Table 1: Overview of previous research into association football referees' locomotion and heart rates

| $\begin{gathered} \hline \text { YEAR } \\ \text { OF } \\ \text { STUDY } \end{gathered}$ | $\begin{gathered} \hline 1992 / 3- \\ 1993 / 4 \end{gathered}$ |  |  | 1991/1992 |  | 1997/1998 | 1992-1996 | $\begin{aligned} & \hline \text { Euro } \\ & 2000 \end{aligned}$ |  |  | 2003 | 2004/2005 |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Authors/ <br> Publ. <br> Year | Castagna \& D'Ottavio (2001)[29] | $\begin{gathered} \text { Harley et } \\ \text { al. } \\ (1999)[30] \end{gathered}$ | $\begin{gathered} \text { Asami } e t \\ \text { al. } \\ (1988)[31] \end{gathered}$ | $\begin{gathered} \text { Catterall et } \\ \text { al. } \\ (1993)[24] \end{gathered}$ | Johnston \& McNaughton (1994)[32] | $\begin{gathered} \text { Krustrup \& } \\ \text { Bangsbo } \\ (2001)[26] \end{gathered}$ | $\begin{gathered} \text { D'Ottavio \& } \\ \text { Castagna } \\ (2001)[33] \end{gathered}$ | Helsen \& Bultynck (2004)[1 9] | $\begin{aligned} & \text { Weston \& } \\ & \text { Brewer } \\ & (2002)[28] \end{aligned}$ | $\begin{gathered} \text { Weston } e t \\ \text { al. } \\ (2006)[27] \end{gathered}$ | $\begin{aligned} & \text { Mallo et al. } \\ & (2007)[27] \end{aligned}$ | $\begin{gathered} \text { Button \& } \\ \text { Peterson } \\ (2005)[34] \end{gathered}$ |
| Subjects/ <br> Matches | 8 Italian referees, 3 international <br> 16 Serie A \& B games | 14 English County level referees County league matches | 10Japanese <br> referees | $\begin{gathered} \begin{array}{c} 14 \text { class } 1 \\ \text { English } \\ \text { referees } \end{array} \\ n=4 \\ \text { premier, } \\ n=21^{\text {st }} \text { div, } \\ n=42^{\text {nd }} \\ \text { div, } \\ n=4 \text { non- } \\ \text { league } \end{gathered}$ | Australian referees | 27 Danish referees, $n=7$ FIFA, $n=5$ other top division, $n=152^{\text {nd }}$ div | 33 Italian referees $n=96$ games Serie A, Serie B | 17 UEFA referees <br> Euro 200 games | 8 English referees <br> Premier, Nationwide League, FA Cup <br> League Cup $\mathrm{n}=60$ | 19 English referees <br> Premier League $\mathrm{n}=254$ | 11 international referees <br> 12 U-17 <br> World Cup games | 5 NZFC referees <br> 6 NZFC <br> Games |
| Distance Covered | $\begin{gathered} \hline 11,584 \mathrm{~m} \pm \\ 1,017 \\ 1^{\text {st } \mathrm{H}:} \\ 5977 \mathrm{~m} \pm \\ 468 \\ 2^{\text {nd }} \mathrm{H}: \\ 5606 \mathrm{~m} \pm \\ 584 \\ * \text { sig less } \\ \text { than } 1^{\text {st }} \mathrm{H} \end{gathered}$ | $\begin{gathered} \hline, 496 \mathrm{~m} \pm \\ 1,122 \end{gathered}$ | $\begin{gathered} 10,168 \\ \pm 756 \end{gathered}$ | $\begin{gathered} 9438 \mathrm{~m} \pm \\ 707 \mathrm{~m} \\ \text { range: } \\ 