Some Contributions to the Study of the Effects of Human Motricities through Nordic Walking

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***Abstract*—The paper aimed to add new knowledge to the study of Nordic walking. For this purpose, the authors presented the results of some measurements of pulse and contrast sensitivity (CS) at the daily walking tour of several kilometers, in the Nordic walking style. The recorded results were modeled by interpolation and were displayed in the form of graphics and processed images. The profile of the optical modulation transfer (MTF) function was simulated, as a function necessary to evaluate the contrast sensitivity. To this end, the authors evaluated the influence of screen brightness and the random motion due to the effort and fatigue accumulated in the human body by traveling the walking tour. The authors took into account the fact that mobility performance can be measured by the distance traveled, by the time required to cover this distance or by walking speed and, above all, by the variation of the contrast sensitivity following the effort of moving.**

***Index Terms*—Contrast sensitivity, Nordic walking, pulse variation, simulation models.**

I. Introduction

Nordic walking is a branch of human motor skills that involves aerobic exercise, with significant pulse variations. Recent research in the field shows that Nordic walking contributes to more intense motor skills than other styles of walking, such as brisk walking or jogging [1], [2]. Thus, for example, when covering a circuit of 0.9 km, after [1] it consumes 45% more calories than when walking, the pulse increases more than when walking fast or jogging, usually varies between 70-160, depending on the speed, from 70 for a speed of 4.3 km / h to 160 for a speed of 8.5 km / h [3]. The length of the step increases when it goes with poles.

Also, the work [1] shows that the effort felt is much greater when walking with poles, which would lead to the conclusion that visual acuity decreases [4] at a normal pace (when walking with poles compared to walking without poles), the increase in heart rate was 14%, the number of calories burned was 23% higher, at average speed of 6.7 km / h without sticks and 7 km / h with walking sticks, walking is a way of medical recovery after trauma or surgery. Among other effects due to the effort is the change in visual acuity and contrast sensitivity while walking for a long time after completing the effort. Thus, in the paper [4] it is shown that, at a walk lasting 5 min. and the travel speed of 1.34 m / s (i.e. 4.8 km / h), the contrast sensitivity was reduced. However, at speeds of more than 5 minutes and at speeds of more than 4.8 km/h, muscle tension and imperceptible eyeball movements are expected to influence contrast sensitivity. In this sense, the paper [5] shows that the tiny movements of the eyeball, unnoticed, affect the visual sensitivity to contrast. The authors also mention that the JMU scientists have shown that the perception is altered during movement [6]. It is important to note that, as shown in the paper [7], proper lighting while operating with vision induces relaxation of the eye muscles and stimulates the function of the retina, increasing visual acuity; that it is an important conclusion of this research, and the present paper are trying to bring new evidences in this direction.

The main objectives of this paper are the following:

-to evaluate (by using concrete data) the influence of the cumulative effort in Nordic walking for long distances (made systematically), on cardiac ritme or pulse as sanogenetic general indicator;

-to evaluate the changes in vision quality variation during a moderate long-time effort and various light of ambient;

-to find appropriate simulation programs which can evaluate satisfactorily the changes in vision quality variation.

Because contrast sensitivity evaluates vision quality better than visual acuity, the work of the authors focuses on it. In addition, the authors introduced values measured in real time on the field, unlike other research that tested walking on treadmills or walking over very short distances.

Consequently, the authors have analyzed 2 specific indicators that evaluate the sanogenetic effect of the effort: the pulse variation and the contrast sensitivity during walking. The muscle strain (ocular and skeletal) is a consequence of cumulative effort and also an effort indicator.

The innovative ideas of the authors is that the visual contrast sensitivity is a significant and fast measurable indicator of physical effort.

The authors appreciated, also, that the results will allow a better understanding of the specifics of Nordic walking.

