TRAINING MONITORING IN FOOTBALL

WHERE ARE WE HEADING?

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BACKGROUND

a) The importance of monitoring training

The monitoring of training represents an important feedback tool by which "data" can be collected to determine if players are both completing and positively adapting to the training that is planned by the coach/practitioner. The importance of player availability to team success has led to the interest in training monitoring in elite soccer rising exponentially over recent years. Monitoring is now frequently used to support the planning of training and match exposure at both team and individual levels making this process a key component of both short- and long-term decision around player management. As such, effective monitoring of training load is an important part of the sport science support strategy of the vast majority of elite teams to both improve performance and reduce injury risk.

b) Performance / injury

Key considerations for the monitoring of training

Training monitoring should involve describing both the exercise (what the player does) and response (how the player changes behaviour or perceives the exercise (see Figure 1). These outcomes are often operationalised as (i) the external load, and (ii) the internal load. While understanding the external load is important assessing the response to the activity is vital to effective practice. Approaches to assessing the internal response have focussed on variables that are broadly classified as "metabolic" (e.g., cardiovascular variables, indications of the energy systems used to support the activity) though football activities also lead to "mechanical" stresses on tissues in the musculoskeletal system (e.g., cartilage, bone, muscle, and tendon tissue. Failure to meet the "target" internal responses in either system represents a training error that can be used as feedback to modify the training plan (feedback loop) (See Figure 1). Through the application of these regulatory processes the effectiveness of training can be enhanced. These improvements are however a direct consequence of the ability of the data that is generated to be analysed and operationalised by the coach/practitioner into the training/competition plan. This would indicate that effective monitoring is a function of both "human", organisational and technical considerations.

Training load monitoring strategies should also include methodologies that evaluate a broader range of factors that have potential to impact the adaptive process (by influencing either the response to exercise or the that in the acute phase following the completion of exercise. The competitive schedule exposes players to high levels of background stress (e.g., public and media attention) as well as frequent travel to play games (often across international borders and time zones). Such things are in themselves a source of "stress" as they can create an environment for the elite player where important lifestyle factors such as dietary routines and sleep habits are altered compared to normal. Monitoring may then include approaches that can provide objective information on more general lifestyle factors as experienced by players. Such multi-dimensional approaches could include sleep, nutrition and general life stress.

Overall then effective strategies to monitor training load need to be flexibly applied and involve multiple methods and outcome variables. Approaches should not be "one size fits all' but rather be tailored in relation to the context. There are many different alternatives for both sensor-tracking (e.g. GPS/LPS systems) and other ways of capturing player data around the response to exercise (e.g. questionnaires). Any measurement variable or method may

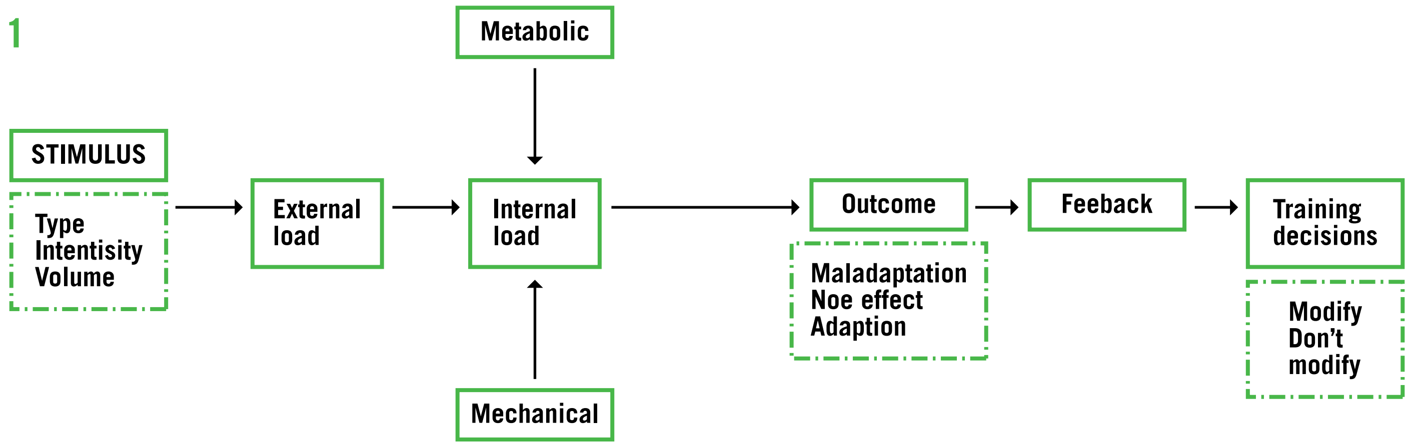

Figure 1: A schematic representation of the role on monitoring training in supporting the training process.

