

Quantification of training load - a basic element of sports performance in the 21st century

La cuantificación de la carga de entrenamiento - elemento básico del rendimiento deportivo en el siglo XXI

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Monitoring the training load is a hot topic in sports science. Scientists and trainers alike are monitoring training loads on a daily basis, using different multidisciplinary approaches. This search for the best methodologies to collect and interpret the data has led to an exponential increase in applied empirical research.

The training load or stimulus involves the combination of the exercise mode and the volume, intensity and density or frequency level. The relationship between the training load, the state of stress (physical, physiological) caused by the load and recovery, is essential in order to bring about positive adaptations that improve sports performance and prevent over-training. A number of models have been proposed to quantify the load components (volume, intensity, density and frequency). These measure the internal and external load and are primarily differentiated by the indicators to measure or estimate effort intensity.

Internal load

Internal load has been defined as the biological stress (physical, physiological and psychological) imposed on the athlete in relation to the training volume (time). There are a number of indicators to measure this internal load:

- Oxygen consumption (metabolic equivalents)
- Heart rate indicators (training zones, HR variability)
- Concentration of blood lactate
- RPE (rating of perceived exertion) scale
- Biomarker concentration or volume (urea, CK, haemoglobin, ferritin, cortisol, testosterone, oestrogen and progesterone in women, etc.).
- Socio-psychological tests (POMS, Rest-Q-Sport)

External load

The external load is the objective measure of an athlete's performance during training sessions or competitions and it is assessed independently of the internal training load. The main metrics to determine it are:

- Speed and/or acceleration of movement during exercise (m/s, Km/h, m/s²)
- Power produced in the movement: absolute watts (W) or power-to-weight ratio (W/Kg)
- Distance travelled (metres, kilometres)
- Exercise time (seconds, minutes, hours)
- Performance statistics: success or failure during decisive performance actions in each sport (goals, points, hits, passes, stops, blocks, spikes, etc.)

Towards optimal and sport-specific load quantification models

The combination of the internal load and the external load in different models gives greater information on the stress on athletes caused by training. For example, the same external load monotonously repeated in training sessions can cause different reactions in the internal load indicators, involving different stress and fatigue levels.

For this reason, it would be more appropriate to use the model that is best suited to the characteristics of the athletes and sport to be quantified. Over the last few years, a number of models have been proposed in the literature.

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Team sports

Historically, the external load is the most-used measure to quantify the training load in team sports, where high-intensity effort is combined with short recoveries throughout the game. GPS, accelerometers and motion analysis systems are used to calculate speeds, accelerations and actions performed by the players when training and competing. It has been more difficult to relate these values to the internal load involved in performing the movement. The heart rate has been the most-used indicator of the intensity of exercise recovery in players. Nowadays, data analysis software programmes are essential to quantify the actions performed and their performance intensity. It is extremely important that the analyst filters the information, the most significant actions for the success of the game, which provides the “big data” for fitness coaches and the trainers of each player. This information, together with the internal load indicator of fatigue (heart rate, RPE, biomarkers, socio-psychological test), will be necessary in order to quantify the training load. There is no single model for all sports, due to the wide variety of rules and the diversity of performance factors that are specific to each team sport in order to achieve success.

Aerobic endurance sports or training sessions

The aerobic internal load in relation to the external load, has been extensively studied and measured for endurance sports. This is why there are a number of load quantification models that relate both loads, such as Foster’s load index, TRIMP or ECOs

- The load index relates the training time (without considering the pause) of each session to the RPE of each athlete.
- The Training Impulses (TRIMP) relate the training time (without considering the pause) of each session to the effort zone, measured by the heart rate of each athlete.
- The Training Stress Score (TSS) relates the training time (without considering the pause) of each session to the individual effort zone, measured in the external mechanical power generated by the athlete in the training session.
- The Objective Load Equivalents (ECOs) relate the training time (considering density, exercise time/rest time) to the individual effort zone of each athlete (measured in the most suitable unit for each zone, including anaerobic and strength) and the different exercise mode in each sport (running, swimming, pedalling, etc.).

All the models offer the possibility of establishing a relationship between the intended form and the fatigue produced based on recovery

time. However, the difference lies in the intensity indicators used by each model. Therefore, the key factor is to use the most appropriate model for each sport with regard to the effort intensity / recovery indicators and the exercise mode, given that the energy expenditure during training is different at the same intensity and for the same time. The method of reference would be to measure the oxygen consumption - energy expenditure at each training session. However this is not very practical at present and remains to be seen in the future.

Strength and power sports or training

Lactic and alactic anaerobic capacity and power are metabolic efforts that cannot be measured internally. For this reason, they are quantified externally as intensity indicators by power and speed of performance of the movements. Accelerometers, linear position transducers, photoelectric cells, inertial sensors or video analysis are used to either estimate or measure the speed or power of performance. The volume in the strength exercises (squat, bench press, etc.) is quantified in numbers of sets and repetitions of exercises with a recovery time between them. While, for sports action, volume is quantified in time of effort (it is very important to take density into account) and, for lactic efforts, the blood lactate value can also be used as an internal effort indicator.

Conclusion

In the 21st century, the training load is a fundamental and valid element that serves to plan training and to calculate the expected state of fitness for the target competitions of each athlete. Different specific models are available for use in each sport in order to optimise performance.

It is an ideal indicator to be used to lessen the risk of injury and over-training. An individual, intra-subject and longitudinal analysis should be made of the training load over time in order to make it possible to compare the training process against improved performance.

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