Protocols of Virtual Rehabilitation for Women in Post-Operative Breast Cancer Stage

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***Abstract*—Women who have had breast cancer and mastectomy and axillary dissection surgery, may present some consequences that hinder the performance of daily life activities, in addition to reducing self-esteem and affect other psychological issues. Combining virtual reality and natural interface, a serious game has been developed for rehabilitation of patients with breast cancer in post-operative stage, with the aim to improve motor and cognitive abilities. The game has been designed to be an interactive and motivating tool for the treatment and prevention of complications of this surgery. The interaction between user and game is done dynamically through infrared motion capture device, to enable the exercises without requiring devices on the hands or body. The application is on trial, with a group of patients who had mastectomy, to validate the use of the game, to compare the improvements and their efficiency.**

Keywords—component; formatting; style; styling; insert (key words)

I. INTRODUCTION

Postoperative therapeutic approaches for breast cancer are quite complex, possibly generating common disabilities and functional limitations, such as restriction of shoulder movement, pain, fatigue, lymphedema and depression, making it difficult to perform daily activities and worsening the quality of life [1].

Technological advances that combine robotics systems and computer graphics have been gaining space in entertainment and health. In this context, studies show that Virtual Reality (VR) has many therapeutic functions that allow patients to perform movements similar to those practiced in the physiotherapy sessions. In addition to encouraging and providing a motivating environment [2][3][4], the use of this technology reduces pain threshold and improves patients' levels of daily physical activity [5][6][7].

Virtual Reality is an advanced computer interface that allows to create rehabilitation protocols, in which the individual interacts in real time with a computer-simulated three-dimensional environment [5][8], while natural user interface enables control of this environment without the use of standards devices (mouse and keyboard) [9].

Thus, integrating the two technologies to create an interactive and motivating tool, it has been proposed its use for rehabilitation of women after making mastectomy surgery due to breast cancer. Its main objective is to improve the functionality of the motor and cognitive skills and provide a unique experience with the patient's active participation in daily activities. Therefore, the aim of the case study is to validate the software and enable use with larger group of patients to enlarge the results.

II. INFRARED-BASED MOTION CAPTURE DEVICE

Virtual Reality allows user to observe and naturally interact with a virtual environment of his interest. Systems that use Natural User Interface seek devices and metaphors to make control and navigation more natural, that is, with as less artificial devices as possible. Some ways of natural interaction are gestures and voice recognition to use the system.

Based on these principles, some devices allow the implementation of software using hand gestures, body and speech recognition as input devices instead of using mouse and keyboard. The depth sensor consists of an infrared laser projector combined with a monochrome CMOS sensor, which captures video data in 3D under ideal ambient light conditions.

The proposed software uses the infrared-based motion capture device. Making the tracking of the patient's body, it draws a picture of the user’s skeleton, which can observe his/her movements in real time on the projection screen. When starting the protocols programmed into the software, the user sees red marks on the screen and when properly position these brands, they become green, showing that the move has been done correctly.

When he finishes a complete sequence of movements properly, a sound of applause and congratulations message appears on the screen showing that the protocol was finalized. The possibility of see yourself doing the exercises and software sounds stimulate and motivate the patient to perform all the exercises and continue with the therapy.

III. CASE STUDY

The case study has been done with a thirty years old woman, under surgical treatment of breast cancer and armpit emptying for over three years.

The project has been approved by Ethics and Research Committee (ERC) filed by number CAAE 07694812.7.0000.5501 on December, 7th, 2012 and registered at Clinical Trials under de protocol number NCT01893944. After accepting, the voluntary signed a Free and Informed Term of Consent (FITC).

The volunteer has been underwent assessment of pain, range of motion, muscles electromyographic activity and muscle strength, before and after a treatment session using the experimental protocol of Virtual Reality. The protocol's execution filled ten consecutive sessions, being held for two weeks, with thirty minutes each session.