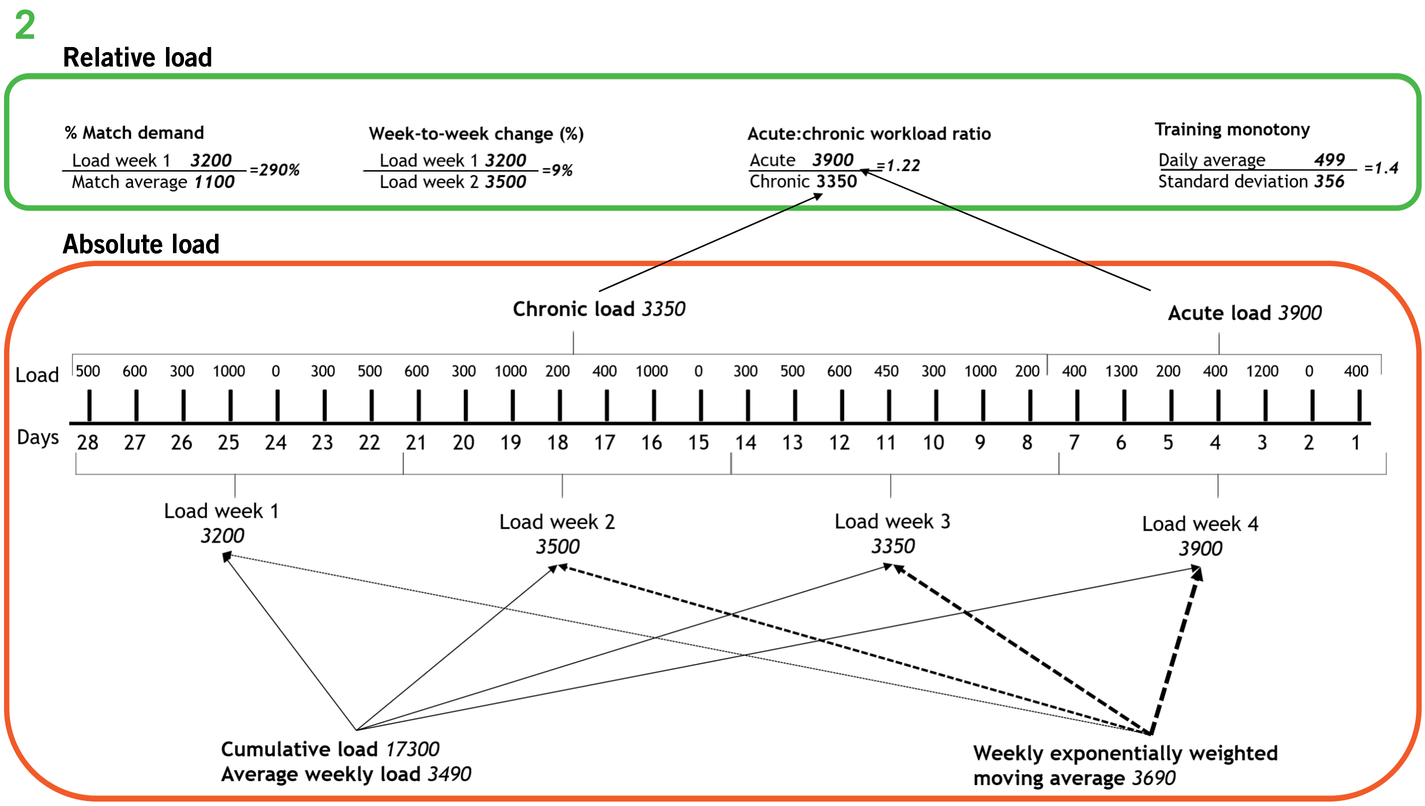

Figure 2: Overview of some of the most used load analysis constructs.

provide useful information if the approach makes logical sense and is well understood by the practitioner (i.e. has an evidence base associated with it). There is a lot of commercial interest in these systems and practitioners should be critical in analysing the claims that are made around the ability of a given approach to provide meaningful data. The companies should provide rationale and evidence for their claims, ideally through third party evaluation (e.g. FIFA) and make the results publicly available. This understanding should include a critical appraisal of the reliability, validity, and utility of the data being collected before systematic use of the approach.

c) How should the data be analysed?

