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Analysis of postural balancing movements in case of gait cycle in people with visual dysfunctions

M I Baritz¹

¹Product Design, Mechatronics and Environment Department, Transilvania University of Braşov, Romania

E-mail: mbaritz@unitbv.ro

Abstract. In the literature, it is often mentioned that uncorrected visual dysfunctions can influence the behaviour and motor activities of individuals, thus causing a limitation or diminution in the amplitude or frequency of their actions. The effects of visual dysfunctions of any kind may be amplified and can vary in time and in varying degrees both the posture, balance, stability and the type of gait of the patients. In this paper are presented the general aspects related to the identification of the parameters that affect the posture and the stability through the visual system dysfunctions and also the ways of compensating some of the causes that determine the postural imbalances. In the second part of the paper the experimental system and the recording methodology that emphasizes the effect of limitations in the functioning of the visual system, on the stability and the cycle of gait is presented. In this regard, a sample of 5 subjects with an average age of 25.1 years, with a visual emmetropic system, were induced a visual dysfunction related to the erroneous perception of the ambient colours and the postural equilibrium during gait cycle time. In the third part of the paper are presented the results and the conclusions obtained by applying the experimental methodology developed in this research.

1. Introduction

As shown in various papers presenting definitions and general aspects of the biomechanics of the human body in a classic way, "ideal postural alignment (viewed from the side) is defined as a straight line that passes through the: ear lobe, bodies of the cervical vertebrae, acromion, bodies of the lumbar vertebrae, slightly posterior to the hip joint, slightly anterior to the axis of the knee joint, just anterior to the lateral malleolus". [1] A correct posture is represented by the normal state of balance between the muscular and skeletal system and as such posture is a continuous action to change the ratio between the muscular effect and the positioning of the skeleton, depending on the activity of the subject. At the same time, the fatigue state installed after a period of motor activity causes a decrease in muscle stability, an excessive movement of the spine accompanied by a stress sustained in the skeletal structure or an increase in pain and pressure in the nervous system. The normal posture kept for a long time brings a number of benefits including: less muscle fatigue, better health, better functioning of internal organs, and generally a well-being and self-confidence. These manifestations are identified in human subjects both, standing and sitting or lying, the different being related to the supporting surface and to the anthropometric dimensions of the human body. If the subject's activity, also includes complex movements of the human body (movement of the arms, legs or neck / head and of course walking on different surfaces), then the musculoskeletal coordination and posture with the



sensory systems are the most important neuro-motor actions, controlled by the "central unit" - the brain. The position as sitting position but on the same place requires a more detailed analysis of the use of the upper part of the human body, predominantly of the hands, trunk or head and eyes. Therefore, the proprioceptive and vestibular sensory systems along with the visual and auditory ones will substantially influence the static and dynamic postural equilibrium level.

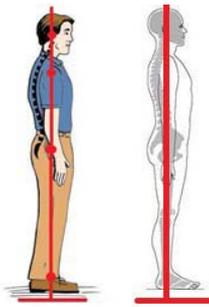


Figure 1. Standing normal posture of human body

Another important element is the working surface and the difficulties the human subject manages, since any overthrow of the anthropometric limits (forcing the worker to perform a certain manoeuvre) can lead to a change in the postural balance, the balance on the period of movement or the induction of musculoskeletal problems with pathological effects.

Various ergonomic and biomechanical researches [2,3,4] have highlighted that incorrect manipulation of objects, weights (volumes) too large, displacement of the human subject on horizontal or vertical distances with these objects can trigger the spine (the most affected by these activities), a series of pathologies requiring long recovery periods, complex methods and means of rehabilitation of dysfunctions and temporary or even permanent incapacity to work. Sometimes these common problems are also associated with visual dysfunctions, thus increasing the difficulty of action of the human subject. This is all the more important as the movements are mainly controlled and coordinated by the visual system and as such it is not only used to form images of objects but also to provide information on the visual cortex about the position and orientation of the movement of the body of the human subject. The central area of the field of vision perceived by the eyeball determines that the subject can clearly distinguish small objects with very good spatial resolution and optimal control over colour perception and contrast differences. The peripheral area of the visual field is "responsible" for identifying the direction and the sense of movement of the objects.

