BARÇA
INNOVATION HUB
Universitas

CHOOSING VARIABLES ARE WE REPEATING INFORMATION OR PROVIDING ADDITIONAL INFORMATION?

CHOOSING VARIABLES

4.1 Introduction

The choice of which variables to monitor, evaluate and periodically report is a key aspect of daily practice and, therefore, a rigorous process must be carried out to decide which variables to monitor. As has been explained in previous modules, the quantity of information we have access to could result in a state of paralysis due to overanalysis. There is so much information available that it is difficult to evaluate what has happened and, much less, make decisions about what we should do in the future.

4.2 What are professional teams doing?

Based on questionnaires sent to trainers who work with elite teams (Table 2), Akenhead and Nassis (2016) highlight that there are a great number of different variables monitored by trainers. Specifically, the authors revealed there are 56 different variables used by trainers of elite teams when monitoring training load. These include internal load indicators or measurements (such as average heart rate) and external load indicators of different levels (for example: distance covered >7.0 $m \cdot s^{-1}$, level 1; frequency of accelerations >3.0 $m \cdot s^{2}$, level 2 and number of jumps, level 3).

Moreover, we should take into account that many of these variables are expressed as absolute values (distance covered in meters or number of actions performed) as well as in relative terms (such as time or total distance covered). Let's review an example to better understand this idea. The distance covered at high speed, using in this case, an absolute value to categorize said actions for example of 18 $km \cdot h^{-1}$, during a soccer match (90-minute duration) can be expressed as follows:

Table 1: Study of distance and time in displacements made at high speed (>18 km h^{-1}) by two different players expressed in absolute and relative terms.

Distance covered in absolute values >18 $km \cdot h^{-1}$ (m)	850 m	950 m
Time invested >18 km h^{-1} (seconds)	132.8	141.8
Distance covered relative to the total distance (% of the total distance covered)	8.5%	8.3%
Distance covered relative to total time (% of the total duration of the match)	2.45%	2.6%

Source: Prepared by the author

In Table 1, we can see the values from two players that have different demarcations within the playing field. The total distance covered by Player A during the match was 10,000 meters, while Player B covered 11,500 meters. Moreover, in the above example we can observe how the analysis could be different. Which player has run at higher speed? Depending on the type of variable selected for monitoring, the answer will be different. Therefore, it can be said that there is a lot of information available that can also be expressed in

different ways. Consequently, we should filter (choose) the variables from the numerous different possibilities.

Table 2: Training load parameters and thresholds identified from 41 questionnaires completed by professional soccer trainers.[1]

Acceleration *	Speed-time *	Relative Speed *	Heart Rate	Subjective	Accelerometry	Metabolic Power *	Other
Peak acceleration ($m \cdot s^{-2}$)	Average velocity	>V_{MAS}	HR_{AVE} (beats)	RPE	Player load† (a.u.)	Average Metabolic Power ($W \cdot kg^{-1}$)	Total distance covered (m)
Velocity change load# (a.u.)	Speed Intensity	>V_{LT}	>HR_{LT} (mins)	Cognitive load	Body load$^{\Delta}$ (a.u.)	Explosive distance	Training duration (mins)
>1.0$m \cdot s^{-2}$	>4.0$m \cdot s^{-1}$	Peak speed	>70%$_{max}$ (mins)	Coach Observations	Step balance$^{=}$	>20 $W \cdot kg^{-1}$	
>2.0$m \cdot s^{-2}$	>4.5$m \cdot s^{-1}$	>60%$_{max}$ speed	>80%$_{max}$ (mins)		Dynamic stress load$^{=}$ (a.u.)	20 - 35 $W \cdot kg^{-1}$	
>2.5$m \cdot s^{-2}$	>4.7$m \cdot s^{-1}$	>65%$_{max}$ speed	>80%$_{HRR}$ (mins)		Change of direction (n)	35 - 55 $W \cdot kg^{-1}$	
>2.75$m \cdot s^{-2}$	>5.0$m \cdot s^{-1}$	>70%$_{max}$ speed	>85%$_{max}$ (mins)		IMA†	>55 $W \cdot kg^{-1}$	
>3.0$m \cdot s^{-2}$	>5.5$m \cdot s^{-1}$	>80%$_{max}$ speed	>90%$_{max}$ (mins)		Jumps† (n)		
>3.5$m \cdot s^{-2}$	>5.8$m \cdot s^{-1}$	>90%$_{max}$ speed	Heart rate exertion score				
>4.0$m \cdot s^{-2}$	>6.0$m \cdot s^{-1}$						
	>6.7$m \cdot s^{-1}$						
	>7.0$m \cdot s^{-1}$						
	>7.5$m \cdot s^{-1}$						

V_{MAS}, velocity at maximal aerobic speed; V_{LT}, velocity at lactate threshold; HR_{AVE} average heart rate during the session; HR_{LT}, heart rate corresponding to the lactate threshold; Cognitive load, assessed by questionnaire; Velocity change load, sum of acceleration load, deceleration load and agility load derived from the force of the action, the number of actions and the body mass of the player; Speed intensity, unknown; RPE, rating of perceived exertion; Player load, Body load, Step balance, Dynamic stress load and IMA - derived from accelerometer and calculated using manufacturers unique algorithm.