Once the data has been collected, the next step is to transform the raw data into tangible insights. There are many ways to analyse training load data, and it can broadly be divided into two categories, absolute and relative (Figure 2)[1]. Absolute loads are simply the amount of load performed through the course of a time period (e.g. cumulative or average loads from training sessions or matches, days, weeks). Shorter periods (i.e.,1-9 days) are typically called acute periods, and more extended periods (i.e.,>9 days) are called chronic periods. Absolute loads can also be analysed as the number of matches during a time period, often referred to as match congestion.

Relative loads are the absolute loads but in relation to a reference (Figure 2).

The most used references are the match demand and training load history. When using match demands as a reference, the absolute training load is divided by the match demand (i.e. the player has this week performed 500m of sprinting or 120% of the game demand) and is contextualised practically for players and coaches[2]. The match demand reference is most often used as a whole match average, but it can also be a "worst-case" period (e.g. the most demanding 60s period), although its usefulness is debated[3].

Many different approaches are possible when using load history as a reference (also referred to as change-in-load). One option is to analyse strain and monotony[4]. Monotony is the daily training load average divided by the standard deviation, and strain is the average weekly training load multiplied by monotony. Another alternative is to calculate basic differences between periods, such as the week-to-week change. This can be done as the absolute change in load (e.g. the increase from week 4 to week 5 was 200m) or the percentage change in load (i.e. 100% increase)[1]. Another concept is the acute-chronic workload ratio (ACWR). ACWR was introduced by Hulin et al. in 2014[5] as a modification of Banister's fitness-fatigue model[6]. It is calculated by dividing the total amount of training an athlete has recently completed (i.e. 3-9 days) by the amount they have completed over a more extended time period (i.e. 14-28 days). ACWR intends to reflect athletes' preparedness for training by accounting for both positive and negative training effects (i.e., fitness and fatigue). There are, however, many different possible ways of calculating this metric, and when combining the alternatives from the literature, more than 100 million permutations are available[7].

d) How should the data be used?

After monitoring and analysing the training load, the next step is to use the data in an informed decision process on training prescription. The training load data can help inform decisions related to

1. the load athletes need to be prepared for in competition,
2. the load they are prescribed, and
3. their subsequent response to that load[8].

In a recent editorial by West et al.[8], the authors propose five overarching levels for training load management decisions. From long to short term, the levels include

1. long-term use (e.g. managing players across several seasons),
2. season planning (e.g. prepare for game demands),
3. day-to-day planning (e.g. plan and perform training session to fit the weekly periodisation),
4. in-session adjustment (e.g. live evaluation and intervention on players physical outputs) and
5. feedback (e.g. how can we learn from this training session for the next session?)[8].

Operationally then the use of training load data can broadly be divided into two major groups, long- and short-term monitoring. Long term monitoring is when you use data that you do not necessarily need in the day-to-day practice but analyse over longer periods to gain insights into trends and tendencies in the training adaptation and performance of the players. One example of this can be an analysis of the external vs internal load in periods of the season. The short-term monitoring is what we normally use most resources on and consists of everything from macrocycle (i.e. months) planning to in-session adjustments. Macrocycle planning and evaluation are key to keeping players fit and injury-free. Unlike microcyles (i.e. weeks) that must taper into the games, macrocycles need to ensure that the players either build or maintain their fitness over time. This is done by administering appropriate amounts of load to each individual player. Although the team sessions often are based on the starting eleven's average load background and history, planning and evaluation of load need to be on an individual level.

e) What should training load data be used for?

When performing training or match play, training load will elicit a psychophysiological stimulus. The physiological systems will then either go through a recovery period and adapt to the increased demand (i.e. increase its capacity) or undergo maladaptation if the stimulus was excessive (i.e. tissue damage)[9]. If a practitioner can manage training load where the load is balanced against a number of contextual factors, this is likely to increase performance and reduce injuries. But exactly which contextual factors, the relationship between these, their influence on training load, and their influence on performance and injury is currently not answered in the literature.

