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Section: Case Study

Article Title: Changes in a top-level soccer referee’s training, match activities and physiology over an 8-year period: a case study

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Journal: International Journal of Sports Physiology and Performance

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Full Title: Changes in a top-level soccer referee’s training, match activities and physiology over an 8-year period: a case study

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Running Title: Case study of an elite soccer referee

Abstract Word Count: 148
Text-Only Word Count: 811
Number of Figures: 0
Number of Tables: 2
Number of References: 6
Abstract

Athlete case studies have often focused on the training outcome and not the training process. Consequently, there is a dearth of information detailing longitudinal training protocols, yet it is the combined assessment of both outcome and process that enhances the interpretation of physical test data. We were provided with a unique opportunity to assess the training load, physical match performance and physiological fitness of an elite soccer referee from the referee’s final season before attaining full-time, professional status (2002) until the season when he refereed the 2010 UEFA Champions League and FIFA World Cup finals. An increased focus on on-field speed and gym-based strength training was observed towards the end of the study period and longitudinal match data showed a tendency for decreased total distances but an increased intensity of movements. Laboratory assessments demonstrated that VO$_2$max remained stable (52.3 vs. 50.8 mL·kg$^{-1}$·min$^{-1}$) whilst running speed at the lactate threshold (14.0 vs. 12.0 km·h$^{-1}$) and running economy (37.3 vs. 43.4 mL·kg$^{-1}$·min$^{-1}$) both improved in 2010 compared to 2002.

Methods

Subject

The subject was a male soccer referee who was promoted to the English Football League referees’ list (non-professional) in 2000 aged 31 years and then to the FA Premier League in 2003 (full-time, professional). In 2010 he became the first referee in history to officiate the UEFA Champions League and the FIFA World Cup finals in the same season. Data were collected as part of the sports science support provided to the referee and the referee gave his informed consent for the study.

Training and Match Loads

Data were collected across seven full soccer seasons (2003/04 to 2009/10), during which period the referee missed only one match due to injury (November 2006). Exercise sessions were categorised into matches, high-intensity aerobic, speed endurance, low-intensity aerobic, on-field speed development (including agility, assisted and resisted sprinting and
plyometrics) and gym-based strength (hypertrophy and muscular endurance). Training load was determined using the session-RPE method\textsuperscript{1}, with the exercise session duration being recorded in 1-min intervals. Physical match performance data, based on the analysis of 15±6 matches per season, were collected using a computerised, semi-automatic video match-analysis image recognition system (ProZone\textsuperscript{®}, Leeds, England) with dependent variable categorisation as in a previous study.\textsuperscript{2}

**Laboratory Assessment**

The referee underwent a physiological assessment during the 2002/03 and 2009/10 English soccer seasons. Skinfolds were measured using a skinfold technique at four sites (biceps, triceps, subcapular and suprailliac). An incremental test was performed on a treadmill (Woodway, Germany) with 1\% of inclination and 4–6 three-minute stages, each separated by a 30-second break for blood lactate analysis (YSI 2300, Yellow Springs Instrument, USA). The starting speed was 11 km\cdot h\textsuperscript{-1}, with speed increasing by 1 km\cdot h\textsuperscript{-1} on each subsequent stage. The lactate threshold was defined as per Jones.\textsuperscript{3} Expired gases were collected during the final minute of each stage (ZAN, nSpire, UK). When the referee indicated he was at point nine (almost maximal) on the CR10 Borg scale\textsuperscript{1}, the treadmill speed was kept constant and the grade was increased by 1\% each minute until volitional exhaustion. A plateau in VO\textsubscript{2}, defined as an increase in oxygen uptake of less than 2 mL\cdot kg\textsuperscript{-1}\cdot min\textsuperscript{-1} with increasing exercise intensity, was used as the maximal oxygen uptake (VO\textsubscript{2}\text{max}) criterion during the final stage of the treadmill test, with running economy defined as the VO\textsubscript{2} required to run at 12 km\cdot h\textsuperscript{-1}.

