Bulletin of the *Transilvania* University of Braşov • Vol. 9 (58) No. 2 - Special Issue - 2016
Series I: Engineering Sciences

HIGHLIGHTING THE MODIFICATIONS OF GAIT BIOMECHANICS UNDER *OCULUS RIFT* INFLUENCES

M. I. BARITZ[1]

Abstract: *Modern multimedia technology used in entertainment and recuperative medicine develops increasingly more through the multitude of equipment and applications. Frequent use and misuse, especially in the field of entertainment applications may cause vision problems, adaptability to the social environment or to different actions, especially human body biomechanics problems. On the other hand, using these devices according to proper procedures in the medical field can contribute to the recovery of malfunctions of the human body biomechanics and adaptability to the environment. In the first part of paper presents some general aspects of variants of virtual reality and multimedia systems also are mentioned several options for recording and video processing. In the second paper is presented the methodology developed in this experiment, structure of systems that includes devices, sequence of procedures and manner of storage and processing of data obtained from equipment. In the final part of the paper presents the results of analysis on two subjects, users of video entertainment systems.*

Key words: *video, biomechanics, posture, oculus rift.*

1. Introduction

Walking, jogging or competitive, simple or obstacles, climbing or descending stairs or slopes of the way, all these actions involve the entire human body muscular system with energy consumption metered in terms of age, difficulty or evaluation moment.

All these actions are carried out comfortably and naturally, often having available functional capabilities of all human sensory systems (visual, auditory, tactile, etc.). When the signals are coordinated from the sensory systems with those of the locomotor system, horizontally, vertically or on the slope movements of the human body is held in comfortable limits. When one of the sensory systems have reduced functional capacity or involved in simultaneous actions (sight, hearing) mechanical movement of the human body is exposed to environmental influences more stressed, over-stretched to unnatural movements or even diminished until the final phase of falls or injury.

Incorrect use of multimedia devices or some communications equipment when human subject is moving in mentioned conditions may alter posture, gait cycle biomechanics, static and dynamic stability,

[1] Centre "Advanced Research on Mechatronics", *Transilvania* University of Braşov.

amend, including normal perception of information from the environment. At this moment there are a number of researches dedicated to using of mobile phone (speaking, listening, reading / writing messages) during gait cycle which highlight its modified points and also recorded posts are distorted and unbalanced. Therefore excessive mobile phone use causes, in addition to thermal changes at the level of skin and circulatory system, also the nonconforming actions of statics and dynamics of the biomechanical human body.

2. Theoretical aspects

Normal gait cycle unfolds on stage support and movement, unipodal and bipodal. The transition from unipodal support to one foot to another is done balancing the human body but keeping the projection center of mass (COM) in the stability area. The trajectories of movement of projection of the center of pressure (COP) on each foot do not intersect during a gait cycle.

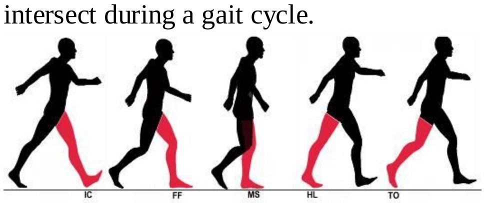


Fig.1. *Gait cycle [1]*

By analyzing the gait cycle finds that stance takes up 62% of the stride and swing takes up the remaining 38%.

As shown in paper [2] ñduring normal walking, the pelvis rotates from side to side about a vertical axis. Also, during the swing phase, medial rotation of ~5^0 at the weight-bearing hip advances the contralateral (swing phase) hip. Pelvic rotation increases the step length, and smooth trajectories arc collisions between R&L legs. Walking racers use exaggerated pelvis rotation to delay transition from walking to running at high speedsò [2]

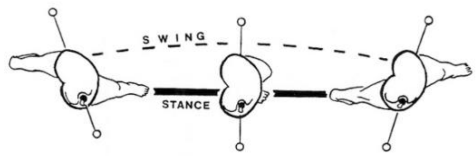


Fig.2.*Pelvic rotation [2]*

In addition body trajectory in the sagittal plane it was determined as defined by the following factors like in fig.3 that raise the low point of the trajectory:

