Title: Applying the acute:chronic workload ratio in elite football: worth the effort?

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The use of the acute:chronic workload ratio (A/C) has received a growing interest in the past two years to monitor injury risk in a variety of team sports.[1 2] This ratio is generally computed over 28 days (i.e., load accumulated during the current week / load accumulated weekly over the past 28 days), using both internal (session-rate of perceive exertion (Session-RPE) x duration) and external (tracking variables, often GPS-related, such as high-speed running and acceleration variables) measures of competitive and training load. While the potential benefit of such a metric is straight forward for practitioners, there remain several limitations to 1) the assessment of relative external load and in turn, injury risk in players differing in locomotor profiles and 2) the effective monitoring of overall load across all training and matches throughout the year. In turn, these limitations likely compromise the usefulness of the A/C ratio in elite football (soccer).

Assessing player's locomotor profile and relative external load.

1. Speed. Considering that subtle differences in sprinting intensity such as high (85-95% of maximal sprinting speed) vs. very-high speed running (>95%) may have important implications with regard to injury risk and prevention,[3] the individualization of high-speed running zones may be important. However, such a sprint-intensity classification requires the use of players' maximal sprinting speed as a reference, which is very rarely assessed in elite players. Therefore, considering the large variations in locomotor profiles between players within the same team, the use of absolute (fixed) speed thresholds to define high-speed running zones may limit the sensitivity of the A/C ratio with respect to high-speed running load[3] and in turn, injury risk.
2. Fitness. Considering that fitness testing (e.g., maximal aerobic speed) is also rare in professional football, and considering the clear impact of fitness on injury risk,[4] it is difficult to define which A/C ratio values may be critical when monitoring players with varying and unknown fitness levels (e.g., A/C ratio >1.2 vs. >1.5 vs. >1.8?).

In summary, the difficulties encountered in elite football to define players' locomotor profile likely limit the sensitivity and in turn, the usefulness of the A/C ratio in this specific population.

Integrating data from different tracking systems. In comparison to other team sports, an important methodological challenge to monitor external load in elite football is that training and matches are often tracked with different systems (e.g., GPS during training and semi-automatic cameras for matches).[5] Of course, practitioners can use calibration equations to integrate all data;[5] however, i) these specific equations are not always readily available and ii) between-system agreements are never perfect, especially for the most important variables, i.e., high-speed running and acceleration variables.[5] The precision of the A/C ratio obtained for those variables is therefore questionable and may also decrease its sensitivity and usefulness.

Dealing with international duties. In all elite clubs, there may be at least 10-12 international players within each team; each of them travelling in-season for international duty for 8-10 days, 4-5 times a year. These 'international breaks' represent one of the greatest challenge for club sport scientists seeking to keep track of their players' competition and training load, since in the vast majority of the cases National teams staff use monitoring approaches and systems that differ substantially from those used in players' clubs. The likely different scenarios are the following (the % in bracket shows the proportion of players for each case in a French Ligue 1 club sending 18 players in 9 different National teams):

1. Monitoring system similar to that used in the club (5%),
2. Monitoring system in place but using different technologies (e.g., GPS brand), different variables (distance ran into different velocity zones vs. metabolic power) or different velocity thresholds (33%),
3. Monitoring system used but for various reasons the communication with the club is very limited or absent (11%)

4. No monitoring at all (50%)

In the best cases (points 1 and 2 above), external load can be estimated throughout the break (thereby aggregating both club and National team training/matches data), and A/C ratios can be computed upon return. In the worst and most frequent cases (points 3 and 4), there is a net loss of external workload monitoring for club practitioners for about 10 days during each break (Figure 1), which in turn compromises the proper use of the A/C ratio for a month… which often coincides with the timing of the next break! To avoid artificial spikes/drops (Figure 1), the least bad option may consist in using players' historical club data to predict the missing session and match loads (based on training schedules and match playing times). While predicted data may be better than no data at all, the veracity of the predicted data remains uncertain, and the trustability of the associated A/C ratios, questionable.

Lack of load monitoring during the off-season period. The inability to monitor load during the off-season leads to unrealistic A/C ratio values during the first weeks of training during the pre-season period (fully realistic ratios likely obtained only when the chronic load is wholly established, i.e., after 28 days, Figure 1). An alternative option during this period could be to reduce the duration required to calculate chronic load, but the most appropriate duration to select remains to be defined (2 vs 3 vs 4 weeks).