* Time-motion variables recorded by teams included the number of discrete efforts and the total distances covered within the defined thresholds.

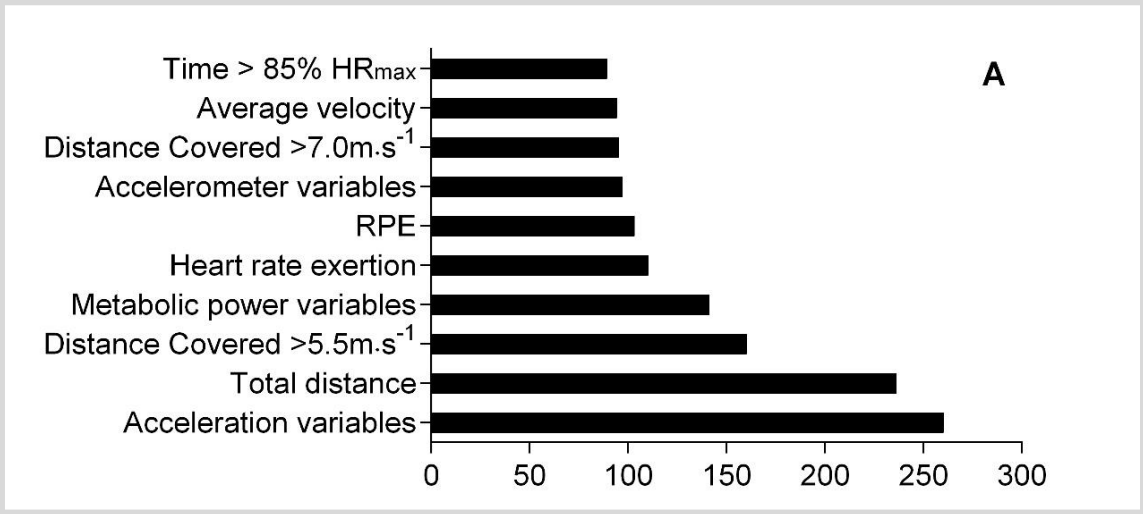
† Catapult Innovations, Scoresby Australia, $^{\Delta}$ SPI-Pro GPSports, Canberra, Australia, $^{=}$ STATSports UK, Co. Down, UK, #Athletic Data Innovations, Sydney, Australia

Source: Akenhead and Nassis (2016).

From all the many options, elite trainers monitor 7 variables on average (between 4 and 10) during training (Akenhead et al., 2016). It can be seen that variables of acceleration (type II), distance covered, distance covered at >5.5 $m \cdot s^{-1}$ and variables related to metabolic power are the ones most frequently used during training (Figure 1).

Figure 1: Frequently monitored variables in elite soccer during training

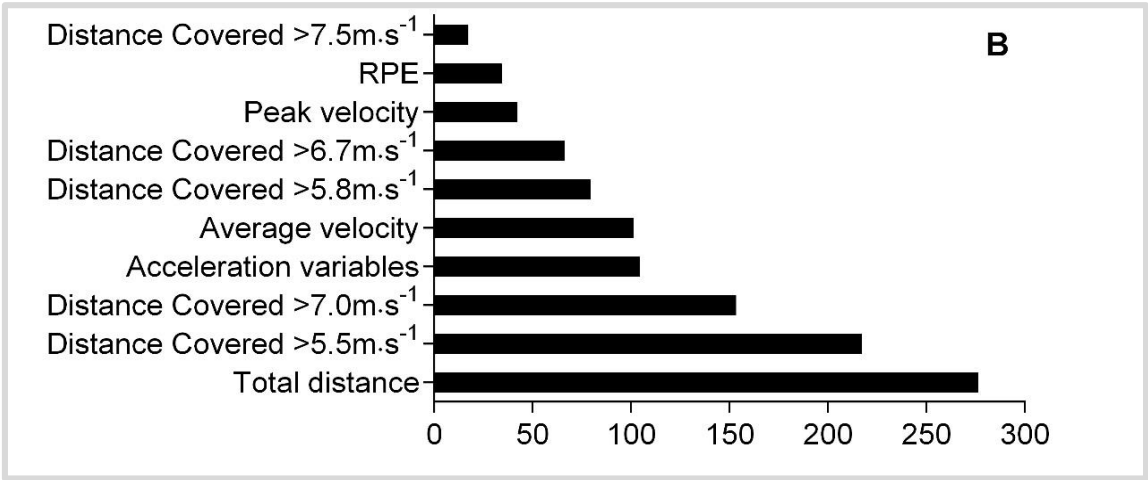
[1] Displacement variables in different intensity categories refer to the number of efforts and the distance covered within the established thresholds.