1) pelvic rotation;

Or factors that lower the apex of the trajectory:

2) pelvic tilt;

3) knee flexion during mid-stance;

Or factors that decrease the slope of the rise:

4) plantar flexion after heel strike

Or factors that decrease the slope of the dip:

5) plantar flexion after heel-off ñ

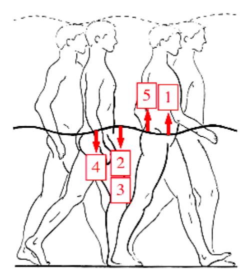


Fig.3. *Human body trajectory in sagittal plan [2]*

In terms of the determination of soil reaction force during gait cycle by movement, in paper [2] found that there are the following main phases:1) upward acceleration, 2) upward deceleration, 3) downward acceleration, 4) downward deceleration, 5) forward braking and 6) forward propulsion, like in fig.5.

For additional study of the gait cycle determining moments of inertia and using inverse dynamics is important stages.

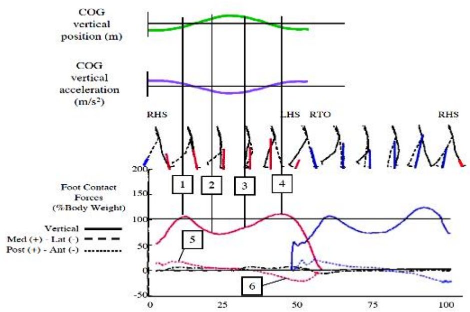


Fig.4. *Phases of the gait cycle [2]*

Thus the locomotor system, the joints and muscular system component is analyzed and simulated by these models: anatomical model, link segment model, free body diagram or free body diagram (with acceleration). [3]

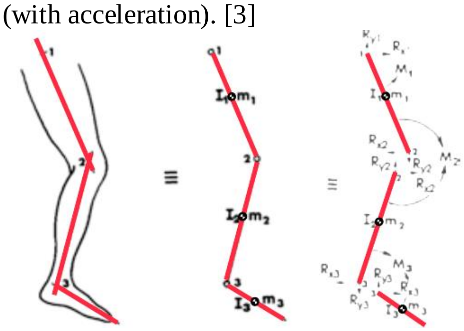


Fig.5.*Model to analyze human locomotor system [2]*

Area of stability, in quiet stance posture is strongly influenced by the size of the bipodal area support of human subject.

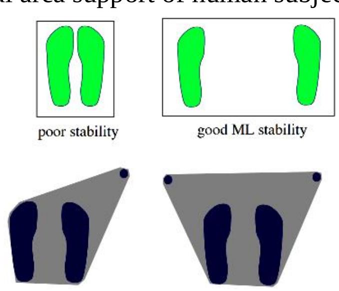


Fig.6. *Stability area with or without help*

Thus, a small area of support determine a weak stability and a normal area in both situation, quiet stance and gait cycle can provide good stability without third fulcrum (crutch or other device) (Figure 6).[4]

3. Experimental Setup

In order to relieve human gait biomechanics changes when using *oculus rift* it has developed a methodology and experimental system consists of specific procedure as shown in Figure 8.

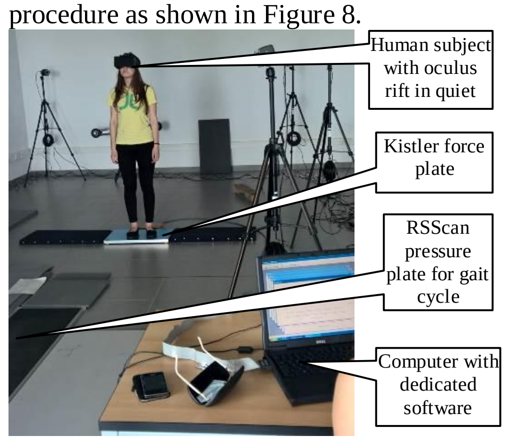


Fig.7.*Experimental setup*

Analysis procedure included a series of steps as follows:

