Individualization of Time–Motion Analysis: 
A Case-Cohort Example

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Purpose: To report the intensity distribution of Premier League soccer players’ external loads during match play, according to recognized physiological thresholds. The authors also present a case in which individualized speed thresholds changed the interpretation of time–motion data. Method: Eight outfield players performed an incremental treadmill test to exhaustion to determine the running speeds associated with their ventilatory thresholds. The running speeds were then used to individualize time–motion data collected in 5 competitive fixtures and compared with commonly applied arbitrary speed zones. Results: Of the total distance covered, 26%, 57%, and 17% were performed at low, moderate, and high intensity, respectively. Individualized time–motion data identified a 41% difference in the high-intensity distance covered between 2 players of the same positional role, whereas the player-independent approach yielded negligible (5–7%) differences in total and high-speed distances covered. Conclusions: The authors recommend that individualized speed thresholds be applied to time–motion-analysis data in synergy with the traditional arbitrary approach.

Keywords: team sports, ventilatory thresholds, work rate, external load, match play

Time–motion analysis (TMA) has been used extensively in team sports to determine the rigors of training and match play. Monitoring systems typically adopt arbitrary speed thresholds to determine the intensity distribution of the task, and in particular there has been a focus on “high-intensity” running to quantify the external load of players. Since opposing players compete on an absolute basis, using arbitrary speed thresholds to quantify high-intensity running enables practitioners and coaches to make interplayer contrasts.1 However, as the exercise-intensity continuum is player-dependent, we believe that time–motion metrics should also be individualized according to recognized physiological thresholds.1 Without an individualized approach to physical match analysis, the true energetic demands of a training or match stimulus are unknown, and the practitioner is unable to administer a player-specific approach to performance monitoring and training prescription. In this case study, we extend our previous work1 by adopting a ramped incremental treadmill test to exhaustion, which provides a greater sensitivity of the speeds corresponding to various physiological thresholds. Hence, for the first time, we are able to report the intensity distribution of elite soccer players during match play by demarcating low-, moderate-, and high-intensity running. Although the rationale for a player-dependent approach to TMA is based on intraplayer monitoring, here we also present a case of 2 players where individualized speed thresholds provided additional information to the player-independent approach, which altered the interpretation of an interplayer contrast.

Method

During the 2008–09 and 2009–10 English Premier League seasons, players’ ventilatory threshold (VT1), respiratory compensation threshold (VT2), peak oxygen uptake (VO2peak), and maximal aerobic speed (MAS) were determined as part of a squad’s routine physiological monitoring. The players performed a ramped treadmill (ELG55, Woodway USA, Waukesha, WI) test to exhaustion that commenced at a speed of 7 km/h for 3 minutes; thereafter the speed was increased by 0.2 km/h every 12 seconds, with a 2% incline throughout. During the test protocol the players’ expired air was measured using an online breath-by-breath system (Quark b2, Cosmed, Rome, Italy). Break points in the ventilatory equivalents and end-tidal partial pressures for O2 and CO2 were used to identify ventilatory thresholds.2

The players’ physical performance during league fixtures was also monitored using the semiautomated Prozone® system.3 The arbitrary speed thresholds used by this system were high-speed running (≥14.4 km/h) and very high-speed running (≥19.8 km/h). We also determined 3 individualized zones (low, moderate, and high), based around the speeds corresponding to VT1 and VT2.1,2 We excluded players who had not participated in
5 or more complete games within 3 weeks of the physiological assessment. We assumed that during the in-season maintenance-training phase, the 6-week period monitored here would not result in marked changes in VT1 and VT2 in injury-free players. Therefore, 8 players were eligible for this analysis (age 24 ± 5 y, height 182.4 ± 5.4 cm, body mass 82.7 ± 6.0 kg, VO2peak 56.7 ± 3.2 mL · kg⁻¹ · min⁻¹, ∑7 skinfolds 53.2 ± 10.6 mm), of whom 1 played as a central defender, 3 were wide defenders, 3 played in central midfield (CM), and 1 was a striker. The descriptive data are presented here as mean ± SD.

Results

The VT1 and VT2 were observed at speeds corresponding to 59% ± 7% (11.3 ± 1.1 km/h) and 77% ± 6% (14.8 ± 1.0 km/h), respectively, of the MAS achieved during the incremental treadmill test. As depicted in Figure 1, the running speeds at these physiological thresholds were player-dependent. This resulted in a small mean overestimation of high-intensity distance covered of 155 ± 598 m (9 ± 20%) when using the arbitrary high-speed-running threshold (≥14.4 km/h), although in individual cases the differences ranged from –959 m (22%) to 852 m (33%). On average, players covered 26%, 57%, and 17% of the total distance at low (<VT1), moderate (VT1–VT2), and high intensity (>VT2; see Table 1).