II. Materials and Method

A. Case Presentation

Nordic walking tests were performed by the first author over several days, through the complete and, depending on the case, partially, a winding walking tour, with a straight road, ups and downs, in several laps per day, at almost constant speed. The specificity of walking (Fig. 1) consisted of two specially designed poles to work the upper body while walking. To determine the correct length of poles before

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starting performing the walking demanded to raise one forearm until was parallel to the ground. The distance between the hand and the ground or between the elbow and the ground gave the correct length of the stick, a 90 degree angle. There are several Nordic walking techniques but the one used was "single poling" which involved using sticks in turn. When the front foot touched the ground, the opposite hand singed forward at the height of the waist, and the end of the stick in that hand touched the ground at the front heel. The sticks never exceeded the body; they were directed backwards and diagonally. It was as if the sticks mimic what feet were doing. The shoulders were relaxed. The hands were slightly open to allow the poles to swing a little bit. For Nordic Walking were used 2 telescopic, aluminium poles, label Karrimor, with adjustable straps and rubber pads at the end of the sticks. The telescopic structure allowed to adapt the length of the sticks. The surface where practiced was made of asphalt. Depending on the nature of surface (snow, tarmac, sand) the participant of experiment has the possibility to attach or not, rubber pads (paws) / rosettes at the end of the poles. On grass or trail the walker can use the inbuilt spike as an anchor to the ground.

Fig. 1. Example of Nordic walking.

B. Methodologies and Equipment Used, Walking Tour Traveled

Most research protocols are based on statistical interpretation on a large number of tested participants. The disadvantage of these protocols, according to us, is that the participant has his own metabolism and responds distinctly and differently to the same test. The authors considered that significantly more accurate results are obtained if it is based on probability theory thus, instead of N participants, the data from a single participant are monitored and processed, with the same number of N tests; the statistical deviation will be much smaller and more plausible.

The participants of experiment used: an iPhone 7 phone, with a maximum screen brightness of 705 cd /m^2, a pulse oximeter, a stopwatch, a pedometer. The iPhone 7 had the Pelli-Robson test [8] displayed on the display, as well as the "step counter and pedometer" application made by Leap Fitness Group; the application displayed, in addition to the walking tour outline, the number of steps, the number of kilometers traveled and the duration of the walking tour. Regarding the Pelli-Robson *test, it consisted of a drawing with groups of black letter, with* decreasing contrast, whose values are indicated in Fig. 2. The numbers indicate the value of the sensitivity to contrast, expressed in units of decimal logarithm. Thus, for example, the group of letters CKR in Fig. 2 visualized in extremes indicates a contrast sensitivity expressed in units of decimal logarithm of 0.30, which is equivalent to contrast sensitivity expressed as a percentage of 2%.

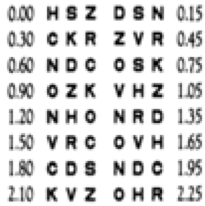
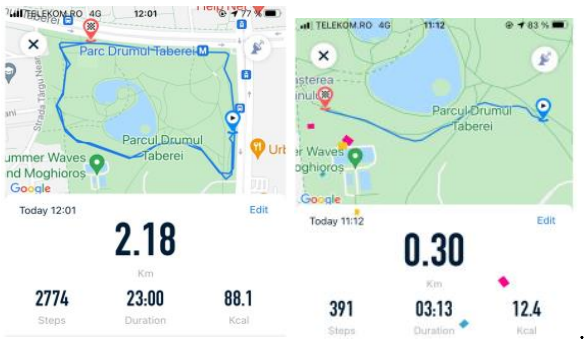


Fig. 2. Example of a Pelli-Robson test board and related contrast sensitivity

It is also stated that other current research [9]-[11] affirms that an image with the Pelli-Robson test sheet can also be used on a tablet or smartphone. It should be noted that, in the Pelli-Robson test used in optical tests in ophthalmology medical offices, the brightness on the board is 64… 85 cd / m^2, and the spatial frequencies are 3, 6, 12.15 cycles / degree [10] or, if these frequencies are expressed in cy/mrad, it results a variation of these frequencies in the range 1… 2 cy / mrad.