**Results**

Frequency of high-intensity aerobic and speed endurance training sessions decreased over the duration of the study. This decrease was offset by an increase in gym-based strength training and on-field speed development. Weekly RPE load increased during the later seasons of the study (Table 1), with the increase being most pronounced during the penultimate season. Mean session RPE showed a propensity to decrease towards the end of the study. Across the duration of the study there was a tendency for reduced total match distance, along with increased match high-speed running distances, total number of sprints and top sprinting
speeds (Table 2). The referee’s body mass was higher in 2010 when compared to 2002 (98.7 vs. 97.1 kg) with a concomitant decrease in the sum of the four skinfolds (42.2 vs. 53.6 mm). The referee’s VO\(_2\)max (52.3 [5.164 l•min\(^{-1}\)] mL•kg\(^{-1}\)•min\(^{-1}\)) and maximal HR (196 b•min\(^{-1}\)) recorded in 2010 were not substantially different when compared to 2002 (50.8 [4.932 l•min\(^{-1}\)] mL•kg\(^{-1}\)•min\(^{-1}\) and 198 b•min\(^{-1}\), respectively). An increase in running speed at the lactate threshold and an improved running economy were observed in 2010 (14.0 km•h\(^{-1}\) and 37.3 mL•kg\(^{-1}\)•min\(^{-1}\), respectively) when compared to 2002 (12.0 km•h\(^{-1}\) and 43.4 mL•kg\(^{-1}\)•min\(^{-1}\), respectively).

Discussion

This study provided for the first time longitudinal data on the training processes and physical performances of an elite-level soccer referee. High-intensity aerobic and speed endurance training dominated the referee’s training process in the early seasons of the study. However, to develop a holistic fitness profile and address the progressive declines in anaerobic fitness with increasing referee age, more emphasis was placed on the development of speed, strength and power during the later seasons of the study. The increase in training frequency and duration accounted for the higher weekly RPE loads observed towards the end of the study, especially during the penultimate season.

An increased amount of player high-speed running over recent seasons has been shown during English Premier League matches. Given that referees’ physical match performances are partly related to those of the players, our data may support the observation of an increased intensity of match performance by the referee towards the end of the study. Higher top sprinting speeds during the final seasons are likely to be a consequence of the increased focus on speed development.

Whilst there was no improvement in VO\(_2\)max, the referee’s running speed at lactate threshold and running economy both improved in 2010 when compared to 2002. Our data would appear to support the suggestion that improvements in submaximal fitness factors can occur in the absence of any further improvements in VO\(_2\)max. The increased strength training during the later seasons of the study may have played a role in the improved running economy. Previous research has demonstrated an age-related decline in the aerobic and
anaerobic fitness of soccer referees. However, despite the study spanning an 8-year period, no age-impairment was observed in either the referee’s fitness or in his capacity to undertake the most physically demanding match activities, namely high-speed running and sprinting.

**Practical Applications**

The data presented within this case study provide a comprehensive insight into training practices involved in helping an elite-level soccer referee reach the pinnacle of his sport, whilst in-turn describing the long-term impact of a professionalised training environment on a referee’s physical performances.
References


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<table>
<thead>
<tr>
<th>Season</th>
<th>Matches</th>
<th>High-Intensity Aerobic</th>
<th>Speed Endurance</th>
<th>Low-Intensity Aerobic</th>
<th>On-Field Speed Development</th>
<th>Gym-Based Strength</th>
<th>Total Time (hours)</th>
<th>Mean Session Duration (min)</th>
<th>Weekly RPE Load</th>
<th>Mean Session RPE</th>
</tr>
</thead>
<tbody>
<tr>
<td>2003/04</td>
<td>49</td>
<td>34</td>
<td>32</td>
<td>26</td>
<td>25</td>
<td>5</td>
<td>190</td>
<td>67 ± 24</td>
<td>1169 ± 463</td>
<td>4.9 ± 2.0</td>
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<tr>
<td>2004/05</td>
<td>46</td>
<td>40</td>
<td>21</td>
<td>56</td>
<td>33</td>
<td>3</td>
<td>199</td>
<td>60 ± 25</td>
<td>1118 ± 450</td>
<td>4.3 ± 2.0</td>
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<tr>
<td>2005/06</td>
<td>55</td>
<td>30</td>
<td>13</td>
<td>53</td>
<td>39</td>
<td>13</td>
<td>220</td>
<td>65 ± 24</td>
<td>1261 ± 400</td>
<td>4.4 ± 1.9</td>
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<tr>
<td>2006/07</td>
<td>47</td>
<td>24</td>
<td>15</td>
<td>41</td>
<td>29</td>
<td>24</td>
<td>198</td>
<td>66 ± 26</td>
<td>1351 ± 346</td>
<td>4.5 ± 1.9</td>
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<tr>
<td>2007/08</td>
<td>50</td>
<td>27</td>
<td>14</td>
<td>42</td>
<td>39</td>
<td>52</td>
<td>249</td>
<td>66 ± 31</td>
<td>1337 ± 451</td>
<td>4.2 ± 2.0</td>
</tr>
<tr>
<td>2008/09</td>
<td>52</td>
<td>22</td>
<td>15</td>
<td>26</td>
<td>44</td>
<td>71</td>
<td>314</td>
<td>82 ± 34</td>
<td>1809 ± 584</td>
<td>4.2 ± 2.1</td>
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<tr>
<td>2009/10</td>
<td>48</td>
<td>28</td>
<td>7</td>
<td>25</td>
<td>52</td>
<td>76</td>
<td>303</td>
<td>78 ± 26</td>
<td>1482 ± 589</td>
<td>3.9 ± 2.1</td>
</tr>
</tbody>
</table>