Creating an accurate framework of the relationship between load, performance and injury is difficult. One reason is likely the multifactorial nature of both injuries and performance. Performance and injury are both complex and dynamic outcomes influenced by a multitude of factors, often without a predictable pattern. Bittencourt et al[10]. exemplified this by their complex model for sports injury, which outlines a web of determinants that display a dynamic and open structure with inherent nonlinearity due to recursive loops and interactions between risk factors. While the complex nature of injury makes prediction extremely difficult, recognising and measuring known risk factors may help determine specific periods when players may be at an increased risk of injuries[8]. Meeuwisse et al[11]. demonstrate how intrinsic and extrinsic risk factors influence risk and are dynamic. For non-modifiable risk factors (e.g. age, sex), single baseline values can be enough. On the other hand, for modifiable risk factors that change over time, one must use repeated measures that coincide with the change. Some modifiable risk factors are relatively slowly changing, such as player strength, muscle balance, and fitness level can be measured over a longer time (e.g. every three months). Contrary to the slowly changing factors, training load is a rapidly evolving risk factors and must be updated daily[8].

In elite football, sports medicine and performance practitioners meticulously and continuously assess each player's training load together with numerous other contextual factors. A few examples of these factors can be history of previous injuries, coach preference, player age, wellness, non-sporting load, communication with player, screening and strength test and the importance of next match. This information is used to inform subjective decisions that aim to increase performance and reduce the risk of injuries. In other words, training load is balanced against a multitude of contextual factors (Figure 3). Individual metrics of training load such as the ACWR are often used in this process.

After the initial praise and endorsement[12], there has been increased scrutiny of the ACWR-concept. This scrutiny can broadly be divided into two categories, studies highlighting methodological weaknesses

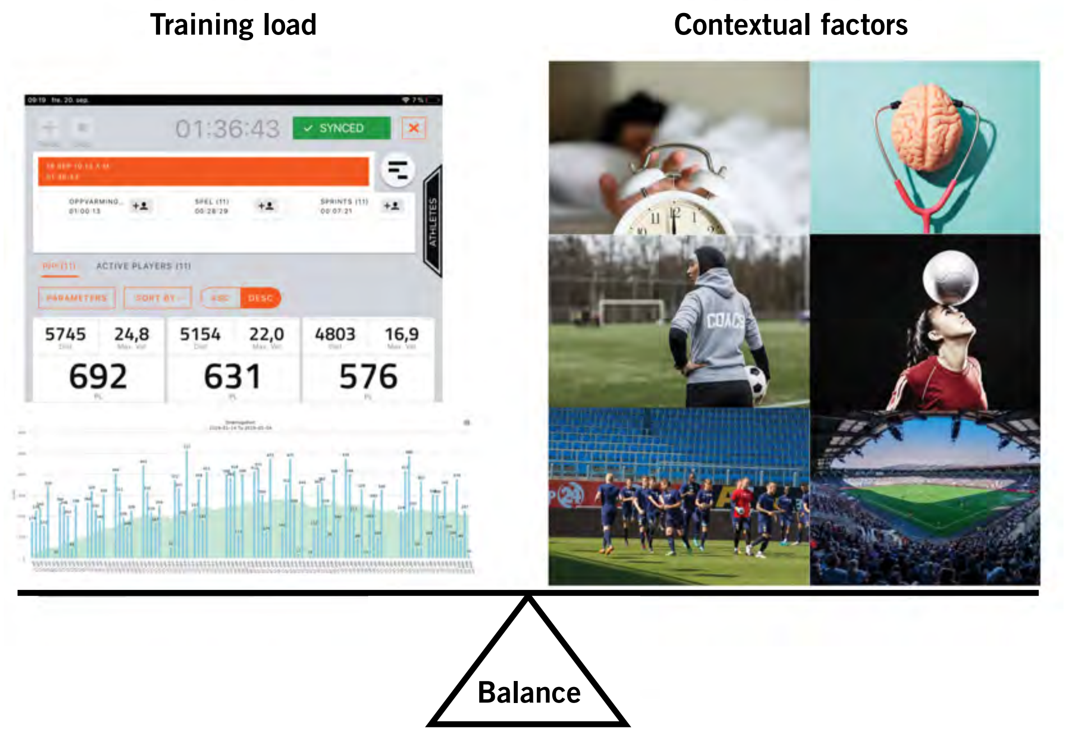

Figure 3: The balance between training load and contextual factors (e.g. the players physical and mental wellness, the coaches and players experiences and opinions, the importance and context of next training session and match).