III. Results and Discussion

In this paper, the data and image modeling and simulation software were used: an image simulation and analysis software for MTF evaluation (MTF modulation transfer function [12]), a data processing software Origin 6.0 [13], respectively image analysis software ImageJ [14]. The analyzed data were obtained from the main author, who recorded the specificity of Nordic walking for several days, on a walking tour (Fig. 3 and 4) repeated in 2 tours during the same day. It is stated that the same walking tour was repeated to evaluate and influence the cumulative effort. The walking tour is shown in Fig. 3, longer walking tour (3a) and shorter walking tour (3b). The walking tour allowed obtaining good speeds when walking, without obstacles (Fig. 4). The recorder results, modeled by interpolation are displayed in Figs. 5-13.



a) b)

Fig. 3. The long walking tour (a) and the short walking tour (b) made in several tours

Fig. 4. Image taken on Google Earth from the walking tour.

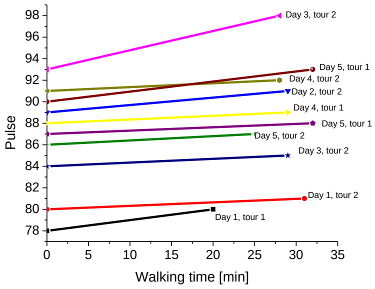


Fig. 5. The variation of the pulse during walking time.

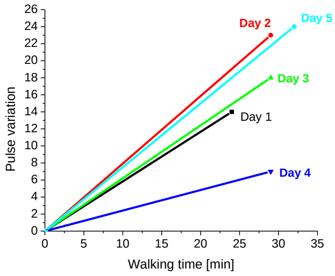


Fig. 6. The variation of the pulse on different days, at the average walking speed of 5.5 km/h.

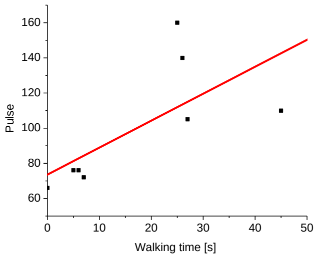


Fig. 7. The pulse variation at moderate exertion fitted by using data from the paper [15].

It can be seen that regular daily walking increases the effort performance and moderates the variation of the pulse, as shown in the paper [16], too.

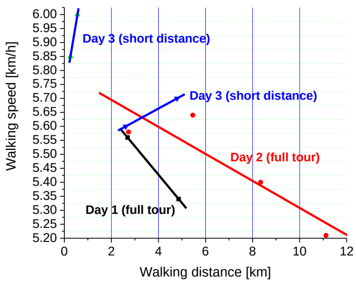


Fig. 8. The variation of walking speed over a period of 3 days

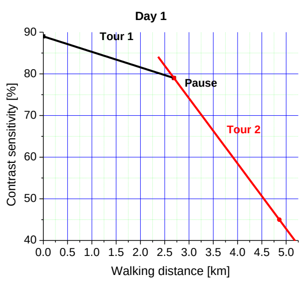


Fig. 9. The variation of contrast sensitivity during two consecutive tours on the first day of walking

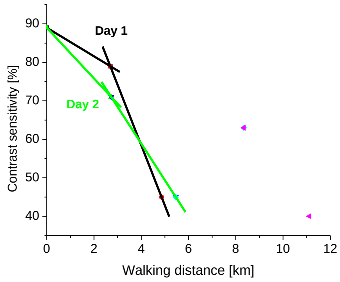


Fig. 10. The variation of contrast sensitivity on 2 days.

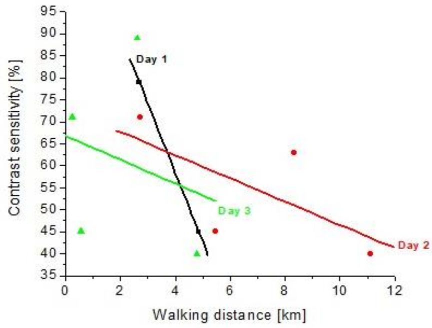


Fig. 11. The variation of the contrast sensitivity during 3 days, depending on the distance traveled daily. It is noticeable how the walking effort speaks for itself.