**Table 1**: An elite-level soccer referee’s typology, volume and intensity of exercise sessions performed across a period of seven consecutive soccer seasons (2003/04 - 2009/10)

Note. The mean duration and RPE of the referee’s different exercise sessions over the duration of the study was; matches (95 ± 10 min; 6.1 ± 0.9); high-intensity aerobic (65 ± 32 min; 6.5 ± 1.1); speed endurance (68 ± 23 min; 5.5 ± 1.1); low-intensity aerobic (61 ± 29 min; 3.2 ± 1.4); on-field speed development (62 ± 29 min; 2.7 ± 0.9); gym-based strength (56 ± 19 min; 2.2 ± 0.7).
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Table 2: An elite-level soccer referee’s physical match performances across a period of seven consecutive soccer seasons (2003/04 - 2009/10)

Note. High-Speed running is defined as all running performed >19.8 km•h⁻¹; sprints are defined as running performed >25.2 km•h⁻¹

<table>
<thead>
<tr>
<th>Season</th>
<th>Number of matches analysed</th>
<th>Total Distance (m)</th>
<th>High-Speed Running (m)</th>
<th>Mean Match Sprints</th>
<th>Top Speed (km•h⁻¹)</th>
<th>Distance from Ball (m)</th>
<th>Distance from Fouls (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2003/04</td>
<td>4</td>
<td>12513 ± 218</td>
<td>808 ± 92</td>
<td>22 ± 6</td>
<td>31.6 ± 1.6</td>
<td>18.5 ± 0.6</td>
<td>14.0 ± 1.2</td>
</tr>
<tr>
<td>2004/05</td>
<td>14</td>
<td>13042 ± 419</td>
<td>941 ± 125</td>
<td>25 ± 9</td>
<td>31.9 ± 1.3</td>
<td>17.4 ± 0.5</td>
<td>13.9 ± 1.8</td>
</tr>
<tr>
<td>2005/06</td>
<td>17</td>
<td>12508 ± 466</td>
<td>1003 ± 252</td>
<td>26 ± 12</td>
<td>31.5 ± 1.5</td>
<td>18.0 ± 0.6</td>
<td>14.6 ± 2.4</td>
</tr>
<tr>
<td>2006/07</td>
<td>16</td>
<td>12249 ± 358</td>
<td>941 ± 242</td>
<td>24 ± 14</td>
<td>31.2 ± 1.9</td>
<td>18.6 ± 0.8</td>
<td>13.8 ± 1.4</td>
</tr>
<tr>
<td>2007/08</td>
<td>11</td>
<td>12151 ± 449</td>
<td>1263 ± 172</td>
<td>48 ± 11</td>
<td>32.4 ± 1.0</td>
<td>18.2 ± 0.5</td>
<td>13.6 ± 1.7</td>
</tr>
<tr>
<td>2008/09</td>
<td>21</td>
<td>11700 ± 473</td>
<td>1126 ± 210</td>
<td>37 ± 15</td>
<td>32.8 ± 1.6</td>
<td>18.7 ± 0.8</td>
<td>14.0 ± 1.1</td>
</tr>
<tr>
<td>2009/10</td>
<td>23</td>
<td>11171 ± 368</td>
<td>1142 ± 180</td>
<td>50 ± 17</td>
<td>33.7 ± 1.3</td>
<td>19.1 ± 0.5</td>
<td>14.5 ± 1.6</td>
</tr>
</tbody>
</table>