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KINEMATIC ANALYSIS OF THE LOWER LIMB DURING GAIT

Daniel GANEA, Marian Sorin TUDORAN, Elena MEREUȚĂ, Claudiu MEREUȚĂ
"Dunarea de Jos" University of Galati, Romania

Abstract
The aim of this paper is to describe the relationship between acceleration and position of the kinematic elements of lower limb model during gait. The linear kinematic analysis of the human lower limb during gait has been studied using an open source kinematic model from OpenSim.
Keywords: *gait, kinematic analysis, acceleration, position, lower limb*

1. INTRODUCTION

The human gait can be defined theoretical by an alternate sinuous movement of different kinematic elements of the locomotors system. Injuries or abnormalities of the locomotion system can cause gait asymmetry. Human gait performed by a healthy subject is nearby symmetrical with insignificant deviation [4].

The effects of this deviation can be caused by differences in gait phases, stance time and swing time [5], differences in ground reaction [1], [2] and differences in the range of motion [6], [7].

Therefore for estimating this deviation researchers have used musculoskeletal models of the human's body based on numerical data from motion captured systems [3], in order to calculate position, trajectories, velocities, accelerations, and data which are impossible to measure in vivo, such as: muscle fiber power generation and tendon force, joint loadings, elastic energy storage and return in tendons, etc.

2. METHODS

In order to conduct the kinematic analyze we have used an open source kinematic model provided by OpenSim, which represents the human lower limb. This model comprises the following kinematic elements: pelvis, femur, tibia, fibula, talus, calcaneus, and toe bone.

The inertial properties and the masses of the kinematic elements are listed in table 1. The following joints connect the elements of the bio-mechanical structure:

- The hip joint is a ball and socket joint with 3 degrees of freedom:

1. A flexion with a range of 90^0 (fig. 1.d)/extension with a range of -20^0 (fig. 1.c), in the sagittal plane (xoy);
2. An adduction with a range of 10^0 (fig. 1.b)/abduction with a range of -40^0 (fig. 1.a), in the frontal plane (yoz);
3. An internal rotation with a range of 40^0(fig. 1.f) and external rotation with a range of -40^0 (fig. 1.e), in the transversal plane (xoz);

- The knee joint is a hinge joint with 1 degree of freedom: extension (fig. 1.g)/flexion (fig. 1.h), in the sagittal plane (xoy);
- The ankle joint is modeled as a revolute joint between the tibia and the talus, and is has 1 degree of freedom: dorsi-flexion (fig. 1.i) and plantar flexion (fig. 1.j), in the sagittal plane (xoy).

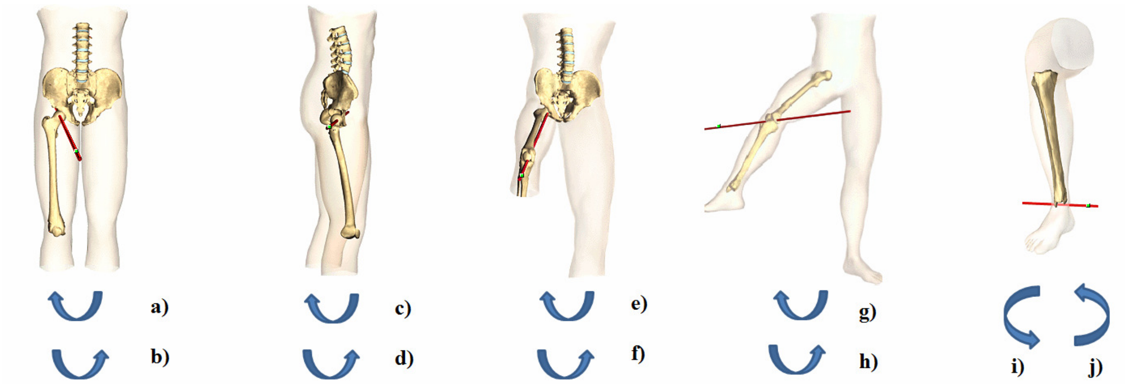

Fig. 1 Possible movements executed by the kinematic model
(a) Hip abduction; (b) Hip adduction; (c) Hip extension; (d) Hip flexion; (e) Hip external rotation; (f) Hip internal rotation; (g) Knee extension; (h) Knee flexion; (i) Ankle dorsi-flexion; (j) Ankle plantar flexion. [9];

Table 2 Inertial properties

Kinematic element	**Mass**	**Moments of inertia xx**	**yy**	**zz**
Pelvis	11.777	0.1028	0.0871	0.0579
Femur	93.014	0.1339	0.0351	0.1412
Tibia	37.075	0.0504	0.0051	0.0511
Patella	0.0862	0.00000287	0.00001311	0.00001311
Talus	0.1000	0.0010	0.0010	0.0010
Calcaneus	1.250	0.0014	0.0039	0.0041
Toe	0.2166	0.0001	0.0002	0.0010