and studies questioning the validity of the entire concept. The methodological criticism has focused on the calculation[7, 13, 14], the statistical and analytical approaches[13, 14] and other questionable research practises[13, 15]. The focus on conceptual problems has surrounded the lack of conceptual and theoretical models[13, 16]. Perhaps the most significant limitation to the current scientific literature on ACWR and health problems is the study design that have been used. Erroneous assumptions of causality is common in sports medicine research in general[17], and the ACWR and health problem literature, particularly[15]. Altogether, the evidence from the existing literature indicates that the relationship between ACWR and injuries is not causal and that ACWR, using a "one size fits all" approach, cannot prevent injuries in football. Are these problems isolated to the ACWR? No, almost all training load and injury literature suffer from the same problems and there is no current causal link between any training load construct and injury.

CONCLUSIONS AND FUTURE DIRECTIONS

As the rewards for successful performances continue to increase it is clear that there will continue to advance in training monitoring. These developments will likely take many forms and be associated with data collection, data analysis, interpretation and reporting.

a) Future research

Sports injury is a complex and dynamic outcome that is influenced by a multitude of factors[10]. There is no doubt that training load plays a part in this complex puzzle of factors, but how, and by which magnitude is currently not answered in the literature.

To create an understanding, we should aim at developing causal frameworks. When exploring the pathways between training load and injury, greater consideration of tissue specificity when assessing injury risk is recommended[18]. Potential challenges with these recommendations are the lack of direct measures of mechanical load and tissue damage[16]. However, as microsensors and other technology are rapidly improving, this might be available in the future[8]. High-quality and high-powered analytical studies using causal inference are one of two ways to move forward. These studies must use appropriate models that can handle non-linearity, have robust methods to handle missing data and use relevant and valid health problem definitions, recording and reporting. Additionally, experimental studies can provide a further understanding of the causal relationship between training load and injuries. Both of these approaches are recommended routes for future research.

In sports that are dominated by one injury type (i.e. patellar tendinopathy in volleyball), inertial measurement units (IMUs) could be one way of providing a sound proxy of tendon load and can be linked to narrow injury definitions or ideally, tissue damage. For football, a sport with numerous injury types, however, the assumption of different relationships between load and different injury types would make specific prevention interventions very complex. A load management intervention aimed at testing the effectiveness of performance would also be challenging. In the same manner that football injuries are highly heterogeneous, the physical qualities that support football performance are ubiquitous and varied. The evidence for load management is currently limited to a low number of observational studies[19].

Previous research has mainly focused on finding an intervention that would work for all players in a team. This "one size fits all" approach is neglecting the fact that the relationship between training load and injury/performance is highly individual. Without considering the multitude of contextual factors for each player, training load management would not be very effective in preventing injuries or enhancing performance[8]. To develop training load interventions that could be tested for their effectiveness on performance or injury, we should look to the best practice approaches.

b) Load management in practise

How will this process look in the future? It is inevitable that new technologies and approaches will become available, which may facilitate the "invisible monitoring".[8] Advances in data analysis may include better connections across different data streams and provide opportunities to describe performance outcomes across a variety of key performance metrics. Furthermore, combining data streams from training load monitoring and more traditional tactical analytics will help teams understand their training load in a more contextualised way. This, together with an improvement in data visualisation techniques can enable better decision making based on load monitoring.

When implementing or testing load management, players and coaches need to be engaged, and a re-calibration from a medical mindset to a performance mindset may help. Although recent research has overemphasised a medicalised rationale for load management (i.e injury prevention), the role has historically been to improve performance, and that is also the main interest of players and coaches.

Finally, until precise models can explain the relationship and experimental studies can document injury preventive- or performance effectiveness, practitioners must embrace uncertainty and move back to the basics. This should be done by trusting their expertise and use the skill and art of coaching to make decisions on training load management. Load monitoring has its main role in ensuring optimal training sessions again and again which over time will improve performance and maybe reduce injuries.

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