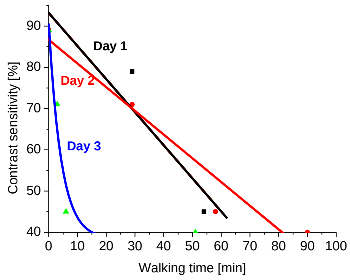


Fig. 12. The time variation of contrast sensitivity [%] over o period of 3 days

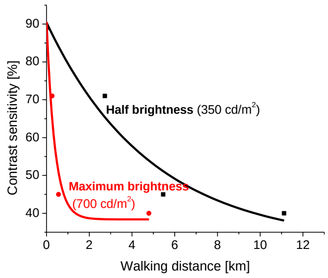


Fig. 13. The variation of contrast sensitivity [%] depending on distance traveled for two distinct brightnesses of the iPhone 7 screen

The influence of ambient lighting on a classic Pelli-Robson test can be similar to the variation of the screen brightness of the iPhone 7. So, it can be seen from the histograms in Fig.14 that the gray level at maximum brightness is much lower than at medium brightness, which leads to a lower contrast, as evidenced by the field contrast sensitivity test.

From Fig. 13 and Fig. 14 it can see that the contrast sensitivity at 350 cd/m^2 is much higher than the the contrast sensitivity at 700 cd/m^2 .

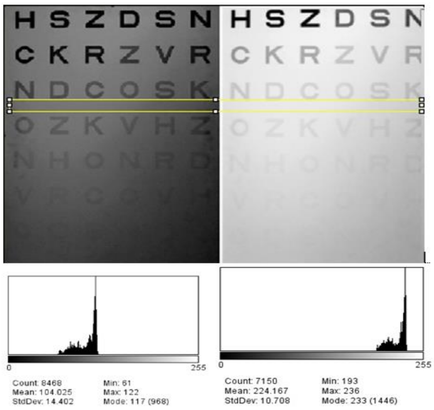


Fig. 14. The Pelli-Robson test and the histograms corresponding to the average brightness (left), respectively the maximum (right) of the screen on the iPhone7 (350 cd / m^2 and, respectively 700 cd / m^2)

IV. Simulation of the Influence of the Walking Effort on Contrast Sensitivity

From Fig. 9-11 it could be seen that the contrast sensitivity (CS) is substantial influenced by the effort made during the walking. The inherent tremor and the fatigue of the eye muscles contribute to this, so the contrast sensitivity test is also an indicator of walking fatigue. It is well known that the visual acuity (and contrast sensitivity, too) is influenced by physical fatigue (due to cumulative effort during walking) and by environmental factors [17]. Eye strain can be simulated by determining the influence of random movement in the MAVIISS 1.5 program. The figures bellow show such a simulation, with a priori selected values of 32 μm. In this simulation the authors considered the the following working hypothesis: the eye can be compared with a camera, made of a lens (corresponding to the natural human lens) and detection matrix (represented by the retinal photoreceptors). In this hypothesis, MAVIISS 1.5 program allows simulation of the modulation transfer function (MTF) related to visual acuity and lens parameters, detection matrix and medium between the lens and the detection matrix (aqueous humor) and the retina. The authors considered the following data: focal length of the lens =18 mm from the retina, maximum eye resolution [mrad] = 0.3 mrad, retinal diameter = 22 mm (the authors analyzed a small retinal area, 1 mm in diameter) corresponding to the possibilities of MAVIISS 1.5 program, 512 photoreceptor cells analyzed in the fovea; it is known that the number of detection elements (photoreceptor cells) = 125 mil.