Tools used to collect data are as follows and Figure 1 illustrates them:

1. Electromyography;
2. Dynamometer of scapular force;
3. Numerical Pain Scale: numbered horizontal line that classifies the pain by grades from 0 to 10, since "without pain" up to "worst pain possible";
4. Goniometry of the shoulder joint.

Fig. 1. Electromyography and Dynamometer of Scapular Force. Source: Personal Archive.

A. *Experimental Protocol*

The patient's image has been displayed on a TV screen, placed in front of the patient in a way to provide a wide field of view, offering real-time feedback related to the movements.

The volunteers have been positioned on a delimited area on the floor 3 meters distant from the device and the image has been calibrated according to individual height. This calibration is done automatically by the software.

On this environment, patients have performed 8 protocols of different exercises during 30 minutes. All of them related to those used in rehabilitation of upper limb and trunk specific, as shown on Figure 2 and 3.

Fig. 2. Visualization of the desktop software. Source: Personal Archive.

Fig. 3. Experimental Protocol – Virtual Reality. Source: Personal Archive.

The protocols are finalized when the patient completes a sequence of predetermined repetition of two or three distinct movements, depending on the protocol. The figures 4 and 5 show drawings of positions of each protocol.

For the surface eletromyography data analysis, we considered the value of RMS (Root Mean Square), from the signal processing in the software EMG Work Analysis™, using filter band pass 4th order Butterworth, adjusted for rate cut 20Hz to 400Hz to eliminate residual noise.

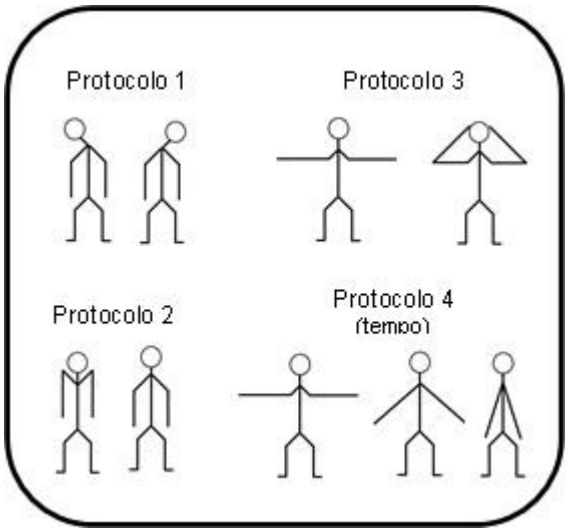

Fig. 4. Protocols List – numbers 1 to 4.

After obtaining the data, they were tabulated in Microsoft Excel™, being organized and analyzed by percentage.

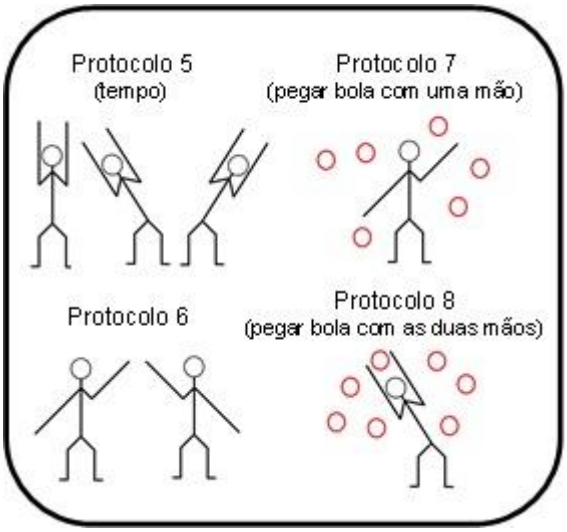

Fig. 5. Protocols List – numbers 5 to 8.

IV. DISCUSSION

The software developed by virtual reality projection features numerous therapeutic benefits for these women who have had breast cancer, focusing on the needs that must be trained or stimulated, in addition to being a motivating and enriching environment when compared to usual rehabilitation protocols, allowing the experience of activities that cannot be commonly performed [8].

According to studies, virtual reality video games are a form of intervention widely used in order to reduce the threshold of pain as well as improve levels of physical activity per day [5][6][7].

