THE DISTANCE COVERED OF SOCCER AND RUGBY REFEREES DURING THE MATCH USING A MOBILE "GPS"

Takayuki Ishii, Takuya Masuda, Hiroyasu Kurogi, Shuichiroh Yabuno and Hiroh Yamamoto
Biomechanics Lab., Fac. of Educ., Kanazawa Univ., Japan

The purpose of this study was to measure the distance covered of soccer and rugby referees during the match using mobile GPS method. And also, the distance covered measured by GPS method was compared with VTR method and manual tracing method, so as to examine availability of a mobile GPS. Nine soccer referees and ten rugby referees participated in this study. The distance covered was measured by mobile GPS method, VTR method and manual tracing method. In the case of soccer referee, there was no significant difference between mobile GPS method and VTR method. While the case of rugby referee, there was no significant difference among three methods. Therefore, it was concluded the mobile GPS might have the possibility of one effective instrument for measuring the referee's distance covered during soccer and rugby match.

KEY WORDS: a mobile GPS, distance covered, soccer referee, rugby referee.

INTRODUCTION: GPS was developed by DOD (Department of Defense). After that, it could be used for civilian purpose in 1993. Then GPS (Global Positioning System) has spread remarkably. GPS indicate distance covered, locomotion, velocity, and time information. Moreover, GPS provides 24-hour navigation services which: 1) include a worldwide common grid, 2) are unchangeable under any weather condition, 3) provide real-time information, 4) support to unlimited number of users and areas, and 5) support to civilian users at a slightly less accurate level. Mobile GPS has become smaller sizes and having a better quality. GPS had included S A (Selective Availability) for the security of national defense. But S A was released from May 2000, that made the margin of error small less than 10m. It is expected that mobile GPS will be frequently used in sports science as a match analysis. The distance covered is one of the important factors of the soccer and rugby match analysis. Soccer and rugby referees must move around to judge the game properly. The types of locomotion during the match include walking, jogging, running, sprinting, back walking and back running. Soccer and rugby referees need to change their motion rapidly to respond to the movements of the ball and players. An analysis of the distance covered, types of locomotion and heart rate of soccer and rugby referees will show quantity and quality of the movement and indicate physical requirements. By determining physiological aspects of soccer and rugby referee, a specific training program can be scientifically devised. But, unfortunately, there has been little work conducted on the distance covered of them. Therefore, the purpose of this study was to measure their distances covered during the match, using mobile GPS method. And also, the distance covered measured by GPS method was compared with VTR method and manual tracing method, so as to examine availability of mobile GPS.

METHODS: Nine male soccer referees (33.9±7.96 years,173.4±3.58 cm,72.3±9.13 kg) were qualified by Japan Football Association, and ten male rugby referees (38.1±2.5 years,172.0± 3.19 cm,75.5±7.65 kg) were qualified by Kyushu participated in this study. Soccer and rugby referees judged in Inter High School Soccer Tournament in Ishikawa, and Population Rugby Cup in Miyazaki, or Inter High School Rugby Tournament in Miyazaki, Japan respectively.

1. The distance covered and track of locomotion of referee

The distance covered and track of locomotion of referee was measured by three methods.

(1) VTR method: Referees' movements were recorded by using video. VTR recoded the numbers of steps in walking, jogging, running, sprinting, back walking and back running. The total distance covered was calculated by stride length of each subject, which had been measured previously.

(2) Manual tracing method: Referees' movements were traced in a miniature copy of a soccer or rugby ground. After that, distance covered was measured.

Figure 1. MAGELLAN GPS-315

(3) Mobile GPS method: Referees' tracks of locomotion and total distance covered were recorded by mobile GPS-315 (MAZELLAN Co. Ltd., San Dimas, CA, USA) (Figure1).

2. The referees' types of locomotion

The ratio of each distance covered in several types of locomotion to the total distance covered during the match was calculated for each subject using the VTR method.

3. The heart rate of the referee

The referees put a heart rate monitor (ACCUREX PLUS, POLAR ELECTRO Co, Ltd., Kempele, Finland) on their body to measure their heart rate.

RESULTS AND DISCUSSIONS: Table1 showed the distance of movement of referees measured by using VTR, manual tracing and mobile GPS methods. In the case of soccer referees, the manual tracing method (5731±944m) was significantly ($p<0.05$) longer than the mobile GPS method (4639±1331m). The manual tracing method was also significantly ($p<0.05$) longer than VTR method (4362±796m). But, there was no significant difference between mobile GPS and VTR methods. In the case of rugby referees, there was no significant difference among three methods. In soccer matches, the types of locomotion of referees was consisted of following: walking 1634m (37.5%), jogging 1216m (27.9%), running 841m (19.3%), sprinting 200m (4.6%) back walking 254m (5.8%) and back running 215m (4.9%) (Figure 2, Figure 3). While rugby matches were: walking 2088m (47.8%), jogging 728m (16.7%), running 550m (12.6%), sprinting 162m (3.7%), back walking 736m (16.9%) and back running 103m (2.4%) (Figure 2, Figure 4).

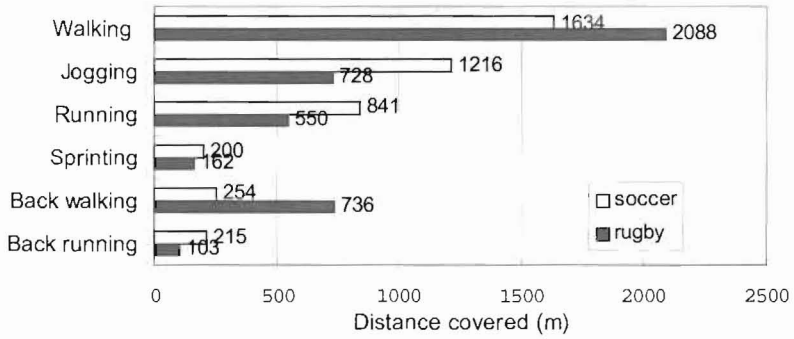

Figure 2. Distance covered in each types of locomotion during matches (soccer and rugby).

