zone 2 x 2) + (T in zone 3 x 3) + (T in zone 4 x 4) + (T in zone 5 x 5)				51.16

Source: Researcher

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3.6.3 Foster RPE Scale:

A subjective method for assessing internal training load by evaluating perceived exertion on a scale from 0 to 10 (Foster et al., 2001).

Example: TL = Duration × RPE = 80 × 7 = 560 (u.a.)

Table 5: Foster's RPE Scale

Rting	Descritor
0	Rest
1	Very, very easy
2	Easy
3	Moderate
4	Somewhat Hard
5	Hard
6	.
7	Very Hard
8	.
9	.
10	Maximal

Source: Foster et al., 2001

3.7 Statistical Tools Used

The following statistical methods were used in this study via **SPSS**:

- Mean
- Standard deviation
- Coefficient of variation (CV)
- Pearson correlation coefficient

3.8 Results Presentation and Analysis

3.8.1 Presentation and Analysis of the Correlation Between RPE and TRIMP

Table 6: Correlation Between RPE Scores and TRIMP Method

Variable	Mean	Std. Deviation	Significance Level	Pearson Correlation (R)	Sig. (2-tailed)
RPE	586.71	64.07	0.05	0.733	0.003
TRIMP	121.29	16.90			

Source: Researcher

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From statistics derived from Table 6, RPE has a mean value of 586.71 with a standard deviation of 64.07, whereas that of TRIMP is 121.29 with a standard deviation of 16.90. To identify how RPE is related to TRIMP, Pearson's correlation is employed. The resulting value for p is 0.003, which is highly significant as it is less than 0.05. The correlation coefficient is 0.733, showing a strong positive association between RPE and TRIMP.

3.8.2 Presentation and Analysis of the Correlation Between RPE and SHRZ

Table 7: Correlation Between RPE Scores and SHRZ Method

Variable	Mean	Std. Deviation	Significance Level	Pearson Correlation (R)	Sig. (2-tailed)
RPE	586.71	64.07	0.05	0.763	0.002
SHRZ	84.43	30.19			

Source: Researcher

As shown in Table 7, the RPE method yielded a mean of 586.71 (SD = 64.07), while the SHRZ method yielded a mean of 84.43 (SD = 30.19). The Pearson correlation coefficient was 0.763 with a p-value of 0.002, which is also below 0.05. This suggests a strong and positive correlation between the RPE and SHRZ methods.

4. Discussion and Interpretation of Results

4.1 Discussion of the First Sub-Hypothesis

The first sub-hypothesis stated that there is a positive relationship between the application of Training Impulse (TRIMP) methods and Rating of Perceived Exertion (RPE) in training load calculations for middle distance runners. As depicted in Table 6, on examining Pearson correlations between RPE and TRIMP training loads, a strong positive association of 0.733 is found between these two variables in the study. The first hypothesis is therefore supported by the findings of this study, in line with those of other past studies on training load methods. For example, Coutts et al. (2003) stated that all correlations between RPE and heart-rate methods were found significant, ranging between 0.41 and 0.96 in value. Carl Foster et al. (1995) also verified that RPE is a valid tool for training intensity quantification, indicating strong correlations with HR and blood La^{-}-values.

As shown by Alexiou& Coutts (2008), the importance of Rating of Perceived Exertion (RPE) cannot be overstated when it comes to assessing what is happening within the body. They showed a convenient correlation between RPE and TRIMP at a coefficient of 0.61-0.79. Manzi et al. (2015) also showed a correlation between TRIMP and RPE at a coefficient that was significant when they conducted a 5,000m and 10,000m run.

Analysing a cycle-specific study, Rodriguez et al. (2012) have established a correlation coefficient of 0.75 between TRIMP and RPE, thus pointing out the similar results that the two systems deliver.

On the whole, there seems to be a consensus among researchers on the opinion that RPE represents a reliable and valid method for assessing internal training load. Secondly, TRIMP

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appears to represent a robust method for the quantification of internal training load on the basis of heart rate, which has a close link with training and oxygen intake. Nevertheless, TRIMP may be considered a rather faulty method, especially with regard to the performance of high-intensity interval training.

However, the limitation was noted to be in TRIMP, where it might be less accurate during anaerobic or weight training activities, since HR does not increase proportionally with the intensity of the training (Foster et al., 2001). Hence, it is more reliable to estimate the training load using different methods.

In conclusion, the current findings, in line with prior research provide evidence in favour of the first hypothesis.

4.2 Discussion of the Second Sub-Hypothesis

The second sub-hypothesis stated that, when determining training load for middle-distance runners, there would be a positive relationship between the SHRZ and the RPE methods. A Pearson correlation of 0.763 can be seen in Table 7 and represents a very positive relationship between SHRZ and RPE.

This corresponds with past findings. High correlations of between 0.75 and 0.90, although SHRZ took lower loads compared to RPE, were noted between RPE and SHRZ by Foster et al. (2001). RPE was also noted by Foster (1998) to be a reliable measure of training intensity. The RPE and SHRZ correlations in soccer training sessions were 0.50-0.85 and were statistically significant according to Impellizzeri et al. (2004).

Moreover, the observations of Minganti et al. in 2011 showed a correlation of RPE with SHRZ during extensive exercise techniques such as long-interval training (5 × 1000 m) with an average value of the correlation ranging from 0.82 to 0.86 for RPE-SHRZ correlations.

On the whole, experts agree that RPE may provide an even more accurate reflection of the intensity of training than traditional approaches when account is taken of the above-described physiological and psychologically based indicators of intensity. Indeed, the relevance of the method was further confirmed in the meta-analysis conducted by Haddad.

SHRZ, in contrast, offers a more sophisticated method of intensity estimation, breaking down heart rate into zones on the basis ofHRmax values, cumulating the load as the duration in each zone multiplied by its respective coefficient (Edwards, 1993).

In summary, based on both the current study and supporting literature, the second hypothesis is also confirmed.

5. Conclusions and and suggestions

5.1 Conclusions

In light of the study's hypotheses, aims, and findings obtained under the current conditions, the following conclusions can be made:

- Rating of Perceived Exertion (RPE) and the Training Impulse (TRIMP) have shown to be very similar, with small variations in the training load measured in middle-distance runners.

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- There also appears to be a strong association between the RPE and the Summated Heart Rate Zone (SHRZ) in this data.
- There is a strong positive association between HR-related objective values and the subjective RPE method in measuring training loads in middle-distance runners.
- The RPE approach offers a valid and effective means of measuring training loads for middle distance athletes.
- -Alternatively, TRIMP and SHRZ, which are based on heart rate, are just as valid and scientifically supported alternatives for training load measurement in this population.

5.2 suggestions

- The correct method for determining the intensity of training varies according to the type of training.
- It's recommended that practitioners not use any single method to estimate the training load. A combination of objective and subjective measures will provide a more comprehensive view. This will enable the practitioners to assess the intensity of the load in a more effective manner.
- When employing TRIMP and SHRZ, for instance, one has to consider the emotional state of the athlete because heart rate can also indicate emotional states.
- The training load tracking during training sessions must have a scientific approach.
- Modify the intensity of the training sessions as required based on the adaptations experienced and the condition of the athletes.
- Coaches need to be informed on the most suitable approaches for rating the intensity in order to better meet the training requirements.
- Trainers should be skilled and competent in data gathering and analysis for effective training.

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