ATLANTIS PRESS

Advances in Health Sciences Research, volume 17

4th International Conference on Innovations in Sports, Tourism and Instructional Science (ICISTIS 2019)

The use of XSens 3D motion tracking system for gait feature extraction

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Abstract. The purpose of the article is to show the possibilities of using the XSens system to assess gait features in people without gait disorders. Materials and methods. The XSens motion tracking system was tested by a man who did not have disorders of the musculoskeletal system. The MBN force platform was also used during the experiment. Results. The study describes the methods for determining the individual characteristics of a normal gait, as well as an analysis of these data. Conclusion. During the study, which combines the biomechanics of human walking and stabilometry, a direct relationship was found between the deviation of the center of pressure at rest and the rotation of the pelvis along the X axis and Y axis.

Keywords - gait, motion tracking system, kinematics, biomechanics, XSens.

I. Introduction

Assessment of movement during complex coordination activities such as walking or climbing stairs is one of the main problems in the study of the musculoskeletal system [1,4,13]. When examined by traditional methods, it is difficult to assess the movements in the leg joints in several planes during functional motor activity [9, 10, 11]. One of the solutions to this problem is the use of systems based on high-speed cameras. However, these systems are usually located in special laboratories, and the equipment itself requires the long calibration time and a high level of technical knowledge [4,7,8].

One of the solutions to this problem is the use of a motion tracking system for measuring motion during complex coordination activity [6,12].

II. Materials and methods

The study was conducted on the premises of the Research Center for Sports Science of the South Ural State University. The experiment was conducted on a man (age 38 years, body length - 186.00 cm, body weight - 82.30 kg) without diseases of the musculoskeletal system.

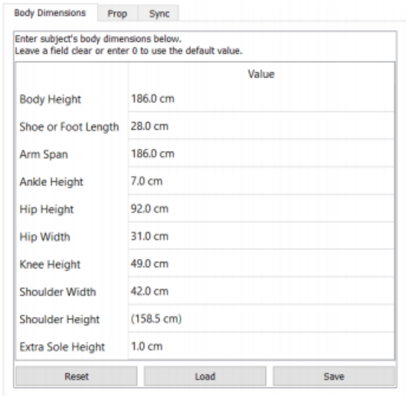

Fig. 1. Personal information window in the XSens system

Gait studies were performed using the XSens motion tracking system. The research methodology included entering personal information, anthropometric data (Fig. 1), calibration and walking 10 m in a straight line. A study was also conducted on the MBN force platform using two samples: standing as comfortable with eyes open and in the main stance with eyes closed [3].

Statistical data processing was carried out using the Statistica V.10.0. software.

III. Results and discussion

The XSens system provides opportunities for the analysis of biomechanics in subjects (Fig. 2). A large amount of data is available for analysis for each segment of the human body (Table 1).

Fig. 2. A dynamic human model in the XSens system

TABLE I. DATA IN THE XSENS SYSTEM FOR ANALYZING HUMAN BODY SEGMETS

position, m	The position vector (x, y, z) of the origin of the segment in the global reference system.
velocity, m/s	The velocity vector (x, y, z) of the origin of the segment in the global reference system.
acceleration,	The acceleration vector (x, y, z) of the origin of the segment in the global reference system.
angular velocity,	The angular velocity vector (x, y, z) of the segment in the global reference system.
angular acceleration, rad /s^2	The angular acceleration vector (x, y, z) of the origin of the segment in the global reference system.
center of mass, m	The position of the center of mass (x, y, z) in the global reference system.

When analyzing the data of angular accelerations, rotation of the pelvis segment along the X axis (Fig. 2) and the Y axis (Fig. 3) was revealed. The average angular acceleration along the X axis is 5.97 rad/s, along the Y axis is –1.09 rad/s, which indicates the movement of the pelvis back and right while walking. Such fluctuations are possibly associated with unilateral flat feet, which leads to a pelvic turn [2].

