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Researches Concerning the using of Moven© Inertial Navigation System in Monitoring the Male Triple Jump Event

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Abstract: Problem statement: This study aims to highlight ways of using Moven© inertial navigation system applied in the monitoring of the male triple jump event technique. Inertial navigation system involves the use of some elements to determine the coordinates and speed of a body by processing information related to its acceleration. **Approach:** The research results point out that this equipment can be used to monitor the triple event technique, using the information provided on kinematics issues, respecting certain steps and guidelines. **Results:** The amount of information generated by the system, information that can be visualized after the import of the data in Excel (161 data columns referring to the position of the 23 segments of the body model analyzed with the device by and 69 data columns referring to the linear velocity and acceleration of them, characteristic of each separate repetition and overall 483 data columns for position, respectively 207 for linear velocity and acceleration plus those for angular velocity and acceleration). **Conclusion/Recommendations:** This system is a complete tool necessary for the sportive training process; its utility can provide an objective expert assistance with the possibility of determination of the possible execution mistakes in real time.

Key words: Monitoring, triple jump technique, velocity, acceleration, motion sensors, inertial navigation system, angular acceleration and velocity

INTRODUCTION

The objectivity of the technique assessment regarding the directing of sportive training and the competition progress' assessment can be achieved by using means and methods that represent true "filters", implemented to remove the errors and to achieve a correct guidance of the strategies for optimizing the process of sportive training.

"Human daily activities are influenced by the growth of science and technology. This growth been used by researchers to rebuild and develop various field in this world including sports and recreation (Ismail *et al*., 2010).

In the literature, the general term, "filtering" referring to the human motion, has the significance of reduction or enhancement of certain components of the signal (information) (Wood, 1982). Any technique or processing carried out at the time or frequency level which has such an effect is called filtering. Another term used in the data filtering is that of mixing (smoothing) which usually refers to an objective way to process the data to fit a particular model (Stergiou, 2004).

The interest in obtaining sport performance as soon as possible, with greater efficiency and minimum of biological risks led to a huge development of scientific research specific to the sport domain, but also to an openness enhanced regarding the knowledge transfer and application in other areas.

The permanent improvement of the instruments and methods used in order to monitor the technique aspects of the human movement determined the obtaining of some more accurate information regarding the basic element of the movement, influencing in a favorable way the scientific research activity that is necessary in order to provide quality and efficiency to the means that are used in the sportive training process (Mihai, 2010).

According as the phenomena and processes are more and more studied, as well as the technology influence, it was found that in many cases the training methodology no longer corresponds, emphasizing the increasing need of having a more objective control over the athlete development during training and competition.

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Inertial navigation technology is part of the new technologies implemented in the research field of sports, especially at national level. It was originally used in the military domain and by the information offered to the specialists of our field of activity, (information on the elements of cinematic 3D) it can be considered one of those "filters" used to optimize athletic training.

The inertial navigation involves determining of the coordinates and the velocity of a corps by processing the information about its acceleration (Grigoras, 2010).

The inertial navigation determines the position and the tracking of a trajectory determined by two or more points, expressed in geographical coordinates based on the information acquired by the acceleration system .**

The inertial navigation system is a navigation device which uses a computer and motion sensors (inertial navigation units) to calculate continuously, by the calculation and estimation "dead reckoning" process, the position, direction and velocity (direction and speed of movement) a moving object without the need of external references.

The inertial navigation technology is an important asset of the scientific research, which provides, on the base of its elements, specific to the kinematics in 3D, objective considerations over the sportive behavior in the terms of sportive training factors, being "recruited" in the category of the instruments used for sportive technique monitoring.

Internationally, the implementation of this technology in science and sport science, has a wide application in some studies and researches, based on the use of complete systems such as Moven©, Animazoo© or the use of components of inertial navigation systems (Willemsen *et al*., 1990; Davey *et al*., 2005; Welk, 2005; Kavanagh *et al*., 2006; Bamberg *et al*., 2008; Tilmann *et al*., 2008; Hesami *et al*., 2008; Kruger and Edelmann-Nusser, 2009; Meamarbashi, 2009; Mbaitiga, 2009).

Nowadays, nationally, from our information, we know that there is a single device that uses inertial navigation technology with practical applications in sports, respectively MOVEN©, a device which is a part of the logistical elements of the National Research Institute for Sport, being used to conduct some researches with application in athletics, boxing, dance.

