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TEST FOR ASSESSING THE VERTICAL POSTURE OF ATHLETES USING THE KINECT SENSOR

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Abstract:
The paper presents a series of tests based on the Kinect sensor that provides information about the deviation of the body from the standard vertical position. The paper describes the protocol for conducting the experiment and collecting data using the Kinect sensor as well as the data acquisition software. A computer program was tailor made for data acquisition using C# as programming language. The paper presents also the new system developed for analyzing the kinematics of the human body. The result allows emphasizing the differences between the normal vertical position and the abnormalities shown by the participants in the experiment It is possible to provide an instrument to physicians, which can be used to develop diagnosis and to correct them through specific exercises.
Keywords: *Kinect sensor, vertical posture, athletes*

1. INTRODUCTION

The shape and size are perceived both directly, based on visual exploration and tactile kinesthetic, but mostly indirectly, based on experience and by reference to the standard size and shape.

Vertical jumping is a complex action characterized by harmonized coordination of the body's kinematic segments like pelvis, thighs, shanks and feet and lower limb muscle and articular systems during push-off of center of mass, then for flight and last for landing [Kazennikov 2012]. During the first phase of vertical jumping (push-off) the jumper's center of mass must have the projection into the supporting polygon formed by de the feet [Filho A.C de Pina., 2007].

The most important criteria for an efficient jump are the height of the jump that is proportional to the detachment velocity of center of mass, followed by maintaining the flight balance which is directly related to the length of kinematic elements and muscle's forces.

The task of the muscles during all vertical jump phases, besides maintaining the balance, is to accelerate the body's COG up in the vertical direction to the extended body position.

In order to analyze the vertical posture during jumps we have created a system based on a Kinect sensor [http://msdn.microsoft.com/en-us/library/jj131033.aspx]. The Kinect sensor is a depth camera that contains data related to the dimension of the surfaces of scene objects from a viewpoint.

The Kinect sensor was produced by Microsoft and PrimeSense Corporation and mainly aims the natural interaction with the subject.

Do to the easiness of interaction with the subject, because it is very affordable and is not as robust as specialized systems, this hardware is an upward trend, being used in the study of human's biomechanics [Ganea 2012] using detection of subjects without fluorescent markers [Schwarz 2012] by 3D scanning, 3D reconstruction and 3D description of trajectories [Zhang 2011].

2. METHOD

The aim of this paper is to study the deviation from vertical posture of a group of 3 athletes performing high vertical jumps. The protocol requires performing jumps under the following conditions:

- without looking at the control monitor (experiments A1, A2 and A3);
- looking at the control monitor (experiments B1, B2 and B3);
- blindfolded (experiments C1, C2 and C3).

Three types of jumps were performed:

- 3x15 jumps on both legs (experiments A1, B1 and C1);
- 3x15 jumps on right leg (experiments A2, B2 and C2);
- 3x15 jumps on left leg (experiments A3, B3 and C3).

To be reliable, the main condition of the experiment was that the group of athletes performs the set of vertical jumps, in orthostatic position. We aimed to see if the projection of the center of gravity is within the sustainable polygon formed by the feet.

Another requirement of the experiment was that vertical jumps reached their maximum height, with full hip and knee flexion. Thus, the center of gravity reached its maximum height.

To analyze the athletes' behavior with respect to time we have developed a system (Fig.1) based on a depth sensor (Fig 2). The analysis system is based on a software component, a Kinect sensor composed by an RGB camera an IR emitter and an IR receiver that forms the depth camera which aims to transform the color images (Fig.3) in depth images (Fig.4). The depth images contain information related to the distance of the surfaces of scene objects from a viewpoint (Fig.5).

Another component is the control monitor through which subjects can follow their actions.
All of the hardware mentioned above is connected to a data processing unit that contains the C# application tailor-made. The role of this application is to initialize the sensor to retrieve process and analyze the center of mass projection on the transversal plane.