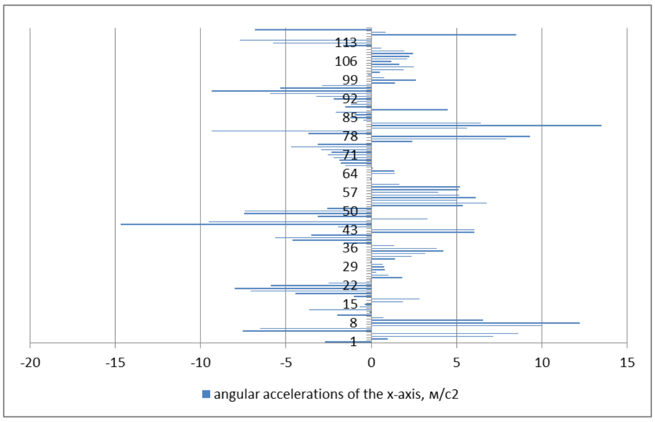

Fig. 3. Results of angular acceleration of the pelvis along the X axis

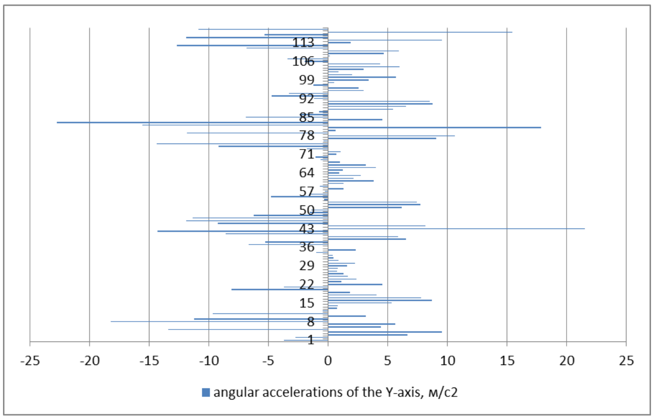

Fig. 4. Results of angular acceleration of the pelvis along the Y axis

When analyzing the positions of individual segments, an increase of an average of 0.6 mm in the segment of the left shoulder along the Z coordinate upward in relation to the right shoulder was revealed.

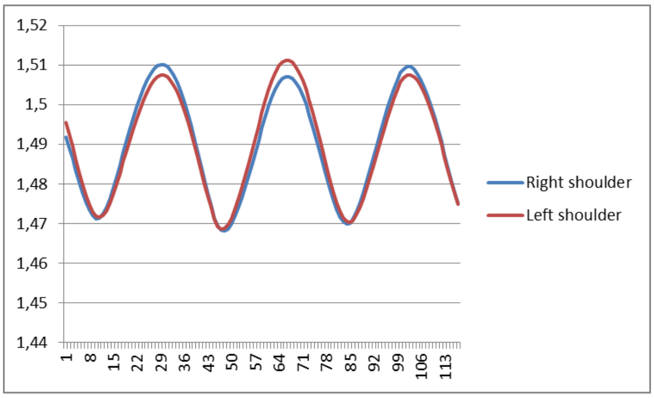

Fig. 5. Comparison of moving along the Z axis of segments of the right and left shoulder

In addition to the XSens motion trackimg system, the MBN force platform was also used. Studies were conducted in the main stance with open eyes (Fig. 6) and in the main stance with eyes closed. Table 2 shows the results of the study.

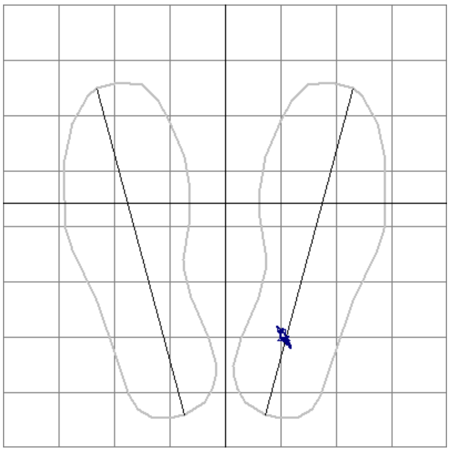

Fig. 6. Results of the stabilometric study in the main stance with open eyes

TABLE 2. RESULTS OF THE STUDY WITH THE FORCE PLATFORM

Parameter	Unit of measure ment	Main stance, eyes open	Main stance, eyes closed
RMS of the center of pressure in the frontal plane	x (mm)	10.33	21.27
RMS of the center of pressure in the sagittal plane	y (mm)	21.75	113.09
Velocity of center of pressure	**V (mm/s)**	**11.45**	**22.53**
Statokinesigram area 90	**S90 (mm2)**	**39.97**	**419.47**
Mean position of the center of pressure in the frontal plane in the European stance	Xe (mm)	53.65	60.79
Mean position of the center of pressure in the sagittal plane in the European stance	Ye (mm)	-121.31	-113.10

As a result, a deviation of the center of pressure back and to the right was revealed, which confirms the data obtained during the study of the walking kinematics. The direction of deviations of the center of pressure and the direction of angular accelerations are codirectional. Thus, we can conclude that postural balance correlates with gait deviations.

IV. CONCLUSION

As a result of studies combining the biomechanics of human walking and stabilometry, a direct relationship was found between the deviation of the center of pressure at rest and the rotation of the pelvis along the X axis and Y axis. Therefore, gait features are primarily a consequence of changes in the postural balance and can be predicted from the data obtained with the help of the force platform.

ACKNOWLEDGEMENT

The article was supported by the Government of the Russian Federation (Act 211 dd. 16.03.2013; contract No 02.A03.21.0011) as a part of the state contract of the Ministry of Education and Science of the Russian Federation (grant No 19.9733.2017/БЧ).

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