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Original Article

PROPOSAL OF ACCURACY ANALYSIS OF INDOOR TRACKING SYSTEMS IN BASKETBALL

PROPOSTA DE ANÁLISE DE PRECISÃO DE SISTEMAS DE RASTREAMENTO INTERNO EM BASQUETEBOL

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RESUMO
O desenvolvimento da tecnologia de rastreamento causou um crescimento exponencial das pesquisas sobre esse tópico. O uso de metodologias padronizadas é útil para contrastar dados de diferentes estudos. Por outro lado, é necessário um sistema de referência de baixo custo. Por este motivo, o principal objetivo da presente pesquisa é a descrição de um protocolo específico para avaliação da acurácia do rastreamento de localização em condições internas no basquete. Pode retomar em três etapas com procedimentos detalhados e fáceis na seção do método. O método de análise de precisão apresentado pode relatar o centímetro de precisão em cada coordenada medida pelo sistema de rastreamento. Um protocolo padronizado para avaliar a localização em condições internas no basquetebol fornecerá aos profissionais de ciências do esporte uma ferramenta útil para analisar a precisão e a confiabilidade de todo o sistema de rastreamento, sendo que os resultados podem ser comparados dentro e entre as quadras.
Palavras-chave: Precisão. Sistemas de rastreamento. Análise de tempo-movimento. Esportes coletivos. Condições internas.

ABSTRACT
The development of tracking technology caused a exponentially grow-up of research into this topic. The use of standardized methodologies is useful to contrast data of different studies. On the other hand, a low-cost reference system is needed. For this reason, the main aim of the present research is the description of a specific protocol to accuracy assessment of tracking location in indoor conditions in basketball. It can resume in three steps with detailed and easily procedures in the method section. The accuracy analysis method presented can report the centimeter of accuracy in each coordinate that the tracking system measure. A standardized protocol to evaluate the location on indoor conditions in basketball will provide to the sport science professionals a useful tool to analyze the accuracy and reliability of all tracking system, being the results can compare both within and between-court.
Keywords: Accuracy. Tracking systems. Time-motion analysis. Team sports. Indoor conditions.

Introduction

The use of inertial measurement units (IMUs) to quantify and monitoring performance is now a basic tool for trainers and fitness coaches[1]. In basketball, tracking systems are currently used to examine time-motion and tactical analysis[2], and these systems require a certain minimum precision.

Different radio-frequency tracking systems have been validated recently[3-7]. For this, different validation protocols have been used due to the technological development. On one hand, Frencken, Lemmink, & Delleman[5] validated a local position measurement (LPM) tracking system in respect to distance and velocity registered by photocells and measuring tape. Although the system was validated in soccer (outdoor condition), it can be used in indoor conditions for basketball. The same system was assessed and compared in outdoor and indoor conditions[8], but only in specific and determined areas of the playing field. The same consideration was detected by Ogris and colleagues[7] when analyzing the accuracy of a LPM system respect to a VICON® cameras system that apply infrared technology, but the protocol was tested in only one side of the field. Later, Leser, Schleindlhuber, Lyons, & Baca[6] validated a ultra-wide band (UWB) tracking system called Ubisense® in respect to the distance measured by a trundle wheel, it only suppose distance validity. Recently, Luteberget and colleagues[9] validated an LPM system respect to a VICON® , but the test was performed in a specific and determined areas of the playing field, since the VICON® system has several limitations regarding the measure of total field[10-12].

Currently, interference with the radio frequency signa due to the environment is one of the main problems. In indoor conditions it is due to the different architecture and buildings used for different courts. It refer to the elements and their arrangement, such as distance from the court to the walls, marker position, and others, and they could cause significant differences and accuracy bias in the values that are reported[4]. Hence, the same system could present different estimation error index of player’s tracking location related to the indoor court that it is placed, as there is a need to use a standardized protocol to accuracy assessment, independent of the court location. Therefore, the purpose of the present research is to describe a specific protocol to accuratly track location in indoor conditions in basketball.

Methods

Protocol

The protocol consists in the execution of three different displacements in the playing area, repeating each one in three times. During the displacements, two devices were carried out and perfectly fixed by a specific harness in the upper back (inter-scapulae line). The different tracks, that represent the specific movements of basketball, were performed in different distances, directions and intensities to simulate the real demands of competition games, completing the displacements up to 15 km/h. The designed tracks to evaluate the accuracy of locations were: (a) perimeter markings of court; (b) middle line court; (c) exterior perimeter of the painted lines; (d) centre circle and (e) 6.75 m line (figure 1). The dimensions were as follow: perimeter of the court: 28 meters of length and 15 meters of width; middle line court: 15 meters of length; perimeter of the paint: 5.8 meters of length and 4.9 meters of width; centre circle: circle of 1.8 m of radius; 6.75 m line: 3.8 m of centroid) where the dimensions adhere to current FIBA basketball laws. The real distance can measure with a trundle Wheel (Mini Rolfix, BMI, hersbruck, Germany). All the task must start from a standing position and behind the marked lines.

