Monitoring the Effects of a Postural Re-education Program Through Biofeedback

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Abstract
Background. The use of the Global Postural System GPS 600 device to optimize the posture of athletes has been the subject of our research since 2019. **Aim.** Through this study we want to investigate the preservation over time, namely at 6 months, of the effects obtained through the postural re-education program with the help of biofeedback. **Subjects.** The study included 12 athletes between the ages of 15 and 28 that practice contact sports. **Methods.** The methods used were posturography, made using the GPS 600 system, the statistical method, the screening method. The analysed parameters were the head position, the centre of gravity position, the weight loading on both legs and the orientation of the transverse axis of the trunk. **Results.** The results of this study indicate that the measured variables maintained the values recorded immediately after the program for six months after the completion of the program. **Conclusion**. The improvements of posture obtained with a biofeedback re-education training with the GPS 600 device are maintained at least for six months after the programme.

Keywords: *biofeedback, athletes, posture, program.*

1. Introduction

Postural balance is considered a related parameter of gross motor performance. It is acquired in early childhood and perfected by adolescence, but it can also be influenced by various conditions. A simplified clinical

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assessment of balance and posture could be useful in monitoring motor development or therapy (Heidt 2021).

Postural control or balance can be defined statically as the ability to maintain a base of support with minimal movement and dynamically as the ability to perform a task while maintaining a stable posture. Factors influencing balance include sensory information obtained from the somatosensory, visual, and vestibular systems and motor responses that affect coordination, joint range of motion and strength. Superior balance is the result of training experiences that influence a person's ability to attend to relevant proprioceptive and visual cues (Bressel 2007).

Postural control involves an organized network of interacting systems. Muscle activity is controlled by the central nervous system to maintain balance by integrating inputs from the musculoskeletal, visual, and vestibular systems. Proprioception, which comes from muscles and skin receptors, provide information about the body's position in the environment, as well as the relative position of body segments. The visual system provides information about the external environment. Cerebellar control provides feedback-feedforward control of muscle activation. Finally, the vestibular system generates information, using specialized organs located in the inner ear, which allow tracking of angular acceleration based on the semicircular canals and linear acceleration based on the sac and utricle. Redundancy of related information from the musculoskeletal and vestibular and visual systems is essential to allow the central nervous system to generate correct responses when these systems receive conflicting stimuli (MariaRubega 2021).

A balanced posture allows sports movements to be carried out with optimal energy consumption and minimal strain on the musculoskeletal system. The existence of a dysfunction in the musculoskeletal system leads to compensations that require high energy consumption and, over time, can cause damage and wear. Overall, the movements performed by the athlete do not reflect the existence of these offsets and a thorough investigation with advanced technological means is required.

With the technology offered by the posturograph, deviations of the center of gravity can be identified as well as weight support points, load level, weight distribution in the soles, posture anteriorized, posteriorized or compressed, and body asymmetries. Possible compensations or decompensations can be identified in the biomechanical context. (Chelaru, Buldus & Monea 2021).

Postural rebalancing training is a highly effective means of improving balance performance with moderate to large effects on static and dynamic balance in healthy young adults, regardless of age, gender, training status, setting, and test method (Gebel, et al. 2018).

Postural control is essential when carrying out everyday activities or sport and its possible disturbances have a very significant impact on personal autonomy and sport performance (Juande la Torre 2017).

The interaction of the various senses of orientation that contribute to postural control is not well understood. Therefore, Maurer performed experiments in which measured the postural responses of normal subjects and patients with vestibular loss during perturbation of their position. The results suggested that in the sway condition, normal subjects altered their postural strategy by heavily weighting the feedback from the plantar somatosensory force sensors. (Maurer 2003).

The goal of balance is to maintain control of the center of gravity, visual feedback helps improve overall balance control (Lakhani 2015).

Hamaoui (2014) found that increased muscle tension along the trunk induces a more disturbing effect on posture when it is asymmetrical. Maintaining balance requires the integration of vestibular, proprioceptive, and visual information and the translation of this input into appropriate motor responses. Postural stability depends not only on subjects being tested with their eyes open or closed, but also on the presence or absence of visual feedback. Since postural stability is regulated by multiple senses, such as the vestibular system and proprioception, auditory stimuli may play an increasing role if one of the systems involved is impaired (Palm et al. 2009)

Visual biofeedback has the potential to enhance balance training in both seated and bipedal positions. Body sway depends on the type of feedback. The results of different types of feedback conditions help us understand how the brain interprets visual biofeedback. Frequency domain analyzes demonstrated that direct and inverted visual feedback reduced swing amplitude at lower frequencies (Goodworth 2020).

The control of postural influence is based on the evaluation and integration of external sensory stimuli by the central nervous system. Visual biofeedback has become a popular method of improving balance due to supplementing natural visual information with visual cues of the center of pressure. It is also possible to further improve balance by increasing visual biofeedback signals (Chamberlin et al 2021)

2. Aim

The purpose of the study is to monitor the preservation of postural balance acquired through biofeedback treatment using the GPS 600 device accompanied by a physical therapy program.