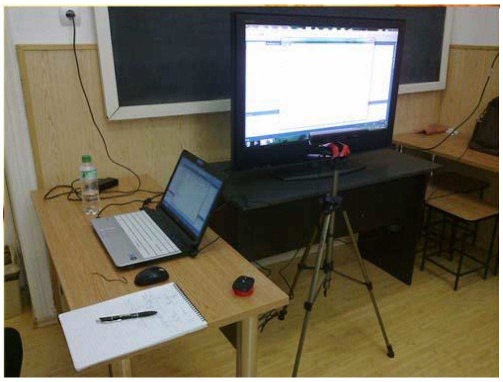

Figure 1. Analysis system

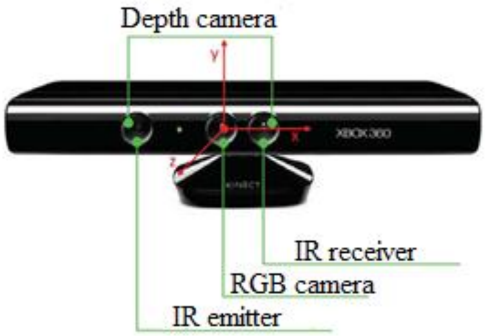

Figure 2. Kinect sensor

Figure 3. Subject 1 RGB color image

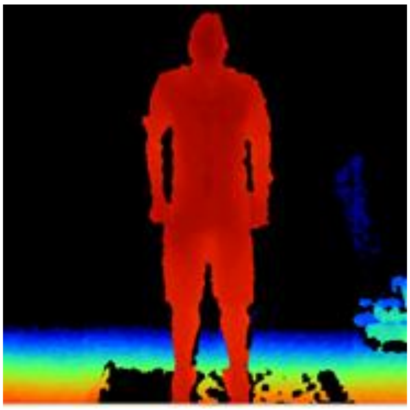

Figure 4. Subject 1 Depth image

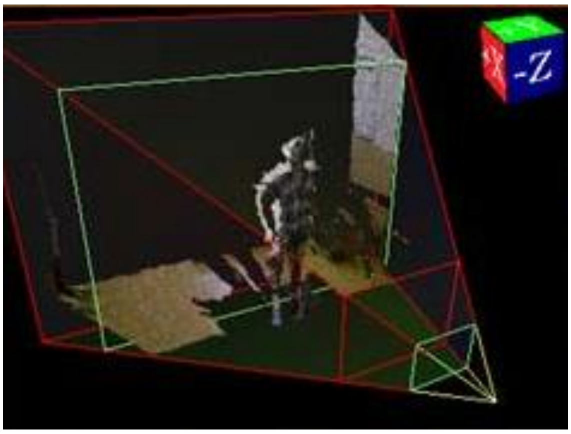

Figure 5. Subject 1 3D image

To conduct the experiment and collect the data, we have connected the Kinect sensor to a control monitor. Therefore the participants were able to see their actions in real-time.
In order to analyze the vertical posture of the athletes, we have decided to track the projection of hip central point in the transversal plane (xOy plane). This point is considered to be the human centre of gravity and a reference point in the kinematic analysis system.

All 405 jumps have been reported to an initial position that has the following coordinates on xOy plane: x: 0.0±1, y: 0.0±1.

3. RESULTS

While performing vertical jumps on both legs, on right leg and on left leg with wide open eyes, it is noticed that the projection of center of mass is mainly situated on the left side of the subject (Figs. 6, 7, 8) and the projection of center of mass describes a surface quite similar.

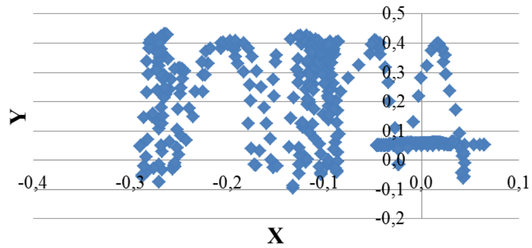

Figure 6. Projection on transversal plane of center of mass during wide open eyes vertical jumps on both legs (A1-subject 1)

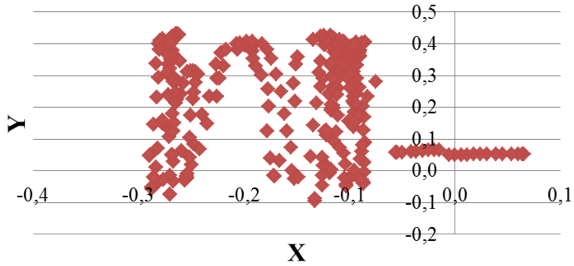

Figure 7. Projection on transversal plane of center of mass during wide open eyes vertical jumps on right leg (A2- subject 1)

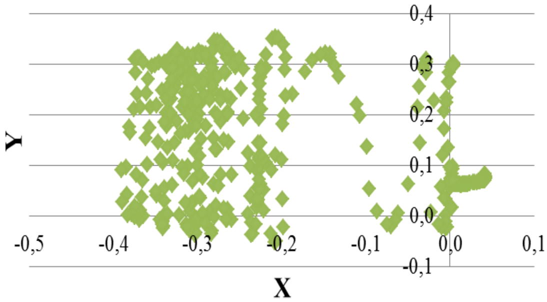

Figure 8. Projection on transversal plane of center of mass during wide open eyes vertical jumps left leg (A3 - subject 1)

During experiment B it can be observed that the projection of the centre of gravity on the transversal plane is distributed on both negative and positive domains of x axis (Figs. 9, 10, 11). This symmetry centered on a small surface is due to the fact the subject could follow his action on the control monitor. This means that the vertical posture can be reached and maintained with precision when the subject is able to follow his action.

