Soccer Velocity Thresholds: Do we really know what's best?

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We thank Vescovi, and Carling & Kavanagh for their commentary and critique of our recent paper examining data-mining approaches to developing generic velocity thresholds for elite women's soccer. We are also sincerely grateful to the editorial board for the opportunity to continue the discussion around the application of appropriate velocity zones.

We whole-heartedly agree with Dr Vescovi's overarching statement that 'context is critical'. We contend that comparing the distances derived in zones from the various velocity transitions adopted in the literature to either promote or critique a particular approach has limited value, beyond logical validity in regards to the locomotor activity distribution. In the paper, we acknowledge that the external load data was sourced from non-competitive fixtures. At the time GPS technology was not permitted in official matches, and the games were often against low-ranking opposition that did not induce high external loads. Between study comparisons of load distribution are also limited by the differing hardware and data processing algorithms which are rarely disclosed (Malone, Lovell, Varley, & Coutts, 2017), yet can have a profound effect upon outcome measures (Varley, Jaspers, Helsen, & Malone, 2017). We support the notion that velocity threshold selection should be evidence-based, our paper did not experimentally test the suitability of the data-mining thresholds, and to our knowledge there is limited experimental research that has experimentally tackled this issue given its inherent challenges (Fitzpatrick, Hicks, & Hayes, 2018; Scott & Lovell, 2018). As we state in the paper, further work is warranted to test our proposed velocity thresholds from multiple teams during competitive tournaments. To facilitate, and to negate the perceived 'time-intensive statistical technique', we have provided the code for the spectral clustering analysis via an online resource (http://staff.scm.uws.edu.au/~lapark/code/velocityThresholds/), so that other researchers and practitioners can derive thresholds from their own data, and independently evaluate the approach.

Context is also critical when evaluating our protocol to identify potentially erroneous GPS data. We used an instantaneous peak speed cut-off threshold of 10 $m.s^{-1}$ on the basis that the fastest player in our study recorded a peak speed of 9.4 $m.s^{-1}$ during 40 m sprint tests (timing gates, 10m splits), and we were cognizant that players can attain higher peak speeds (up to +0.4 $m.s^{-1}$) when tracked by 10 Hz GPS technology during matches (Massard, Eggers, & Lovell, 2017). Unfortunately, we were not aware of rigorous peak instantaneous acceleration data on elite female athletes to guide our exclusion criteria. Notwithstanding, our approach to GPS signal evaluation is in line with other physiological processing techniques, and GPS users are encouraged to adopt similar signal evaluations into their workflow to avoid erroneous interpretation (Malone et al., 2017).

The commentary of Carling and Kavanagh is a welcome addition to the ongoing debate regarding the interpretation of external load data. In our contributions to this area, we have consistently suggested that the application of both generic and individualized (based upon player athletic qualities) velocity zones might be applied to support both between and within-player monitoring (Abt & Lovell, 2009; Lovell &

Abt, 2013; Malone et al., 2017). On this journey, a number of practical hurdles have emerged, challenging either the adoption (Akenhead & Nassis, 2016), or the method in which player-specific zones are used (Hunter et al., 2015; Scott & Lovell, 2018). The main barrier at this time was that external load software platforms were not designed to dual process data according to both absolute and relative zone approaches, and the practice was labor intensive (Malone et al., 2017). However, recent software upgrades have now enabled this feature. Another evolution of sport science support has been a reduction in the frequency of maximal capacity testing of physical qualities, partly driven by the increased physical demand combined with the greater number of matches. Maximal fitness testing to determine a threshold provides a snapshot of the players' status, which may vary according to the season schedule, player readiness, or injury (Hunter et al., 2015). To circumvent, there is an increasing trend to use peak-speed (Gabbett, 2015) or peak-acceleration (Abbott, Brickley, Smeeton, & Mills, 2018) determined from GPS training or match data to anchor external load zones, yet there is no physiological justification to inform zone criteria, and these measures are particularly insensitive to changes in sub-maximal fitness (Hunter et al., 2015). Whilst there is limited data available, studies so far have shown that using the individual player's peak speed to anchor relative zones may lead to more erroneous interpretations regarding the individual's load versus the application of generic zones (Hunter et al., 2015; Scott & Lovell, 2018).

Whilst we certainly agree with the notion of using relative velocity thresholds to monitor load in the individual player, the challenges faced by practitioners in obtaining accurate fitness assessments at an appropriate frequency may threaten its implementation. Moreover, there are very few studies that have provided empirical evaluation of individualized versus arbitrary thresholds, and the findings are as yet inconclusive (Fitzpatrick et al., 2018; Scott & Lovell, 2018). Further work is certainly warranted in this area. Although we used the spectral clustering technique in our paper to determine generic zones for elite women's football, figure 1 of our original paper depicts the highly individual nature of the transition velocities for each player. In this data-set, we did not have an accompanying longitudinal data set that adequately tracked player's individual athletic qualities, and we were unable to draw comparisons. Future work may be warranted to examine the utility of applying individual velocity transitions derived from spectral clustering of serial match observations. Considering the availability of extensive player tracking data-sets, spectral clustering may represent a practical solution to evaluate and prescribe training and competition loads on both an individual and generic basis, without the need for routine exhaustive fitness assessments.

To conclude, we welcome the dialogue regarding the application of appropriate velocity zones, and echo the recommendations of our colleagues in their letters; that this field of enquiry would benefit from rigorous and empirical evaluation of different approaches to external load monitoring, and their potential 'added value'. Such work might further evaluate the acute (i.e. internal load, recovery kinetics) and chronic (i.e. changes in fitness, workload-injury relationship) dose-response to external loads processed with different velocity zone approaches. Refining techniques to accommodate and amalgamate both velocity and acceleration data in external load monitoring is also likely to advance our determination of work (Polglaze et al., 2018), and enhance our support service to coaches and players.

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