The session-RPE method: a solution to these limitations? While internal and external loads are two separate components of load which can't be used interchanging, it is believed that the session-RPE method may offer some advantages over measures of external load in the specific context of elite football. First, the validly of session-RPE to quantify exercise intensity and in turn, overall training load, is well established.[6] Second, several studies have shown good associations between changes in session-RPE load and injury risks in various sports.[1 2] Finally and more importantly, RPE can be collected across:

- all sessions or matches regardless of the external motion analysis system,
- all training/competitive periods of the year, i.e., when players are with their clubs, with their national teams, or eventually training on their own during the off-season. In theory, this should allow a continuous tracking of load throughout the year.

Despite the above-mentioned arguments, and despite the lack of strong scientific evidence suggesting otherwise, there is a feeling that external load monitoring may be more relevant in the context of injury surveillance in elite football.[7 8]

1. In fact, RPE is unlikely sensitive to subtle differences in sprinting intensity, while this may be of importance in terms of injury risk and prevention,[3]
2. RPE is sometimes not even collected by National teams (cases 3 and 4 above); the validity of session-RPE recalled upon players' return is questionable, which again limits the validity and usefulness of the A/C ratio.
3. The number of professional players able/willing to keep track of their own session-RPEs during their off-season is likely less than 5 in the entire elite football world.

To conclude, practitioners likely need to adapt a cost-benefit approach when trying to use the A/C ratio in elite football; balancing the important efforts required to 'get the data alright' (integrating the different systems, variables and speed zones when the data are available, predicting data when nothing is available, collecting questionable RPEs upon players' return from international duties) vs. the actual output (trustability of the final A/C ratios and difficulties to define 'at risk' A/C thresholds in

players with unknown fitness level). While the use of session-RPE as an alternative input of load may be relevant, some substantial limitations remain, such as the lack of sensitivity of RPE to subtle differences in high running speeds. The optimal duration of both the chronic (2 vs. 3 vs. 4 weeks, based on off- and pre-season durations) and acute (3 vs. 7 days, based on matches occurrence) periods of load need probably to be discussed to better fit the specific training/completive patterns of elite football. Injury prevention can't be limited to the monitoring of a single (A/C?) number; understanding players' individual needs and profiles, and using common sense when programming workloads are probably as important to keep players fit and healthy.