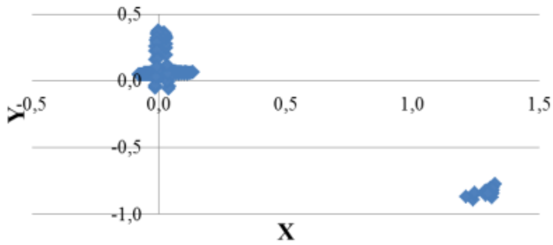

Fig.9 The projection on transversal plane of center of gravity during vertical jumps on both legs while watching the control monitor (B1 - subject 1)

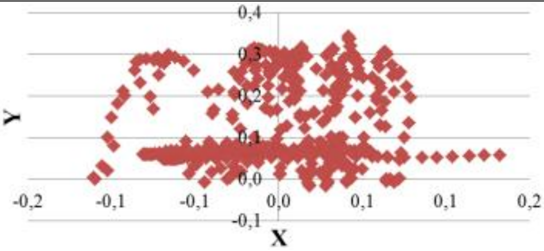

Figure 10. Projection on transversal plane of center of gravity during vertical jumps on right leg, while watching the control monitor (B2 - subject 1)

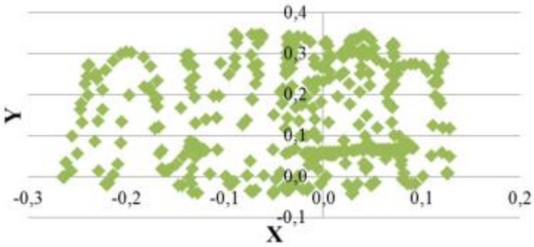

Figure 11. Projection on transversal plane of center of gravity during vertical jumps on left leg, while watching the control monitor (B3 - subject 1)

It can be observed that during experiment C, the distribution on the transversal plane of the projections of center of gravity is rather similar, but more spread relatively to experiment A. Due to the fact that the subject was blindfolded, the projection of center of gravity on the transversal plane is widespread, in both negative and positive domains of x axis and y axis (Figs. 12, 13, 14).

Experiment C has proved that due to the lack of perception of the surrounding space, the subject was not able to synchronize the lower limb dynamic system and therefore the phases of the vertical jumps.

The results revealed that the group of athletes had maintained their vertical position during vertical jumping when they were able to visualize their actions on the control monitor. In this case the deviations from the origin of the reference system are relatively symmetrical.

Thus, for vertical jumps on both legs with live view execution, a good symmetry of the center of gravity projection was observed (Figs 9, 10, 11), compared to the same jumps performed without visualizing their actions (Figs. 6, 7, 8) or blindfolded (Figs. 12, 13, 14).

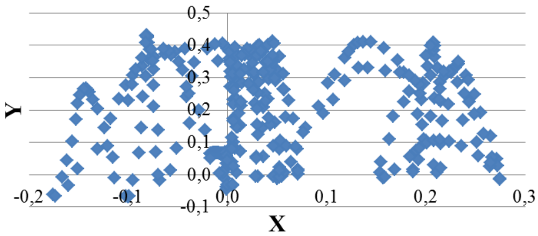

Figure 12. Projection on transversal plane of center of gravity during blindfolded vertical jumps on both legs (C1 - subject 1)

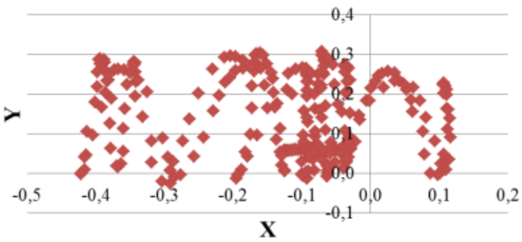

Figure 13. Projection on transversal plane of center of gravity during blindfolded vertical jumps on right leg (C2 - subject 1)

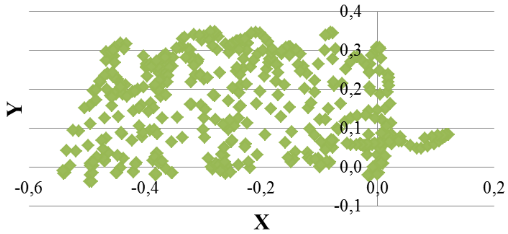

Figure 14. Projection on transversal plane of center of gravity during blindfolded vertical jumps on left leg (C3-subject 1)

Experiment B revealed that the subject was able to coordinate the lower limbs muscle activity with the visual information that led to a very good postural control, both in push-off, balance and landing phases.
The vertical jumps performed on the right leg in all 3 cases have shown that if the subject is able to follow his action on the control monitor he is able to maintain its vertical posture.
During experiment C, due to the lack space perception, the subject was not able to maintain the vertical posture during vertical jumps.
The resulting data demonstrates that maintaining the vertical posture is achieved through a complex mechanism that involves the interaction of lower limb muscle activity with vestibular, somatic and visual analyzers.
The visual perception plays a crucial role in maintaining the vertical posture as proved by the results from experiment B.

4. CONCLUSIONS

All data reveal the fact that if both legs are involved in all 3 phases of vertical jumps, the projection of the center of pressure on the transversal plane is more symmetrical.
The shift of weight on one leg leads to an asymmetrical projection of center of mass and a lower coordination. This is due to fact that the leg which maintains the weight of the body becomes responsible to the push-off and landing phase while the other leg has to maintain the balance during the flight.
The results also revealed the fact that the proposed system with a Kinect sensor was able to accurately retrieve the information from the scene.
The best vertical posture was attained when the subject performed the vertical jumps on both legs during experiment B.

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