3. Study design

The study involved 12 subjects, athletes between the ages of 15 and 28. The subjects have an average age of 21 years, are contact sports practitioners, and participate in training at least 3/week. Former research we developed in 2019 studied the influence of a physical therapy program and postural biofeedback training on athletes' postural control. This second phase of the research is a follow up study to monitor the persistence of the postural control improvements after six months.

4. Materials and Methods

The Posturograph or Global Postural System (GPS) is an advanced postural analysis system that uses noninvasively diagnostic and evaluation techniques and methods in the field of medical recovery.

The posturograph includes 2 diagnostic units and a software:

- Podoscope - is used in the analysis of static foot disorders and the position of the centre of gravity; with his help are processed the captured images, determining the exact length of each leg, the existence of static plantar disorders (flat foot, hollow, etc.), as well as possible deviations at the ankle level.

- The unit of postural analysis - is used to determine the deficiencies in the spine, through a system of video cameras that allow the acquisition of high-resolution images, images that are then processed through the software, to analyse all segmental or global deviations of the body.

Postural analysis is performed from the front, back and profile and can diagnose the deficiencies of the spine in the sagittal or frontal plane (scoliosis, kyphosis, hyperlordosis).

The software allows the storage of the patient's medical data, both of those resulting from the posturographic tests, as well as those related to the medical history or the medical treatments that the patient follows. It is useful for monitoring the evolution of patients and the effectiveness of the recommended therapies.

Based on the data obtained from a complete posturography, customized kinetotherapy and medical recovery programs are developed.

We used the following methods:

- the method of bibliographic study - the study of the specialized literature to update the theoretical basis
- observation method - intentional tracking, accurate and systematic recording of manifestations and situational context for each subject
- measurement method - the evaluation of the subjects using the posturograph provides somatometric and functional data
- experimental method - application of the program proposed by the working methodology
- statistical method - data processing and interpretation using SPSS program, descriptive statistical analysis.

The intervention protocols are:

- Postural re-education through visual biofeedback with the GPS 600 device

The subject is positioned on the podoscope in the center of the crystal with bare soles, the screen of the device is positioned in front of the subject so that it has approximately at eye level the parameters that must be followed.

The device shows in real time the movements of the center of gravity in 3 main points (2 points in the middle of the soles and a central point, located in the middle of the two points in the sole). This center point is the point to show us the direction and trajectory of the center of gravity movement.

The first scan is performed, the subject must be still, eyes open, looking straight ahead. The device shows us the movements/oscillations of the center of gravity in real time and the ideal position of the center of gravity. The 3 key points that indicate the ideal position of the center of gravity are marked on the monitor with 3 white dots (the dots are made of white paper, and they are glued to the screen).

The center of gravity ideal position and the postural corrections he must perform are explained to the subject. Postural corrections are performed by very fine movements of the whole body without moving the feet on the podoscope. The purpose of the movements is to position the center of gravity line in the marked position as the ideal one, once the subject has managed to position the center of gravity in the ideal position, they must maintain that position until the 20 seconds are up.

These postural corrections are performed 10 times per session, each session lasts 20 seconds. The sessions were conducted over 2 weeks for 10 days.

- Physical therapy program

After the specific warm-up, a set of 3 fundamental exercises was chosen to be performed in an individual circuit for 30 seconds each, 2 times.

Climbing the balance cushion by stepping and isometrics:

From orthostatism at floor level, the athlete will step on the balance cushion with the non-dominant leg, followed by a slight flexion from hip, knee and dorsiflexion (triple flexion); position to be maintained for 5 seconds. Repeat with the dominant leg. The descent is done backwards, in the reverse order of climbing the balance cushion (the first leg to descend is the dominant one, followed by the non-dominant one). The athlete will perform as many correct repetitions as possible in the given time interval of 30 seconds.

Support on one leg on the balance cushion:

From orthostatism on the balance cushion, perform flexion from the hip and knee of one leg, so that the support is realized by the contralateral limb. The flexed limb can be abducted to help maintain balance throughout execution.

If the athlete falls from the pillow, he should reposition himself and continue to maintain the position for the rest of the time.

Keeping balance on the wobble board:

From orthostatism on the wobble board, maintaining balance for 30 seconds.