Source: Akenhead and Nassis (2016).

However, during matches the same trainers on average monitor 3 variables (between 4 and 7) and the variables related to accelerations, which were most frequently monitored during training, are monitored less frequently. It is important to mention that on many occasions, the technology used by the teams in the training process and in matches is different, and this partly justifies said differences. That is to say, during training, most teams use GPS devices that study accelerations based on the velocity-time signal. However, during matches, they use video tracking systems that do not provide information regarding the athlete's accelerations. This also occurs with regards to metabolic power variables that rely on accelerations being studied in order to calculate the energy expenditure. As a consequence, they are available in training but they are not available for many trainers while monitoring matches (Figure 2).

Figure 2: Frequently monitored variables in elite soccer during matches



Source: Akenhead et al (2016).

4.3 Proposal of variables to monitor

Halson (2014) proposes that the variables and indicators to consider in order to quantify the load or intensity of tasks and complete training sessions should include, if possible, a high variety of dimensions. Managing these variables and indicators ensures a better understanding of the demands imposed on athletes at different levels. It mainly addresses the demands related to cardiovascular impact (demands related to resistance capacity), actions performed at high displacement speed (demands related to the velocity capacity) and demands related to the accelerations/decelerations made by the athlete (demands related to strength capacity).

Below, we will outline a proposal for load variables to monitor and the rationale used to analyze a training session. As mentioned in the previous module, the relationship between variables changes depending on the content (based on the type of session) which is why this proposal should be adapted to the demands of each specific session. On the other hand, a proposal should be established for each training session as a monitored temporal unit. The analysis of other temporal structures, in addition to methodological details that will improve the analysis, will be detailed in the following course. Although load is accumulative over the specific time period of a task or session, the intensity of the session or task can be determined turning those load values into values relative to the practice minute (min^{-1}), as a percentage (%) or ratio of the total accumulated during the session or task. However, we should consider that the relative values calculated as regards the total task or session will be influenced by the time invested. In this case, it seems more logical to use intensity indicators when the tasks are being analyzed. In this way we avoid incorporating pauses and explanations between tasks when calculating intensity. It is therefore justifiable that load variables be used to monitor the session as these can be easily converted into intensity indicators when analyzed relative to the training minutes. For example, a distance of 5000 meters covered (external load variable) in a training session that lasts for 80 minutes would result in a distance of 62.5 $m{\cdot}min^{-1}$ covered per minute (external nature intensity variable). Therefore, the established proposal aims to be very specific due to the great number of possibilities outlined throughout the course.

- Duration in minutes (gross, net and % of the actual time)

This represents the volume of the training session. We can include the total duration of the session (gross duration) or only the player activity periods (net duration) excluding the rest and hydration periods, trainer's explanations and corrections. Moreover, through the quotient of both variables, we can calculate the % of actual session time (net duration/gross duration). This value provides information about the density of the session, in addition to the session volume.

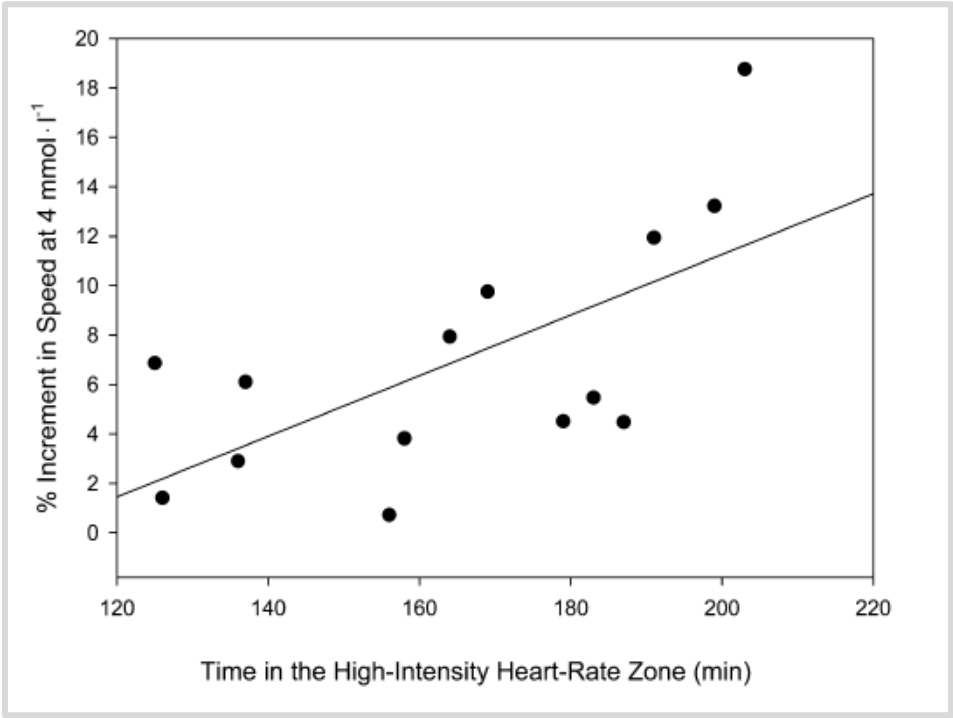
- Total distance covered or player load (load indicator obtained through accelerometry).