Sharar and collaborators verified the hypothesis of this therapy acting directly on the central nervous system, altering the perception of pain with simultaneous reduction of activity in the brain (cerebral cortex and brainstem), which are directly related to the pain [10].

According to researches, virtual reality provides sensory feedback that promotes intense stimuli needed to induce brain reorganization, where the user gets similar experiences to activities and events that occur in real life, preparing and developing self-confidence and self-esteem in a safe environment [11].

It is believed that the performance of a specific physical activity program, involving the free movement after breast cancer surgery, provides for the woman greater well-being and less fear when performing shoulder movements, promoting significant improvement in mobility and quick return to daily activities [12].

Consistent with the results obtained in the case study, after performing the treatment protocol, a significant increase in the range of motion of the shoulder joint could be noticed. These findings justify the fact that virtual reality provide women intrinsic learning conditions, caused by limb motion, essential for improving the movements quality [13].

V. RESULTS

The results obtained in the numerical pain scale, responsible for assessing the intensity of pain sensation, showed an 85% reduction after treatment.

In relation to the movement of shoulder flexion, there was a reduction of the RMS values for the biceps brachii (79.9%), triceps (28.1%), middle fiber deltoid (33%) and trapezius (0, 51%), as shown in figure 6.

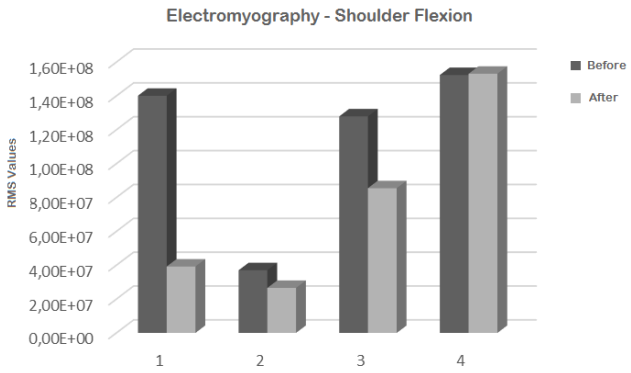

Fig. 6. Representation of the eletromyography values, in which number 1 is biceps brachii; number 2 is triceps brachii; number 3 is middle fiber deltoid; and number 4 is trapezius.

When analyzing the movement of shoulder abduction, there is a decrease in the myoelectric potential for biceps brachii (66.3%), triceps brachii (29.4%), and middle fiber deltoid (20.2%). However, there is an increase in the RMS value for the middle fiber trapezius muscle (6.3%), as shown in figure 7.

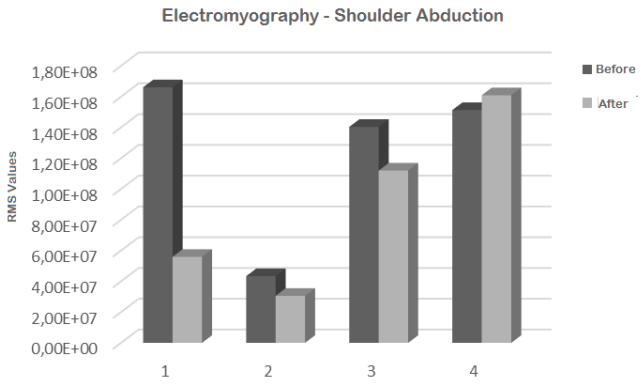

Fig. 7. Representation of the eletromyography values, in which number 1 is biceps brachii; number 2 is triceps brachii; number 3 is middle fiber deltoid; and number 4 is trapezius.

Table 1 shows the increased range of motion of the upper limb affected by the surgery, when compared before and after the treatment protocol for all movements analyzed.

TABLE I. PERCENTAGE DISTRIBUTION (%) OF RANGE OF MOTION.