5. Results

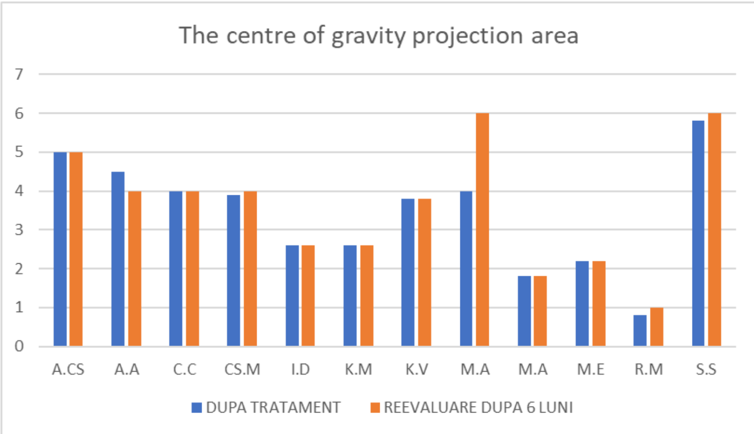

Figure 1. The centre of gravity area projection

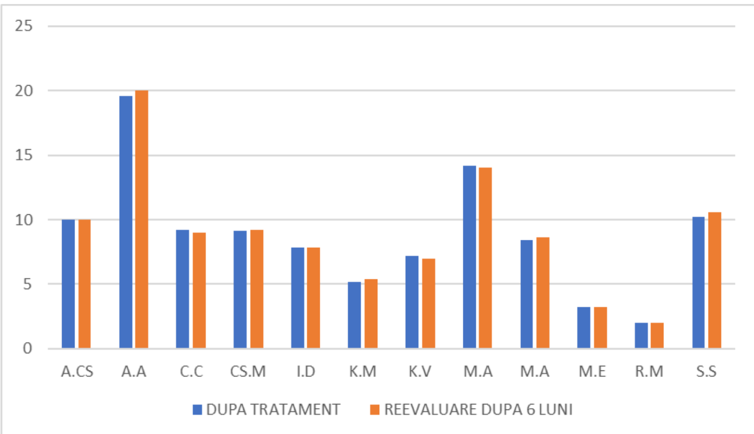

Figure 2. The head anterior posture comparison

The comparative analysis of the results of center of gravity area projection after the intervention and six months after are shown in Figure 1

The head anterior posture comparative analysis is shown in figure no.2

As shown in figure 1, out of 12 subjects, 7 preserved the posture obtained 6 months ago after the postural re-education program, 3 subjects had a minimal, insignificant change and for 1 subject the changes were 0.5 cm. Only one of the subjects presented a greater change of 2 cm.

In figure 2 is shown that out of 12 subjects, 4 mentioned their posture obtained 6 months ago after the postural re-education program, 6 subjects had a minimal, insignificant change and for 2 subjects the changes were 0.4 cm.

The gravity loading on the left foot comparative analysis is shown in figure no.3.

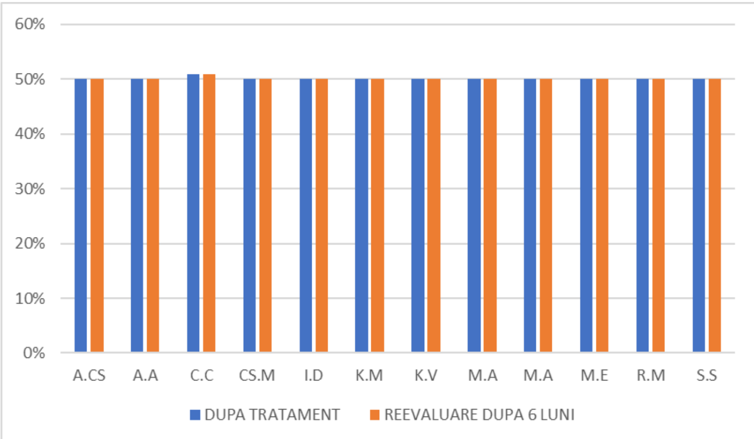

Figure 3. The gravity loading on the left foot

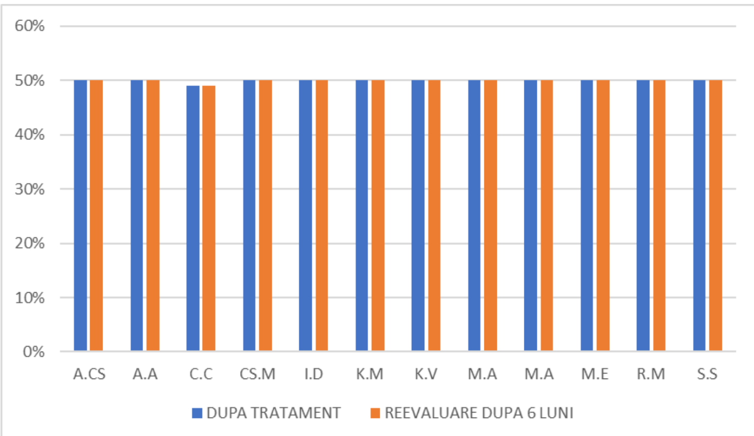

Figure 4. The gravity loading on the right foot

The gravity loading on the right foot comparative analysis is shown in figure no.4.

For all subjects, the weight distribution on the two hemi parts of the body was maintained at the values obtained after the postural re-education program.

The results show that the new posture acquired following the complex treatment of postural re-education through visual biofeedback and a physical therapy program was preserved. We note that at the re-evaluation carried out 6 months after the end of the postural re-education intervention program the results were maintained. It should be noted, however, that all subjects in the study are performance athletes who continued their training at a normal pace.

6. Conclusions

The postural reeducation protocol we used, proved to be a treatment that maintains its effects even 6 months after the intervention. The improved posture was memorized in the muscle fibers and movement memory.

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