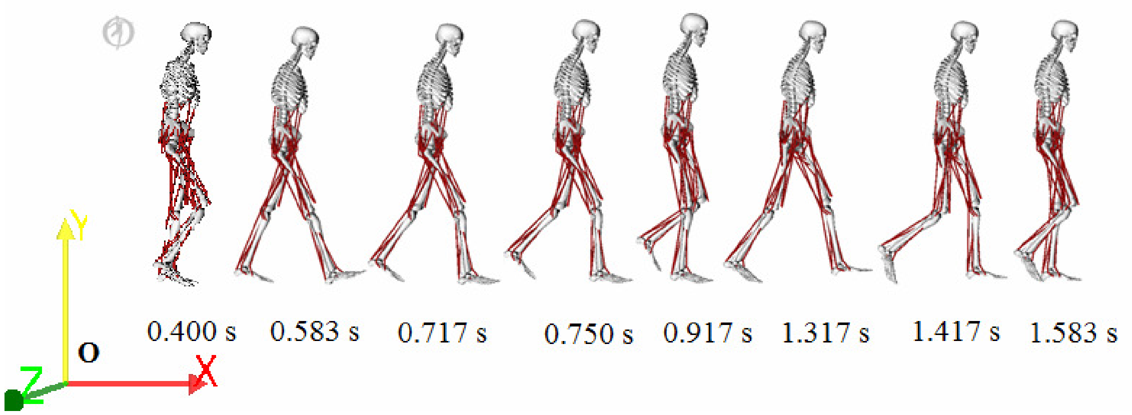

Fig. 2 Gait model phases [10]

3. RESULTS

We have focused our study on the kinematics of a model provided by OpenSim which represents the right lower limb. Therefore, we have studied the positions and accelerations of the lower limb model with respect to the global system.

The position of the right lower limb model can be described at the initial moment as follows: time 0.400 s: hip flexion= 20^0, hip adduction= -2.9^0 and hip rotation= -6.9^0; knee extension = 55^0; $=2.5^0$.

Table 2 Input positions

Time [s]	Hip flexion [°]	Hip adduction [°]	Hip rotation [°]	Knee extension [°]	Ankle [°]
0.4	20	-2.9	-6.9	55	2.5

The hip angle of flexion has reached a maximum angle of 21.115^0 at the moment 0.717 s. That increasing phase is followed by a decreasing phase of the angle of flexion which has reached a minimum value of -20.557^0 (extension) at the moment 1.317 s.

For the hip rotation and adduction the range of angles variation is smaller. Thus, the hip rotation angle rate is $\pm 2^0$ and for the hip adduction angle rate is $\pm 3.50^0$.

For the knee joint the range of angle variation is bigger than for the other joints. First we were able to notice an extension of 55^0, followed by a 2^0flexion and then a maximum angle of extension

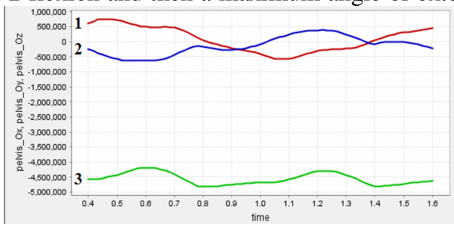

Fig. 3 Acceleration of pelvis with respect to the global system (1) Pelvis Ox; (2) Pelvis Oy; (3) Pelvis Oz

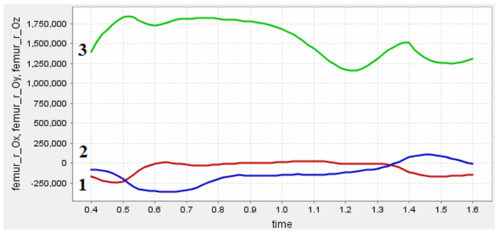

Fig. 5 Acceleration of Femur with respect to the global system (1) Femur Ox; (2) Femur Oy; (3) Femur Oz

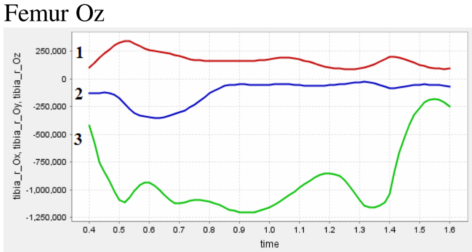

Fig. 7 Acceleration of tibia with respect to the global system (1) Tibia Ox; (2) Tibia Oy; (3) Tibia Oz

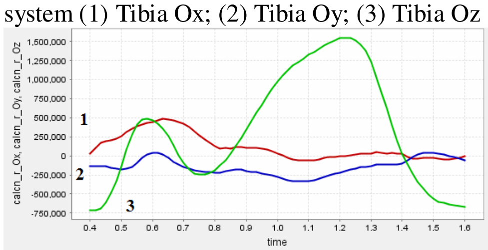

Fig. 9 Acceleration of calcaneus with respect to the global system (1) Calcaneus Ox; (2) Calcaneus Oy; (3) Calcaneus Oz

of 65.758^0. The ankle joint varies from the initial position $\pm 3^0$.