Movement	Before	After	Average±SD	Percentage
Flexion	140	160	150±14,1	14,2%
Extension	30	40	35±7,0	33,3%
Abduction	100	160	130±42,4	60%
Adduction	10	20	15±7,0	100%

VI. CONCLUSIONS

This research has shown that Virtual Reality is a valuable tool for the treatment of secondary pain to breast cancer, by setting dynamically the interaction between patient and game. The use of the proposed software shows that this technology is useful in the rehabilitation and can be significant in reducing the discomfort caused by the disease, especially in pain reduction.

So it can be concluded that the virtual therapy has good results and it is intended therefore continue the study with larger group of patients.

ACKNOWLEDGMENT

The authors acknowledge the opportunity and financial support granted by CAPES (Brazilian Federal Agency for the Support and Evaluation of Graduate Education), without which the completion of this work would not have been possible and acknowledgement to Fapemig (Foundation for Research Support of the State of Minas Gerais) to the projects APQ-02934-11 e PPM-00511-13.

REFERENCES

[1] Binkley, J. M. et al. (2012) "Patient Perspectives on Breast Cancer Treatment Side Effects and the Prospective Surveillance Model for Physical Rehabilitation for Women With Breast Cancer" *Cancer*, v. 15, n.8, p. 2207-16.

[2] A. L. Betker, et al., "Game-based exercises for dynamic short-sitting balance rehabilitation of people with chronic spinal cord and traumatic brain injuries," Physical Therapy, vol. 87, n. 10, pp. 1389–1398, Oct. 2007.

[3] K. Brutsch, et al., "Influence of virtual reality soccer game on walking performance in robotic assisted gait training for children," Journal of NeuroEngineering and Rehabilitation, vol. 7, n. 15, pp. 1–9, Apr. 2010.

[4] J. E. Deutsch, et al., "Use of a low-cost, commercially available gaming console (Wii) for rehabilitation of an adolescent with cerebral palsy," Physical Therapy, vol. 88, n. 10, pp. 1196–1207, Oct. 2008.

[5] A. M. Acosta, H. A. Dewald, J. A. Dewald, "Pilot study to test effectiveness of video game on reaching performance in stroke," Journal of Rehabilitation Research and Development, vol. 48, n. 4, pp. 431–444, Jan. 2011.

[6] H. Hurkmans, et al., "Energy expenditure in chronic stroke patients playing Wii Sports: a pilot study," Journal of NeuroEngineering and Rehabilitation, vol. 8, n. 38, pp. 1–7, Jul. 2011.

[7] K. Laver, et al., "Is the Nintendo Wii Fit really acceptable to older people?: a discrete choice experiment," Bio Med Central Geriatrics, vol. 11, n. 64, pp. 2–6, Oct. 2011.

[8] Meldrum, D. et al. (2012) "Effectiveness of conventional versus virtual reality based vestibular rehabilitation in the treatment of dizziness, gait and balance impairment in adults with unilateral peripheral vestibular loss: a randomised controlled trial" BMC Ear, Nose and Throat Disorders, v. 12, n. 3, p. 1-8.

[9] Lin, J. et al. (2013) "Developing Home-Based Virtual Reality Therapy Interventions" *Games for Health Journal*, v. 2, n. 1, p. 34-38.

[10] Sharar, S.R., et al. (2008) "Applications of Virtual Reality for Pain Management in Burn-Injured Patients" *Expert Review Neurotherapeutics*, v. 8, n. 11, p. 1667–1674.

[11] Fluet, G.G. et al. (2010) "Interfacing a haptic robotic system with complex virtual environments to treat impaired upper extremity motor function in children with cerebral palsy" *Developmental Neurorehabilitation*, v. 13, n. 5, p. 335–345.

[12] Volaklis, K.A., Halle, M., Tokmakidis, S.P. (2013) "Exercise in the prevention and rehabilitation of breast cancer" *Wiener klinische Wochenschrift*, v.125, n. 11-12, p. 297-301.

[13] Subramanian, S.K., Levin, M.F. (2011) "Viewing medium affects arm motor performance in 3D virtual environments" *Journal of NeuroEngineering and Rehabilitation*, v. 8, n. 36, p. 2-9.