Subsequent research expected by the authors will establish the limits of variation on different tours and specifically Nordic walking.It is specified that the contrast sensitivity can be evaluated from the MTF curve (the modulation transfer function), based on the relation [18]:

$$\mathrm{CS}(f) = \mathrm{RTF} \cdot \mathrm{MTF} \quad (1)$$

where RTF is retinal test function and f the frequency or, based on the relation described in the paper [19], the relation (1) can be written as follows:

$$\mathrm{MTF}(f) = \frac{C(f)}{C(0)} \cdot 100\% \quad (2)$$

where *C (f)* is the contrast corresponding to the frequency f [cycles/mrad], and C (0 is the contrast corresponding to the frequency f=0.

So that, taking into account the paper [20], can be written:

$$\mathrm{CS}(f) = const \cdot \mathrm{MTF} \quad (3)$$

and more, taking account the fig.13, it can be written: $\frac{CS90-CS40}{CS90} = \frac{MTF90-MTF40}{MTF90} = \frac{90-40}{90} \approx 0{,}5$, value similar to the ratio between maximum and minimum contrasts sensitivities as seen from fig.12. Graphically, it can be seen, in fig.15, this difference from the MTF simulation with the program MAVISS 1.5.

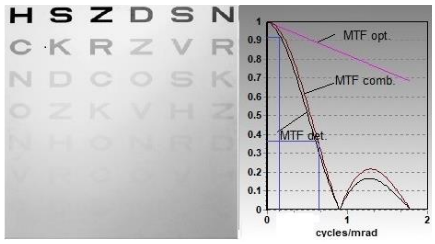


Fig. 15. MTF simulated at maximum brightness of the iPhone 7 during off-road tours.

Regarding the Fig. 15, it is specified that the value of MTF=MTF $_{comb}$ is given by the product between MTF_{opt} and MTF_{det}, in which the abbreviations opt. and det. refer, respectively, to the vision simulation of the optical and, respectively of detectors systems.

To assess the influence of fatigue during walking, the authors simulated (with MAVIISS 1.5), the MTF variation between extremely similar values of CS presented in fig.12, Day 3.

The results are shown graphically in the Fig.16.

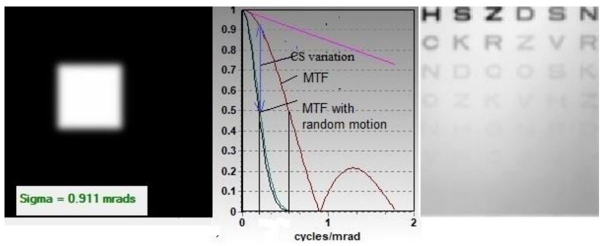


Fig. 16. The influence of random motion in walking on MTF when simulating a random motion sigma 0.911 mrad for a square scene and for the Pelli-Robson test, too.

The random motion is expressed from the relation [11]:

$$\boldsymbol{MTF_{Random} = e^{-2(\pi\sigma f)^2}} \quad (4)$$

where σ (sigma) indicates the amplitude of the random motion and can simulate the small eye movements.

V. Conclusions

1. Due to the complexity of the movements in the Nordic walking performed systematically, the speed of movement is almost constant, and the length of the step is long, which leads to much lower pulse peaks compared to the typical average effort.

2. The contrast sensitivity is, really, a significant indicator of cumulative physical effort, is predictable, and can be assessed by appropriate calculation programs, as MAVIISS 1.5.

3. The results showed a strong correlation between the contrast sensitivity, the effort during walking, and the ambient light.

4. The quality of vision can be improved in the effort made while walking by using glasses that reduce the degree of ambient light.

5. It is important that this research continues with new experiments.

Conflict of Interest

The authors declare no conflict of interest.

Author Contributions

The contributions of each author are as followings: Steluţa Sârbu (as an effective participant) collected measurements for Nordic walking, chapter I-III and collaborated in the final writing. Cătălin Spulber performed the simulations in Chapter IV and contributed to the final writing. All authors had approved the final version.

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