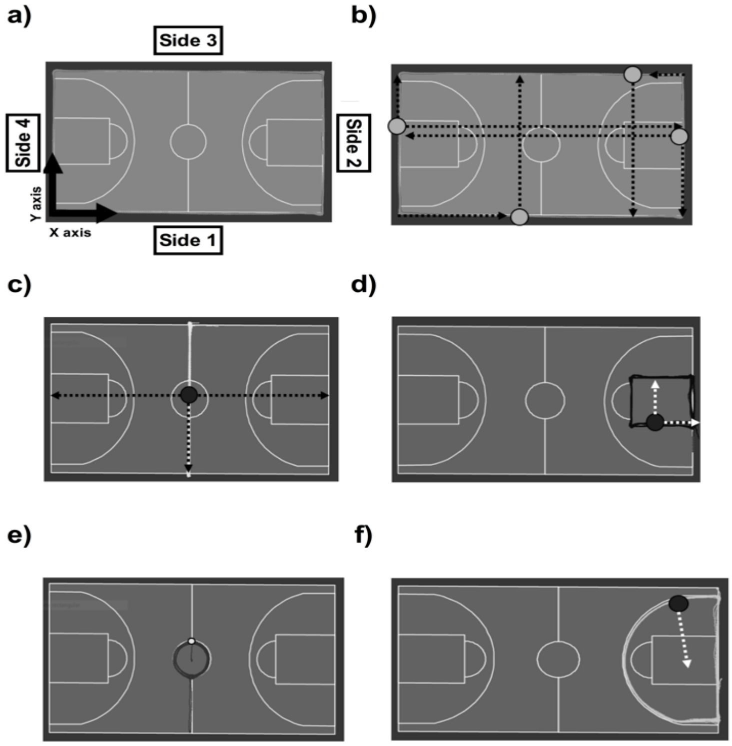

Figure 1. (a) Arrangement of sides and axes for the analysis of the movements made by participants in this study and design of the different travels carried out by them: (b) perimeter markings of court; (c) middle line court; (d) exterior perimeter of the court lines; (e) centre circle and (f) 6,75 m line

Source: Authors

1st step: data extraction

The UWB system was installed on the field as follows (Figure 1): (i) six antennae with UWB technology were fixed 4.5 m from the perimeter line of the field, except for the ones located in the middle line of the field that were fixed at 5.5 m, in this way the antennae formed a hexagon for a better emission and reception of the signal. All of them were located at a height of 3 m, held by a tripod; (ii) once installed, they were switched on one by one making sure that the master antenna was the last, and then a process of autocalibration of the antennae was carried out for 5 seconds; (iii) in a last step, the tracking devices were switched on and a process of recognition and automatic communication with the antennae was carried out during 1´. Each participant was equipped with two lightweight (70 g) inertial devices, measuring 81 x 45 x 16 mm. The two inertial devices were placed in a custom vest located on the back of the upper torso fitted tightly to the body, as is typically used in games. In the custom vest, the devices were placed in parallel (with a separation of 2 cm) and at the same height. When the data extraction was finished the devices were turned off.

2º step: data processing

To investigate the accuracy of the tracking systems (UWB) for monitoring players' positions on the pitch, the data were transformed into the raw position data (x and y coordinates), using S PRO software (RealTrack Systems, Almeria, Spain). The reference system to compare the results was projected in the software using a desktop GIS mapping and data editing application that allows making all kinds of geometrical shapes such as polygons or circles with millimeter accuracy (Geographic information system). In this way, the routes executed with the real measurements as well as the data in x and y coordinates of the two devices carried by the participants were introduced. Of all the data entered, only those that corresponded to the execution of the routes were selected, according to registers obtained using ANT + technology at the beginning and end of the test[13]. In routes a) and b) a number was assigned to each edge of the projected rectangle, so in each test the software automatically calculated the distance of the participant's position with respect to the same side in which displacement occurs (y coordinate) and opposite side (x coordinate). In lane c) the centroid of the projected circle was assigned, so in each test the software automatically calculated the distance of the position of the participant from the indicated centroid (coordinate x). The calculation of the distance of the participant's position according to the reference element was made every 0.5 seconds, obtaining a total of 9,586 samples. The precision error was considered as the difference between the real distance and the distance reported by the tracking systems (see Figure 1).