1. Establish the environmental conditions in which proceedings are pending analysis;
2. Election of the subjectôs sample;
3. Training subjects;
4. Registration, on Kistler force plate of a bipodal posture of subjects with and without *oculus rift*;
5. Registration, on the pressure plate type RSScan of normal gait cycle performed by subjects with and without *oculus rift;*
6. Analysis of correlative areas of stability in a quiet stance and posture trajectory of the center of pressure during the gait cycle in the two cases mentioned (with and without *oculus rift*).

Analysis of the records that had occurred in regard to measuring environmental parameters (temperature, pressure, humidity) and keeping in constant values the entire period of the experiment. The action of choice of the subjects took into account the interest and preference subjects using a system like *oculus rift* therefore subject sample has the average age 21.8 years and consists of a total of four humans female with mainly educational and entertainment activities and having comparable anthropometric dimensions. [5,6]

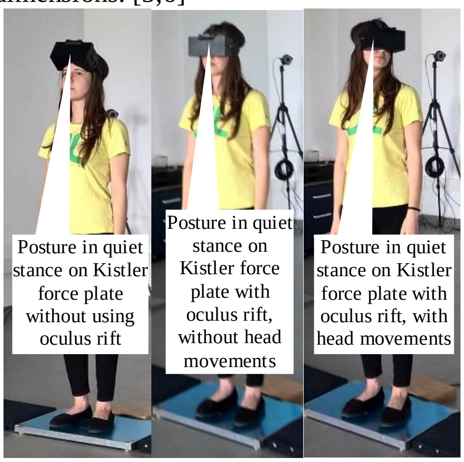


Fig.8.*Recordings on Kistler force plate*

Also training action of the subjects was conducted for knowing, understanding and active participation of the subjects to conduct proper experiments. During tests it was found that head motion tracking in action image substantially alter the dynamic behavior of the subject in two types of records. Therefore the set of records was completed with the analysis of posture and gait cycle when subjects were conducted imposed movements of the head or watched the oculus rift developed dynamic images (Figure 8 and Figure 9).

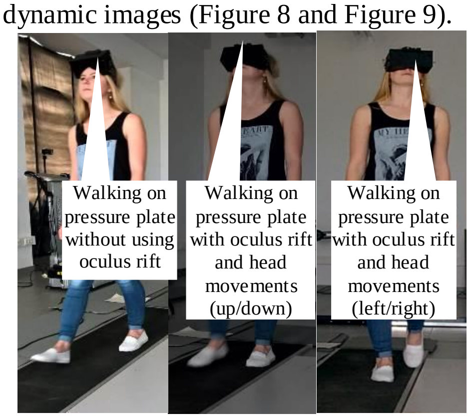


Fig.9.*Recordings on pressure plate*

Following these records were found some general aspects: in the initial phase, subjects reacted similar to posture registering on Kistler force plate, being careful to position and support base; in case of pressure plate subjects achieved a constant cycle went without deviation from the main path. In the second phase (rotating head up / down or left hand / right with *oculus rift* on eyes) subjects had hesitations and conducted jerky head movements, and if the gait cycle showed a larger number of steps on the pressure plate, those with smaller distance between them and the path was diverted, sinuous and in some cases shorter than the length of the pressure plate.

4. Results and Discussions

The results of these records are divided into two areas: stability and walk cycle (fig.10-13).