A good technique of the triple jump event is obtained if the athlete can accomplish the following requires: smaller brakes in landings, an economic distribution of the involved forces, strong and fast hit phases, relatively grazing flights (Mihailescu, 2006).

The base mechanism of the triple jump event technique is very complex and its short time of achievement determines that the direct observation, achieved without inertial navigation assistance, cannot offer objective elements of evaluation and assessment of the kinematic parameters of the technical elements, implicitly the correctness of the individual technique of the athletes.

In this research we started from the assumption that the Moven© inertial navigation system-can be used as an objective way to monitor men's triple jump technique event by manipulating the independent variables of the system: the position, linear speed, linear acceleration, angular velocity, angular acceleration.

The purpose of this study was to determine how the inertial navigation system-Moven© can be implemented in the monitoring and assessment of the male triple jump technique.

For this purpose we have considered the following objectives:

- Study of the bibliographical sources specific to the research direction approached in the study
- Definition of the elements specific to the triple jump technique that will be included in the research
- The definition of the phases that will be the basis of the use of Moven© system in monitoring of the male triple jump technique

MATERIALS AND METHODS

In conducting of this research, we considered to be necessary the use of the following research methods to ensure proper scientific rigor in this study:

- Meta-analysis (qualitative and quantitative by highlighting the information referred to the link between the methodology used in the sportive training process and the necessity of the using of some tools that provide more objective information referring to the athletes' evolution both in training and in competition; the use of the inertial navigation technology at international and national level)
- Documentary informatics method (accessing some electronic information sources, of major utility for our research)
- Experiment method (manipulating the independent variables represented by the use of inertial navigation device-Moven© in order to acquire some data, dependent variables, on which it can be determined the utility of the device in the monitoring activity of the triple jump technique)

* Observation method (it helped to obtain useful information to fulfill the purpose of this research, by using the Moven© device and its software used for the acquisition of the information specific to the 3D kinematics)
* Inertial navigation method

The necessary experimental assembly was achieved in the sporting club "VIITORUL", Bucharest, running track, jumping sector.

The logistics component necessary to carry out this research was provided through the collaboration with the National Institute for Sports Research, Bucharest.

The Moven© equipment includes an inertial navigation system that allows the kinematic analysis (it provides information on time, position, velocity, acceleration, angular velocity, angular acceleration) used for the complete acquisition of movement with practical application both in limited, indoor areas and outdoor.

In terms of configuration, the Moven© system is composed:

* A suit made of lycra, elastic, fitted with a number of cable channels and special pockets for the sensors, motion sensors
* 17 movement sensors (MTx and MTx-L)-"a MTX sensor is a miniature inertial measurement unit consisting of 3D integrated magnetometers that measure the Earth's magnetic field, 3D linear accelerometers, that measure acceleration, including gravitational acceleration and 3D gyroscopes, components that provide information about angular velocity
* 2 Xbus terminals (transmitters)-Fig. 1-they interconnect the inertial motion sensors MTx via a Xbus cable. The Xbus cable supplies (with power) and acquires data from the motion sensors, by synchronizing them at the same time. The acquired data are transmitted via a wireless Bluetooth terminal connected to a computer the or an USB cable
* 2 Moven© (WR-A) receptors-they provide "information traffic (via antenna) between the Xbus terminals and the computer. Each receiver must be connected to a USB port and in order to realize the data acquisition procedure with maximum efficiency, the distance between the receivers must be at least 1 m (Fig. 2)
* 8 AA batteries + Charger
* 2×12 V DC power adaptors

Fig. 1: Xbus terminal

Fig. 2: Wireless Moven© RW-A receiver.

Fig. 3: Inertial motion sensor.

In the suit there are two types of sensors MTx: MTx and MTx-L. They have similar components inside, but have different connectors:

* MTx sensors (Fig. 3) have two connectors positioned on the same side and they are in the pelvis, head and hands level
* MTx-L sensors (Fig. 3 b) are provided with a cable between the connector and the carcass and they are at the shoulder blades, upper and lower limbs (excluding hands and legs)

RESULTS

After a preliminary exercise of using the Moven© system in which calibration was performed in a parallel plane with that the action was supposed to take place (half distance from the first hit place and the proximal edge of the landing area). We found that a very important role in maintaining continuous contact between senders and receivers, it is the place where the system calibration is performed and, therefore, the position of the receptors to transmitters. This conclusion is based on the fact that, after calibration, the time where the subject was removed from the calibration place, the reception signal decreased to its loss.