Discussion

Here we sought to describe the intensity distribution during match play based on an individualized approach, as well as demonstrate the differences in time–motion-analysis (TMA) data associated with applying both arbitrary and individualized speed thresholds. To our knowledge, this is the first documentation of the player-dependent intensity distribution of elite soccer match play, although an analogous technique has recently been employed in the training environment.4

In terms of contrasting the use of arbitrary and individualized approaches, an interesting observation was denoted by comparing the TMA data between CM1 and CM2 (see Figure 1). As confirmed by the coach, these players performed a very similar tactical role during match play, and they also played in the same 5 games during the experimental period. Using arbitrary thresholds, their 5-game mean total, high-speed-running and very high-speed-running distances differed by 5% (531 m), 5% (167 m), and 7% (79 m), respectively. Such differences are likely interpreted as negligible given the typical short-term match-to-match variability in these parameters identified both here (Table 1) and in previous research.5 However, when the TMA data were individualized, we observed a 41% difference between the 5-game mean distance covered at high intensity (>VT2) in CM1

Figure 1 — Player running speeds corresponding to VT1, VT2, and MAS. VT1, ventilatory threshold; VT2, respiratory-compensation threshold; MAS, maximal aerobic speed; WD, wide defender; CD, central defender; CM, central midfielder; ST, striker.
(2712 m) versus CM2 (3814 m). Thus, the application of individualized speed thresholds provided additional and practically significant information in regard to the external load of these players. Accordingly, practitioners seeking to use monitoring tools to inform individualized recovery practices or subsequent training prescription should consider taking a player-dependent approach to TMA to complement the traditional absolute approach.

We acknowledge the practical challenges of administering this individualized approach to TMA, together with the associated limitations. Future work is required to determine whether the speeds determined for physiological thresholds from continuous laboratory tests can be applied to team sports with stochastic movement demands. Moreover, the individualized approach to TMA does not account for the high metabolic cost of utility movements, impacts, and accelerations; however, this limitation is also a feature of arbitrary speed categories. Further research may also be required to subcategorize the high-intensity zone used here, as it currently accounts for ~50% of elite players’ speed range. Finally, the facilities and expertise required to administer the laboratory-based tests in our approach may be restrictive, and work to refine existing techniques to determine physiological thresholds in the field is warranted.

### Practical Applications

Users of TMA data should consider applying player-dependent speed thresholds for monitoring the external load of training and match play. In accordance with arbitrary speed thresholds, an individualized approach based on physiological thresholds determines practically relevant differences both within and between players.

### Acknowledgments

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### References


### Table 1  Time- and Distance-Based Distribution of Exercise Intensity During Premier League Fixtures, Mean (SD)

<table>
<thead>
<tr>
<th>Velocity category</th>
<th>Distance Covered</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>m</td>
<td>%CV</td>
</tr>
<tr>
<td></td>
<td>min</td>
<td>%CV</td>
</tr>
<tr>
<td>Arbitrary</td>
<td></td>
<td></td>
</tr>
<tr>
<td>LSR</td>
<td>7035 (336)</td>
<td>4.8 (2.5)</td>
</tr>
<tr>
<td>HSR</td>
<td>3088 (309)</td>
<td>10.2 (4.4)</td>
</tr>
<tr>
<td>VHSR</td>
<td>1106 (169)</td>
<td>14.9 (5.1)</td>
</tr>
<tr>
<td>Individualized</td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;VT₁</td>
<td>6446 (313)</td>
<td>4.9 (3.6)</td>
</tr>
<tr>
<td>VT₁–VT₂</td>
<td>1850 (281)</td>
<td>15.4 (10.6)</td>
</tr>
<tr>
<td>&gt;VT₂</td>
<td>2933 (337)</td>
<td>10.6 (3.6)</td>
</tr>
<tr>
<td>Total</td>
<td>11,229 (434)</td>
<td>3.8 (3.6)</td>
</tr>
</tbody>
</table>

Abbreviations: %CV, percent coefficient of variation; LSR, low-speed running (<14.4 km/h); HSR, high-speed running (≥14.4 km/h); VHSR, very high-speed running (≥19.8 km/h); VT, ventilation threshold.