These are two external load variables that are sometimes confused with session volume. However, they refer to the training load, as they are obtained by multiplying the volume (minutes) by the intensity (distance covered per minute or player load per minute). The player load makes reference to the athlete's level of activity (it takes into consideration the movements in three planes of motion), while the distance covered makes reference only to the number of displacements made by the athlete. The trainer should chose only one of them, as they are variables with a high correlation between them.

- Time invested at >90% of the maximum heart rate.

It is an internal load variable that tells us about the time invested at high cardiovascular impact zones. Although the specific example provided makes reference to 90% of the maximum heart rate, other intensities can be used to determine the high cardiovascular impact zone (for example time above 84% of the individual maximum heart rate). Another possibility is to use thresholds calculated using tests on athletes. For example, to monitor the time invested above the heart rate related to the ventilatory threshold or to the lactate concentration of 4 mmol (Figure 3). It is pertinent to include this variable, as significant relationships have been revealed between the time invested in these areas and the aerobic improvement experienced by athletes (Castagna et al., 2011; Manzi et al., 2014).

Figure 3: Relationship between the time invested in the high cardiovascular intensity zone (heart rate above the that related to 4 mmol·L-1) and the pre-post change after the intervention period at the velocity associated to 4 mmol·L-1 (r=0.65; p<0.01; n=14).



Source: Castagna et al. (2011).

- Distance covered at 70% of athlete's maximum velocity.

The distance covered at high speed is a variable that must be included in this type of analysis. Therefore the demands placed on the athlete at their maximum capabilities must be put into perspective. This is why individual velocity ranges should be used when studying these displacements.

- Number of sprints (>90% of the athlete's maximum velocity).

The study of the maximum speed actions undertaken by the athlete during competition and the training process requires a detailed analysis. As a result, we highlight the need to use, once again, the individual velocity ranges to clearly identify the number of individual sprint actions made by each player. If individual ranges are not used when studying this type of action, the validity of the measures will decrease and, consequently, its usefulness is reduced. If we do not use this parameter, we will underestimate the load imposed on slower athletes–who have difficulties accumulating distance above an absolute value of velocity–while the opposite will occur with faster athletes and we risk overestimating the distance covered by them. In order to avoid this, it is important to relativize the sprint actions to individual ranges of velocity.

- Average acceleration/deceleration

We need information about the demands related to the “strength” dimension. Therefore, taking into account the stochastic nature of the demands in match situations and in competition in team sports, average acceleration/deceleration could provide a more global representation of the reality for these types of practices (Delaney et al., 2017).

- Training efficiency indicator: Player load / TRIMPx

This is an indicator of cardiovascular training efficiency that relates the external load measurements with internal load measurements and provides information about the athlete's state of adaptation. Consequently, it is a very interesting variable to use to make decisions about changing the focus of training. However, the analysis of a specific session will have reduced utility/importance. On the contrary, it will allow us to make decisions analyzing the behavior of said variable in a longer period of time. Therefore, it is necessary to have a daily record of this indicator.

4.4 Conclusions

When evaluating the training load, in order to optimize the selection of training loads, it seems to be necessary to choose a small number of variables. For this point it is worth emphasizing the need to select indicators and variables that provide information on the three dimensions or energy systems: aerobic, metabolic (or high-intensity runs) and neuromuscular processes (acceleration/deceleration, changes of direction, turns, jumps and peak speed). Based on the above, it seems that the intervention (training) and competition should be evaluated using a variety of relevant internal and external indicators of athletic performance (Weaving et al., 2014). The information obtained from load indicators, related to variables that include aspects about the activity at high intensity are seemingly interesting. Combining intensity indicators associated with external and internal load variables could be a useful solution to avoid losing information about what is being done, but it needs to be sustainable! Programmed alerts across several dimensions will allow us to more accurately measure the demand imposed on players, since in soccer training, a broad range of tasks are required of the players and–most of the time–the different characteristics of these tasks occur simultaneously (Castellano and Casamichana, 2016).

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