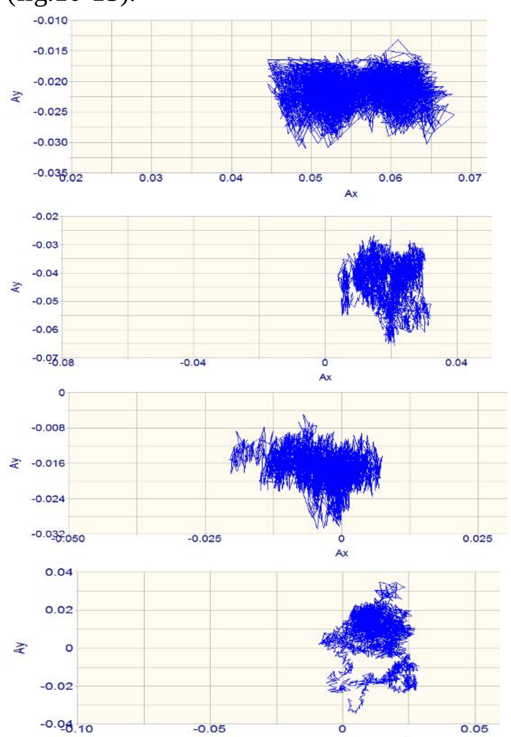


Fig.10.*Stability area for human subject no.1*

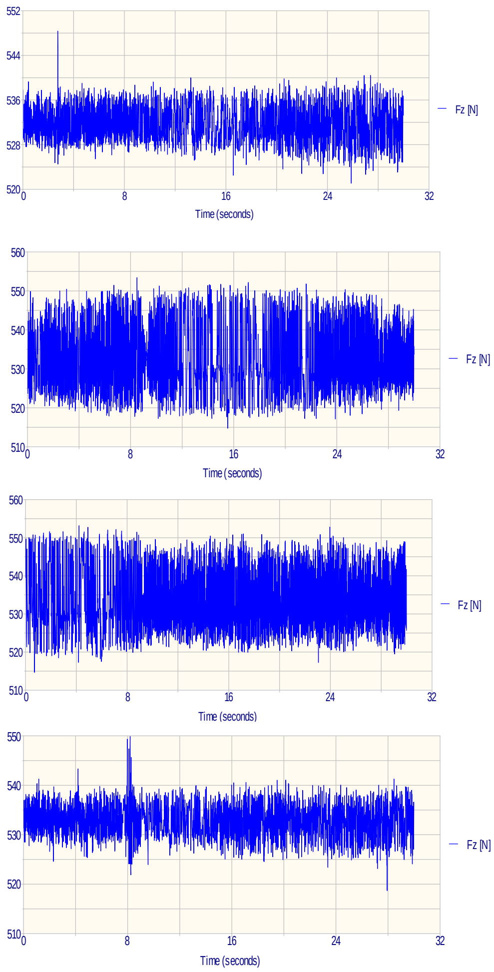
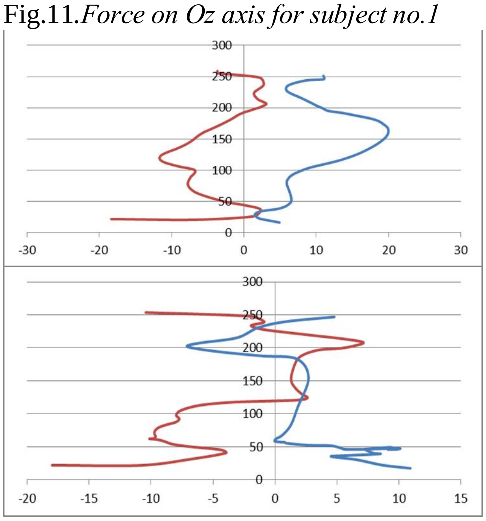