The variations of the acceleration components and position components during the cycle described above are shown in the figures from 3 to 10.

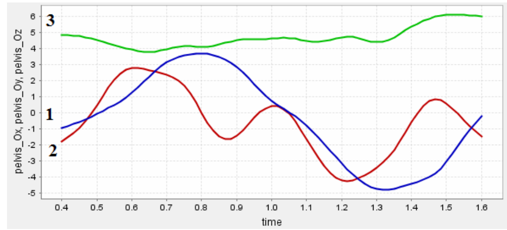

Fig. 4 Position of pelvis with respect to the global system (1) Pelvis Ox; (2) Pelvis Oy; (3) Pelvis Oz

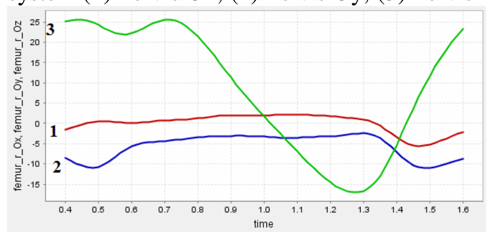

Fig. 6 Position of femur with respect to the global system (1) Femur Ox; (2) Femur Oy; (3) Femur Oz

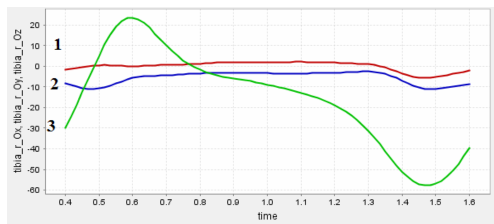

Fig. 8 Position of tibia with respect to the global system (1) Tibia Ox; (2) Tibia Oy; (3) Tibia Oz

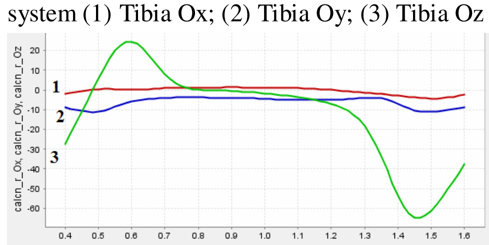

Fig. 10 Position of calcaneus with respect to the global system (1) Calcaneus Ox; (2) Calcaneus Oy; (3) Calcaneus Oz

4. CONCLUSION

Nowadays, the need to study the biomechanics of the human body, even if is in sports or daily activities, is constantly increasing because this is a condition for maintaining a healthy body. Even if the human movements are fairly symmetrical, using motion capture system and simulation programs we can study the deviations and we can act where the asymmetries exceed the normality.

The numerical and graphical results obtained from the assessment of human body kinematics can be used in rehabilitation and ergonomics.

ACKNOWLEDGMENTS

This study has been supported by the POSDRU Projects: 1.88/1.5/S/61445 EFICIENT and 107/1.5/S/76822 TOP ACADEMIC.

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METHOD FOR ASSESSING THE TRAINING OF ELITE FOOTBALL PLAYERS

Claudiu MEREUȚĂ, Elena MEREUȚĂ
"Dunarea de Jos" University of Galati

Abstract:
In order to conduct scientific sports training, it is necessary to use appropriate methods that highlight the energetic parameters. The experimental method developed by Miron Georgescu originates from the test for determining the anaerobic capacity of effort in a force - velocity maximal effort test. The paper presents the energetic parameters of the football players of the team that has lead the national championship, together with the data analysis accordingly. The paper presents the estimation of football players' physical preparation using the energetic parameters experimentally established.

Key-words*: average unit power, average flying height, repetition rate*

1. INTRODUCTION

Sports competition is the engine of sports development and also offers the opportunity to check the athletes' status of training. During the competition, the athletes prove the quality of their training, value the previous training stage, enrich their experience. The trainers must conceive such a physical preparation that takes into account the competition, as a method to reach the maximum preparation stage.

That is why, it is very important to determine the energetic parameters for the football players, at different stages of training, before the championship, at the middle at the end of the championship.

The proposed experimental study emphasizes the general energetic resources of a football player, considering that the muscle tissue has, besides motor qualities, elasticity and viscosity (Almeida, Hong, Corcos, and Gottlieb - 1995).

2. EXPERIMENTAL METHOD

The proposed experimental method is called the MGM-15 test (Mereuta & Mereuta – 2010, MGM test description) and consists of a series of 15 vertical jumps. The human performance is evaluated using a series of repeated vertical jumps, on a special carpet, connected to a computer, by measuring the time of ground contact, respectively, the flying time. The data are processed mathematically or statistically according to necessities, considering that the mean of the ground contact time (170-180 ms.) during the jump on both legs is smaller than the reaction time measured during jumping on one leg (300 ms.).

The test protocol requires 3 series of 15 vertical jumps, on both legs, on right leg and on left leg. The program removes five of vertical jumps, considering for further analysis only ten of them.

The energetic parameters involved in this experiment are: average unit power (AUP), the