Table 1. Distances covered of soccer and rugby referees of each method.

	Method of measure	1st half	2nd half	Full time
Soccer	VTR	2153±388	2209±431	4362± 796
	Manual tracing	2884±404	2847±570	5731± 944
	Mobile GPS	2393±620	2275±725	4639±1331
Rugby	VTR	1885±306	1835±234	3761± 602
	Manual tracing	2019±362	1923±264	3942± 603
	Mobile GPS	1848±229	1892±183	3739± 368

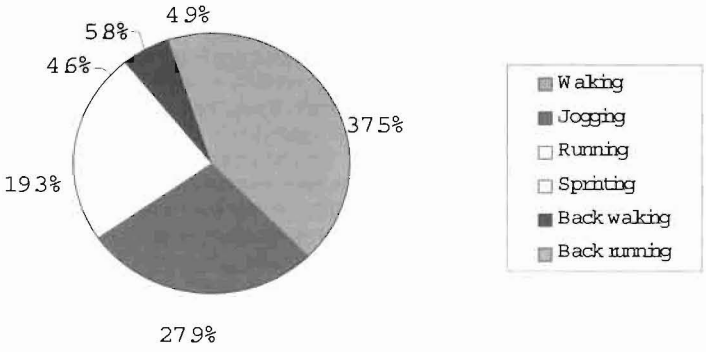

Figure 3. Distance covered in each types of locomotion during soccer match.

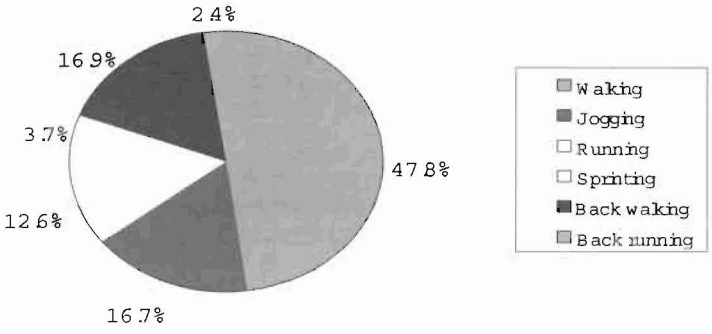

Figure 4. Distance covered in each types of locomotion during rugby match.

In soccer referees of heart rates in the 1st half and 2nd half were 147b·min^{-1} and 149b·min^{-1} respectively. No significant difference existed between heart rates in the 1st half and 2nd half. The average of heart rate in full time was 148b·min^{-1}. In this study the exercise intensity of each soccer referee during the match was approximately 80%HR_{max}. In rugby referees heart rates in the 1st half and 2nd half were 152b·min^{-1} and 155b·min^{-1} respectively. No significant difference existed between heart rates in the 1st half and 2nd half. Heart rate in full time was 154b·min^{-1}. In this study, exercise intensity of each rugby referee during the match was approximately 85%HR_{max} (Table 2).

Table 2. Heart rates of soccer and rugby referees during the match.

		Soccer			**Rugby**	
	1st half	2nd half	Full time	1st half	2nd half	Full time
Mean	147	149	148	152	155	154
S.D.	24.8	26.4	25.5	10.2	8.2	8.6

CONCLUSIONS: In the case of soccer match, no significant difference existed between mobile GPS and the measure of the VTR methods. It is thus concluded that the mobile GPS

may possibly be an effective instrument for measuring the referee's distance covered during the match. There was not significant difference among three methods. It is thus concluded, that the mobile GPS may be possible as an effective instrument for measuring the referee´s distance covered during the match.

REFERENCES:

Ali, A. and M, Farrally. (1991). A computer-video aided time motion analysis technique for match analysis. *Journal of Sports Medicine and Physical Fitness*, **31**, 82-88.

Catterall, C. et al. (1993). Analysis of the work rates and heart rates of association football referees. *British Journal of Sports Medicine*, **27**(3), 193-196.

Ekblom, B. (1986). Applied physiology of soccer. *Journal of Sports Medicine*, **3**, 50-60.

Healey, J. (2000). Future possibilities in electronic monitoring of physical activity. *Research Quarterly for Exercise and Sport*. **71**(2), 137-145.

Masuda, Takuya. et al.; The distance covered of soccer referee using a mobile GPS. *In Proceedings of Oral Sessions X IX International Symposium on Biomechanics in Sports* (Edited by J. R. Blackwell), University of San Francisco: U.S., June 2001. Unpublished.

Reilly, T. and V. Thoams. (1976). A motion analysis of work-rate in different positional roles in professional football match-play. *Journal of Human Movement Studies*, **2**, 87-97.

Schutz, Y. and A, Chambaz. (1997). Could a satellite□based navigation system (GPS) be used to assess the physical activity of individuals on earth? *European Journal of Clinical Nutrition*, **51**, 338-339.

Schutz, Y. and R. Herren. (2000). Assessment of speed of human locomotion using a differential satellite global positioning system. *Medicine and Science in Sports and Exercise*, 642-646.

Terrir, P. et al. (2000). High□precision satellite positioning system as new tool to study the biomechanics of human locomotion. *Journal of Biomechanics*, **33**(12), 1717-1722.