Fig.11.*Force on Oz axis for subject no.1*



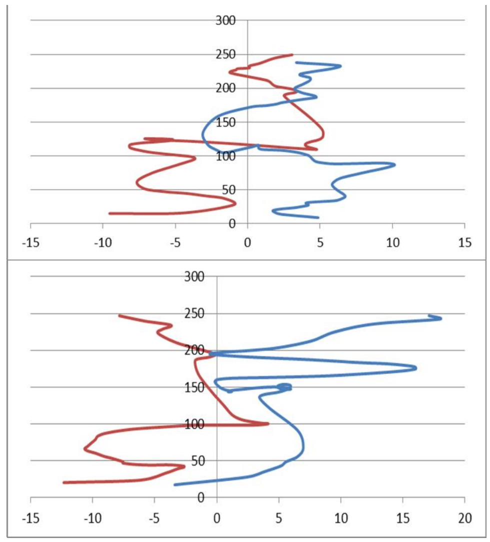


Fig.12.*Force line trajectory for subject no.1*

As shown in Fig.10 in the chart above, subject to No.1 was in steady state bipodal without *oculus rift* on eye, on the other two, with him on the eye front and doing the head up / down, left / right movements, and last chart making random movements as it shows the application on the mobile device.

Stability areas reflect the balance more and more unbalanced, with variation limits lowering from the initial state up to the most complex. This denotes a system's concentration and muscular tension in the entire human body with increased energy consumption.[7]

In Fig. 11 are represented variations on Oz axis of the force F_z from the same subject in the same situations.

These variations can identify moments when the subject performs these moves, the values of forces and also the general appearance of the behavior of the subject.

As graphics have a greater range of variation around the average value of both the subject made larger body movements.

Variations lower compared to the average value indicate the concentration and tension of the muscular system. In Fig.12

forces lines variations developed by the subject also went to No.1 in the cycle of experimentation in the same situations are shown.

Analyzing the total recordings was highlighted a similar behavior for all subjects of the sample in terms of the gait cycle, namely:

- Subjects show the separate trajectories left and right foot in the initial phase, presenting a balanced swing of gait axis.
- In case wore *oculus rift* on eyes and made successive head movements, vertical and horizontal trajectories lines centers of power were strongly deviated, intersected showing an equilibrium unbalanced and deviations of up to 30% to the axis of displacement.
- The strongest effect on postural imbalance on gait cycle was revealed in case when subjects conducted random head movements, watching dynamic motion pictures displayed on the *oculus rift* screen.

This imbalance was manifested by deviating by up to 64% compared to the axis of displacement and in one case even leaving the pressure plate.[8]

5. Conclusions

Following the development of these investigations were some important conclusions:

-young subjects without health problem, show a bipodal balance in equilibrium and steady;

-the use of electronic devices that limit the visual field cause a decline in displacement speed, a decrease of base support of bipodal posture and balance stressed, unbalanced gait cycle or stability.

The continued use of these devices for a long time can increase energy consumption for maintaining balance and cause an increase in tension in the muscular skeletal system.

Acknowledgements

In these experiments we've developed the investigations with equipment from "Advanced Mechatronic Systems Research Center - C04" and optometric laboratory at University Transylvania of Brasov with the students help from Optometric study Program.

References

1. http://www.footbionics.com, accessed Oct.2016;
2. Robinovitch S., Clinical biomechanics of gait, http://www.sfu.ca, accessed Oct.2016;
3. Braun, B., et al. *Locomotory Diseases Influence on Body Equilibrium and Balance*, Applied Mechanics and Materials Vol. 555, 2014, p.652-658;
4. Braun B., *Non contact displacement transducers implementation as stage in the development of a flexible low cost coordinate measuring machine*, Applied Mechanics and Materials, vol 772, 2015, p.312-317.
5. Barbu, D.M. *The Effects of Radiation on the Eye in Industrial Environments*, Annals of the Oradea University, Volume XIV, Issue 2, 2015; pp. 7-12;
6. Hayot, C., et al., *Biomechanical modeling of the 3D center of mass trajectory during walking,* Movement & Sport Sciences – Science & Motricite, ACAPS, EDP Sciences, 2013, DOI: 10.1051/sm/2013047;
7. Wiltz, Ch., "*The Oculus Rift – Changing Virtual Reality for Healthcare*", July 17th 2013;
8. Chiarovano, E., *Maintaining balance when looking at a virtual reality three-dimensional display of a field of moving dots or at a virtual reality scene,* Frontiers in Neurology Journal *http://journal.frontiersin.org/journal/neurology* accessed oct.2016