3rd step: Statistical analysis
The data obtained by the analysis in the S PRO™ software were introduced in a specific spreadsheet (URL to download: https://drive.google.com/file/d/1s_Q4Ns1dDwgwpowG5t2KZiCFhrPLaxfz/view?usp=sharing). This spreadsheet realizes the mathematical calculations to check the validity of a tracking system through the mean difference in each coordinate and type of displacement, as well as the inter-unit reliability by the intraclass correlation coefficient (*ICC*) and the systematic error percentage (*%TEM*).

Results

Accuracy

Table 1 summarizes the mean differences of the position estimation error in different courses. The mean absolute error of all position estimations can calculate by total mean ± SD of the differences and percentage of differences in each axis. Significant differences can calculate between the different courses and devices used.

Table 1. Accuracy in mean differences (cm) and percentage of differences of x- and y-position coordinates

Designed Travel	Device	Differences		Percentage of Differences	
		X	Y	X	Y
Perimeter of court	1	8,59	6,70	0,61%	0,48%
	2	6,95	7,92	0,50%	0,57%
Center line of the court	1	10,43	5,42	0,70%	0,36%
	2	13,47	6,83	0,90%	0,46%
Perimeter of the paint	1	5,88	6,44	3,27%	3,11%
	2	5,92	6,66	3,29%	3,65%
6.75 m line	1	9,06	-	1,34%	-
	2	8,72	-	1,29%	-
Center circle	1	6,95	-	0,50%	-
	2	7,45	-	0,58%	-
Mean ± SD		8,63±2,52	6,71±1,02	1,19%±1,19	0,47%±0,08
LOA (L to U)		6,11 to 11,15	5,69 to 7,73	0 to 2,38	0,38 to 0,55

Note: LOA: Limits of agreement (L: Lower; U: Upper); SD: Standard deviation
Source: Authors

Inter-Unit Reliability

Table 2 show the inter-unit reliability by ICC and %TEM for the x-coordinate and y-coordinate

Table 2. Inter-unit reliability of x- and y-position coordinates

Axis	Unit 1 (Mean ± SD)	Unit 2 (Mean ± SD)	ICC	90% CI	% TEM
x	8,49±1,65	8,76±3,33	0,65	0,15 to 0,94	2
y	6,06±0,90	7,37±0,76	0,88	0,26 to 0,99	2

Note: ICC: Intra-class correlation coefficient; CI: confidence interval; TEM: Typical error of measurement; SD: Standard deviation
Source: Authors

Discussion

The designed protocol presented here used only the own tools of a same tracking system (WIMU PRO^{TM} inertial device and S PRO^{TM} software). Currently, in sport science research, the reference method of validation consists in a concurrent validity analysis with video-analysis[7]. The problem presented by the analysis respect to the "*gold standard*" is firstly the high economic cost and secondly the difficulty of the installation and use of the system. For these reasons, its use in this sense does not seem adequate. Besides, all available studies analyzed a reduced area of the field[7–9,14], limiting the real assessment of a tracking system during the register of a official match in a full-court.

For all this, in here is presented a standardized low-cost protocol with an easy-use to report the estimation bias. The optimum estimation bias it has been argued that it must be less than the error of the natural position of the center of gravity of the body (15-20 cm) in each observed moment[15]. Therefore, when a value lower than 15 cm in each coordinate (x,y) in the analysis, it could be assumed that the tracking system is valid to measure time-motion analysis in real time. This proposed assessment performed a comparison of 2-data per second, that assume a more exhaustive process than other studies that compare their data with other measurements (photocells, manual measures, etc.)[3,5,6]. Even so, this comparison frequency of data could be configured to increase or decrease. For this reason, if a development of the higher data frequency chipsets that compose the tracking device is produced, this spreadsheet will be ready to use in the future. On the other hand, there is a degree of variation in basketball courts characteristics, hence standardization of homologous precision of a tracking system technology on indoor conditions presents challenges. This aspect is important when calculating a progress or a comparison over time on this data. To know whether or not there has been progress, the difference of one measure with the other must be greater than the system error and the test-retest reliability.

Conclusions

A standardized protocol to evaluate the location on indoor conditions in basketball will provide to the sport science professionals a useful tool to analyze the accuracy and reliability of all tracking system, being the results can compare both within and between-court.

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