As shown in the literature "for gathering details from a moving object, the fovea has to perform pursuits by coordinated eye and head movements. Eye following movements are used to register floating objects in the fovea with a velocity up to 50–100°/s. If there is a higher velocity, a retinal slip is inserted resulting in saccades". [4]

Another important factor by which the postural balance in both static and dynamic position may deteriorate is identified by the age of the subjects. [5] The higher the age, the greater the likelihood of falling (to lose the postural balance) and all aspects of the resources that ensure the existence and preservation of the posture are altered (cognitive processing, biomechanical constraints, movement strategies, control of dynamics, orientation in space and sensory strategies).[6,7,8]

2. Experimental setup

To carry out the research, a methodology has been developed to analyze the effect of a chromatic visual dysfunction on posture and trajectory of the gait cycle. The experimental installation consists of a *footscan* pressure plate connected to a laptop with dedicated software for recording planting pressures along with all the gait cycle parameters (the centre of force trajectory, time, speed etc.), a set of special glasses with a filter (red and green), white light source with continuous and intermittent emission, dimensional measurement equipment for evaluating and framing the sample of subjects in anthropometric standards (Fig. 2). The sample of subjects consists of five emmetropic subjects, with an average age of 25.1 years old and no loco-motor dysfunction. They were tested on an identical procedure for all, and the evaluation of the influence of chromatic stress and luminous intensity applied to the visual system, the gait cycle and the postural behaviour of the subjects was followed. In order to have a system that only indicates the influence of visual stress, a normal ambient noise level, no vibrations or other sources of distraction, with constant environmental conditions (temperature 22°C, humidity 40%, pressure 750 mmHg) was ensuring. The subjects were informed about the stages

of the procedures and were trained to participate effectively and affectively (concentration ability) during the experiment.

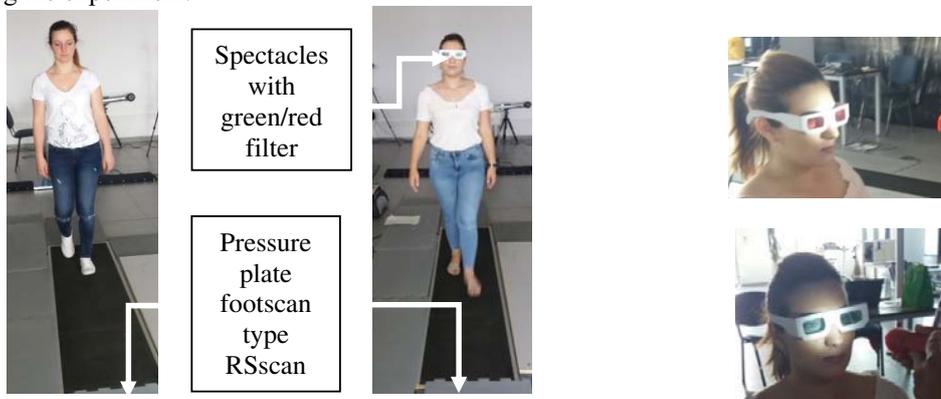


Figure 2. Experimental setup

For the evaluation process to be correlated between all the subjects of the sample, at the initial stage there were recorded the cycle of these subjects, in optimal conditions, without any visual stress or of any other nature, wearing all the same type of footwear. Monocular and binocular visual acuity was tested before starting the recordings and was ultimately compared with the visual acuity of the subjects measured while wearing coloured glasses and after inducing stress with compound



Figure 3. Visual acuity measure (monocular OS/OD and binocular) with chromatic filter spectacles

white light. Each time, it was intended to obtain visual acuity values from subjects under the same environmental conditions and immediately after induction of intermittent light.

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3. Results and conclusions

Following this test, constant visual acuity values were identified prior to recording, with all subjects having visual acuity (VA) monocular (OD-right eye, OS-left eye) and binocular 1/1 for both eyes (emmetropic subjects) and different values when using coloured filter spectacles (fig.4).