Therefore, we proceeded to make a new calibration, in the same parallel plane to the plane where the action was going to take place, but this time, the position of the receptors and consequently, the calibration area were located in the middle of the runway area. We noticed that, this time too, the signal between transmitters and receivers was reduced to its loss, as the distance between the two components of the system increased.

After the second test of the Moven© system use, the receptors were positioned in a transverse plane to the plane where the movement was going to take place, behind the runway area, this being the area where the third calibration took place, followed by the start of data acquisition. This time, the signal between transmitters and receivers, has not diminished as distance increased between the two components, which led us to conclude that, to have a continuity of the signal (a basic condition in using Moven© inertial navigation) between senders and receivers, the area where the calibration and transmitters position take place, must be behind the movement plan.

However, we noticed that after the basic mechanism performance of the triple jump event, when the subject's body interposed between the transmitters and receivers (the subject turned to face the receptors). the signal was interrupted. This led us to realize a fourth test where the subject was told not to face the receivers after the jump, but to approach the area where he started his runway walking backwards.

Establishing these details was the first part of using inertial navigation equipment, the second aimed the data's acquisition and processing.

When processing data acquisition we faced the following situations:

- When the hop was performed, done with the right foot, we noticed that, after its separation from the ground and his swing forward when its foot passes by and exceeds the foot of the left leg (which is engaged in a swinging motion) the software behaves as if it recognized a new contact to the left foot level (although it is in the air). in this case we come to the situation of not knowing exactly where contact with the ground is (the ground position during the first flight)
- The problem occurs when both feet are in the air as a result of taking off the ground, meaning the moment when the right foot passes by the left foot (this foot performs a forward swinging motion) and when there is no moment of real contact
- The problem is that after the taking off of the right foot from the ground, when the software sees the left foot position as the contact point, we cannot give a real value of the ground position

DISCUSSION

The results show that the use of Moven© inertial navigation equipment, in order to implement it as a mean of monitoring the triple jump event technique can be an effective way to optimize the process of the sportive training.

The "unprocessed" acquisitions in a MVN format must be reprocessed through the software features of the equipment, whereas, because of the complex nature of the elements of the basic mechanism of the triple jump event as well as because of the movements high execution velocity, these representing obvious changes to the actual movements, changes that can be sources of error in digital data analysis to achieve the necessary kinematic analysis of the monitoring.

As a result of the difficulties encountered during the reprocessing and analysis of the data specific to the basic mechanism of the male triple jump, is indicated that, the use of this inertial navigation equipment, as a mean of monitoring, to focus on the running until the moment of the first hit performance, as well as, on the three successive hit phases analyzed from the moment of the hit foot contact with the ground until its takeoff.

The use of the Moven© equipment provides the necessary conditions to monitor the technique of the triple jump event offering the possibility of kinematic analysis of the runway and the three successive hits, providing the following kinematic parameters: position, linear velocity, linear acceleration, angular velocity, angular acceleration.

The information acquired in MVN format must be transformed in MVNX format, which, besides the visual traceability of performed movements, played by the body model composed of 23 segments, allow the storage of the information characteristic to the three coordinates (x, y, z) in the digital format too.

From the MVNX format, the data are exported in Microsoft Excel where they are ranked according to body structure model provided by the system. The ranking involves the ordering of the data as columns corresponding to each body segment, with a total data volume of 161 columns for position and 69 columns for linear velocity and acceleration, characteristic for each repetition and a total overall of 483 columns for position, respectively 207 for linear velocity and acceleration.

CONCLUSION

This research demonstrated that by using this equipment it can be determined, in real time, the information specific to the human movement aimed in this athletic event, as position, linear velocity, linear acceleration, as well as angular velocity and acceleration, respecting the calibration achievement in order to provide a continuity of the signal between emitters and receivers during the acquisition time.

The Moven© inertial navigation system can be used to acquire kinematic data to aim only certain moments of the triple jump event, such as: running on the runway until the time of the first hit, the three successive hit phases analyzed from the moment of the hit foot contact to the ground until its taking off, specific to the hop, step and jump.

The information obtained by this research can be implemented in the acting technologies in order to optimize the technical training in male triple jump event with influences over the optimization of the whole sportive training process.

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