7,977- \\ 10,187 \\ 1^{\text {st }} \mathrm{H}: 4876 \\ \pm 45 \\ 2^{\text {nd }} \mathrm{H}: 4561 \\ \pm 366 \\ * \text { sig less } \\ \text { than } 1^{\text {st}} \mathrm{H} \end{gathered}$ |  | $\begin{gathered} \hline 10,070 \mathrm{~m} \pm \\ 707 \mathrm{~m} \\ (9,200- \\ 11,490) \end{gathered}$ | $\begin{aligned} & 11,469 \\ & \pm 983 \mathrm{~m} \end{aligned}$ |  |  | $\begin{gathered} 11,617 \pm \\ 617 \mathrm{~m} \end{gathered}$ | $\begin{gathered} 11,059 \\ \pm 935 \mathrm{~m} \\ 1^{\text {st }} \mathrm{H}: \\ 5699 \mathrm{~m} \pm \\ 489 \\ 2^{\text {nd }} \mathrm{H}: \\ 5360 \mathrm{~m} \pm \\ 496 \\ * \text { sig less } \\ \text { than 1 } 1 \end{gathered}$ | $\begin{gathered} 10,4290 \mathrm{~m} \\ \pm 507 \mathrm{~m} \\ \text { Range: } \\ 9,200- \\ 11,490 \\ 1^{\text {st }} \text { Half: } \\ 5213 \\ 2^{\text {nd }} \text { Half: } \\ 5147 \end{gathered}$ |


| Ave HR (bpm) |  |  |  | $\begin{gathered} 165 \pm 8 \\ 1^{\text {st }} \text { Half: } \\ 165 \pm 8) \\ 2^{\text {nd }} \text { Half: } \\ 165 \pm 9) \end{gathered}$ |  | $\begin{gathered} \hline 162 \pm 2 \\ \text { (taken at } 5 \mathrm{~s} \\ \text { intervals) } \end{gathered}$ |  | $155 \pm 16$ | $153 \pm 6.7$$1^{\text {st }}$ Half: 154$\pm 7$$2^{\text {nd }}$Half: 152 <br> $\pm 6$ | $\begin{aligned} & 83 \pm 3 \% \\ & \max \mathrm{HR}, \end{aligned}$ |  | $162 \pm 2$ |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Sprint \% | $13 \%$ $(1436 \mathrm{~m})$ | 3\% |  | $12 \%$ $(1109 \mathrm{~m})$ | 6\% | 1\% | 5\% |  |  |  | 13\% | 2\% |
| Run \% | $\begin{gathered} 25 \% \\ (2744 \mathrm{~m}) \end{gathered}$ | 47\% | 18\% | $\begin{gathered} 47 \% \\ (4444 \mathrm{~m}) \end{gathered}$ | 12\% | 6\% | 37\% |  |  |  | 24\% | 11\% |
| Jog \% | $\begin{gathered} 44 \% \\ (4840 \mathrm{~m}) \end{gathered}$ |  | 48\% |  | 47\% | 24\% | 37\% |  |  |  | 34\% | 18\% |
| Walk \% | 9\% | 42\% | 34\% | 23\% | 19\% | 40\% | 8\% |  |  |  | 22\% | 69\% |
| Stand \% | (975m) |  |  | (2163m) |  | 23\% |  |  |  |  | 8\% |  |
| $\begin{array}{\|c} \hline \text { Backward } \\ \text { s \% } \end{array}$ | $\begin{gathered} 9 \% \\ (966 \mathrm{~m}) \end{gathered}$ | 8\% |  | $\begin{gathered} 18 \% \\ (1722 \mathrm{~m}) \end{gathered}$ | 16\% | 6\% | 13\% |  |  |  |  |  |
| Other info |  |  |  |  |  | 11 m from decisions in middle of field 15 m from decisions in attacking third | Sprints lasted no more than 2-4 seconds |  | Estimated energy expended $1^{\text {st }}$ Half: 846 $\pm 107 \mathrm{kcal}$ $2^{\text {nd }} \mathrm{Half} 855 \pm$ 119 kcal |  | Differences in the mean distance from infringements in left attacking zone between first half and second half | Tempo changes $1,087 \pm 141$ ie every $5-6$ secs $\left(1^{\text {stt }}\right.$ $528,2^{\text {nd }}:$ $561)$ |