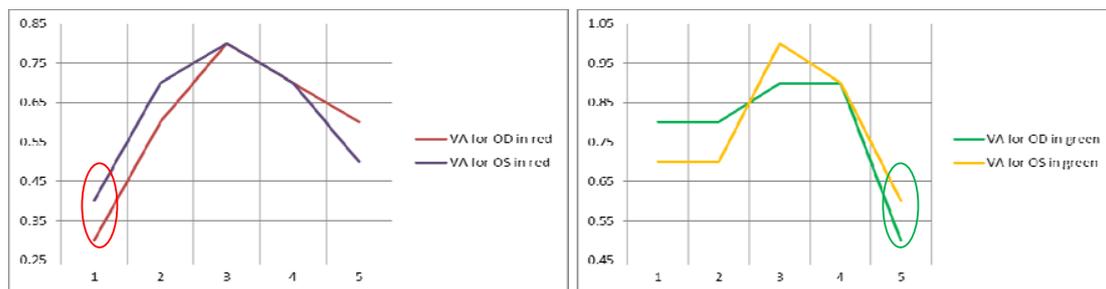


Figure 4. Monocular visual acuity in red and green filter spectacles and compound white light

Therefore, a visual diminution of the visual acuity of the subjects was induced temporarily, and there were at that moment recordings of the leg centre trajectory of the left leg force, respectively for the right foot. In Fig.5, the recordings for the subject No. 1 having the lowest visual acuity for the red filter simulation spectacles and the subject No. 5 having the smallest visual acuity for the green filter spectacles are presented.

(In Fig. 5, the black line represents the initial trajectory without the filters spectacles, and the coloured ones the trajectories corresponding to the use of the spectacles with red or green filters).

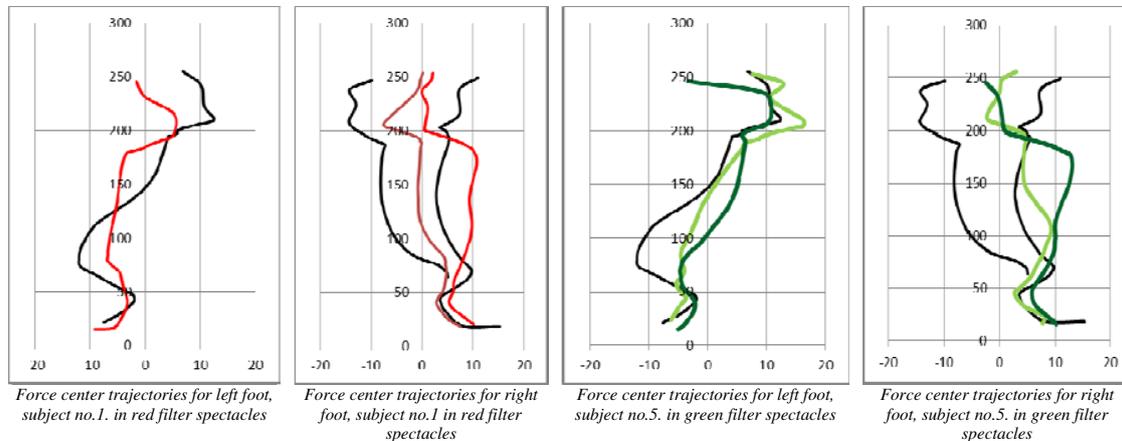


Figure 5. Force centre trajectories (mm x mm) for subject no.1/no.5 with red/green filter spectacles

From the analysis of these records (Fig. 5), there was a change for the left / right leg (in the sense of diminishing) of about **50%** of the maximum and minimum positioning points of the red filter spectacle of the original ones (black line) when it went normal and relaxed. This aspect indicates an additional contraction in the loco-motor system that causes the subject to go much tense and strained when wearing the red filter spectacles. These aspects are corroborated by the change in the level of visual acuity for both the right eye and the left eye under the same conditions. In the case of the subject No. 5 it changes the maximum and minimum limits, with the preponderance to the right foot, in percentage of about **67%** indicating a bigger imbalance on the right side of the left posture.

Due to the fact that the force centre variation traces recorded by the *RSscan pressure plate* for each left / right foot contact are analyzed as polynomial functions it is possible to use the **ARMAX** model to estimate the temporal evolution of these trajectories.

As a future research direction, we can identify the possibility of using this ARMAX model in recording situations with multiple visual stress variants to model the behaviour of subjects in relation to temporal evolution.

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