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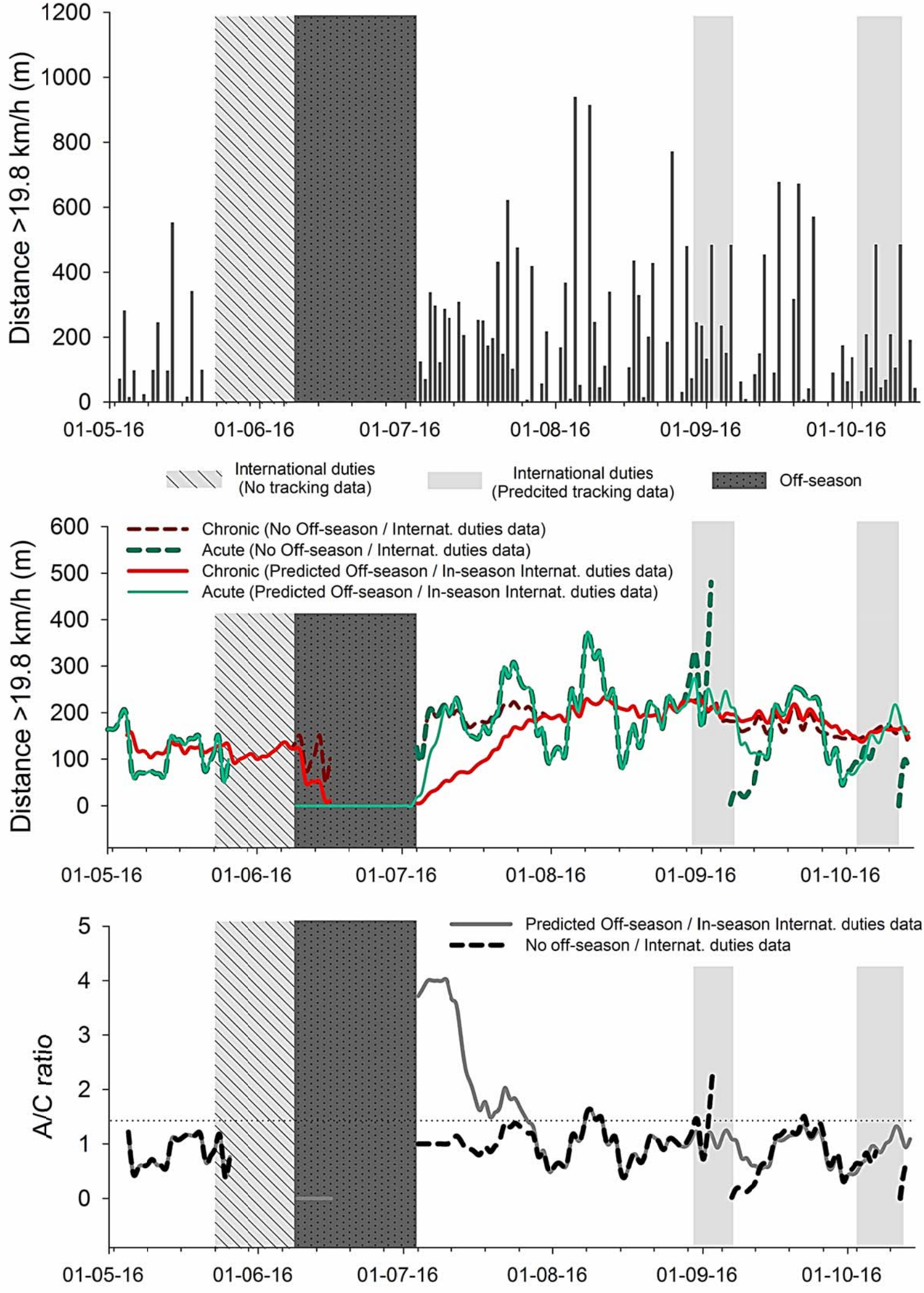
Figure 1. Daily distance (top panel) ran above 19.8 km/h by an international player (French Ligue 1) during a 6-month period (with matches and training data integrated [5]) and associated 28-d chronic and 7-d acute workloads (middle panel) and their ratio (bottom panel). The player was selected with his national team to prepare for the Euro 2016 (21/05/2016 to 08/06/2016) but wasn't selected to participate to the final tournament. He then took ~3 weeks of rest before starting the pre-season with his club (04/07/2016). Since the national team staff didn't use GPS, there are no running data available during his Euro preparation. We then assumed that during his holidays, whatever the sporting activities he practiced, he was very unlikely to reach a running speed >19.8 km/h – high-speed load is therefore set at "0 distance" for these 3 weeks. Note that in-season, national team training and competitive loads have been predicted using players' historical club data (based on training schedules and match playing times). As a consequence, the predicted running distance of the 4 matches played with the national team (2 per international break) are similar. While this may be seen as a limitation given the usually large (>15-20%) match-to-match variations in high-speed running, this approach allows at least to produce the A/C ratio through these periods while avoiding erroneous spikes/drops. Finally, these data illustrate also nicely the limitation of the A/C ratio during the pre-season period when no off-season data are available. With no off-season data (which differs from "0 distance"), chronic and acute loads are mathematically defined as similar for the first 7 training days, which results in an unrealistic A/C of 1!? The use of predicted off-season data draws fortunately a much more realistic picture, with a ratio >4 at the start of the pre-season, which decrease as training, and in turn fitness progresses.


Distance >19.8 km/h (m)
1200
1000
800
600
400
200
0
01-05-16
01-06-16
01-07-16
01-08-16
01-09-16
01-10-16
International duties (No tracking data)
International duties (Predcited tracking data)
Off-season
Distance >19.8 km/h (m)
600
500
400
300
200
100
0
Chronic (No Off-season / Internat. duties data)
Acute (No Off-season / Internat. duties data)
Chronic (Predicted Off-season / In-season Internat. duties data)
Acute (Predicted Off-season / In-season Internat. duties data)
01-05-16
01-06-16
01-07-16
01-08-16
01-09-16
01-10-16
A/C ratio
5
4
3
2
1
0
Predicted Off-season / In-season Internat. duties data
No off-season / Internat. duties data
01-05-16
01-06-16
01-07-16
01-08-16
01-09-16
01-10-16