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José Marino Neto
Renato García Ojeda *Editors*

IX Latin American Congress on Biomedical Engineering and XXVIII Brazilian Congress on Biomedical Engineering

Proceedings of CLAIB and CBEB 2022, October 24–28, 2022, Florianópolis, Brazil—Volume 3: Biomechanics, Biomedical Devices and Assistive Technologies

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Preface

The IX Latin American Congress on Biomedical Engineering and XXVIII Brazilian Congress on Biomedical Engineering (CLAIB&CBEB 2022) took place simultaneously on October 24–28, 2022, in Florianópolis-SC, Brazil, and were organised by the Institute of Biomedical Engineering of The Federal University of Santa Catarina (IEB-UFSC), the Regional Council of Biomedical Engineering for Latin America (CORAL) and the Brazilian Biomedical Engineering Society (SBEB). These events were held remotely for the most part, with a small set of conferences taking place in person on the premises of IEB-UFSC (Florianópolis, Brazil). They included 11 hands-on technical workshops for students, 26 keynote speakers and symposia, and 40 oral and poster presentation sessions attended by about a thousand participants, including undergraduate and graduate students, academic researchers, and public and private sector agents.

We are proud to present in this book a selection of papers presented at this event by researchers from all over the world, reporting recent and innovative findings and technological outcomes in the many areas of interest of biomedical engineering. These papers represent nearly 50% of those original contributions presented at the CLAIB&CBEB 2022. Their academic quality has been warranted by careful peer review coordinated by an expert scientific committee of leading Latin American senior researchers in biomedical engineering. The content is organised into four volumes and eleven chapters, covering the most relevant areas of scientific and technological developments within the broad spectrum of biomedical engineering interests. We are sure that the contributions presented in this book give a deep overview of the leading edge in your expertise and other areas.

On behalf of Scientific and Organising Committees, we thank authors, academic reviewers and sponsoring societies such as CORAL, SBEB, UFSC, FAPESC and IEB-UFSC for their contributions. Moreover, we encourage readers to enjoy this amazing piece of scientific literature as a breadth of knowledge in the biomedical engineering field.

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CLAIB&CBEB 2022 was organised by the Regional Council of Biomedical Engineering for Latin America (CORAL) and the Brazilian Biomedical Engineering Society (SBEB) in cooperation with the International Federation for Medical and Biological Engineering (IFMBE).

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Biomechanics, Neuroengineering and Rehabilitation

Usability Validation of a Parallel Bar Device with Vibrating Stimulus for Neuropathologies Treatment

A. V. Morais(✉), S. R. M. S. Boschi, L. A. Moura, Y. F. Moniz, S. C. Martini, T. A. Scardovelli, and A. P. Silva

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Abstract. Neurological diseases are usually associated to motor functions impairment, such as gait and balance implication. In general, rehabilitation aims to provide performance gain on daily live activities. The use of whole-body vibrations allied to conventional treatment has been increasing. It is suggested that vibrations increase the sensory afferents excitability, contributing to gait, balance and proprioception, in addition to decreasing spasticity. Among the vibrating platforms used for this purpose, a vibrating device that allows walking on it was selected, enabling the performance of static or dynamic vibratory protocols. With this equipment, improvement opportunities were identified then motivated its retrofit. The changes were made aiming the robustness increase, better mass distribution and the development of an intuitive HMI. Besides the engineering tests, considerations about user interaction with the equipment and technology are essential. Usability testing addresses aspects that allow evaluating the implications of the applied technology for the user. In this sense, in order to verify the effectiveness of the retrofit for the user. In this way, a usability test was performed with professionals through the SUS scale. The test was applied to five physiotherapists, resulting on 97.5 points average evaluation. This grade suggests the device classification as the"Best Imaginable". Regarding the SUS evaluation, it is suggested that execution of static and dynamic protocols is feasible, since, according to the professional evaluation and considerations, the device can be used to perform neuropathological patients protocol.

Keywords: Whole body vibrations · Neuropathologies · Gait and balance rehabilitation · Vibrating platform · Usability validation

1 Introduction

Neuropathologies are diseases usually related to gait and balance that can contribute to motor disability and, consequently, to a lower life quality [1]. In general, the main objective of rehabilitation is to improve muscle function and daily live activities [2].

The use of whole-body vibrations is growing, both as a therapeutic method and auxiliary therapy in neurological rehabilitation also [3]. Although there is still no consensus on its action mechanism, whole-body vibration is a type of physical therapy that

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increases the excitability of sensory afferents, contributing to the improvement of gait and balance [4].

Among the diversity of devices for whole-body vibrations found in the literature, Morais et al. [5] developed a vibrating device that allows walking on it, presenting a single degree of freedom with the same amplitude throughout its length. Thus, it is possible to treat the patient statically, but also to develop dynamic protocols, providing greater device flexibility.

With this equipment, a retrofit was effectuated to increase the robustness structure, better mass distribution and an intuitive HMI development. In order to the improvement validation, engineering tests were performed to evaluate physical and constructive characteristics. However, among technical and security concepts, Usability is an important aspect to be evaluated [6]. This study encourages the assessment of learning ability and safety related to the equipment.

In this sense, this paper aim is to evaluate the usability of the parallel bar device with vibratory stimulus controlled via HMI for neuropathologies rehabilitation. As evaluation tool, the SUS—System Usability Scale was used. This test is com-posed by ten questions that use the Likert scale for valuation. After score calculate, the results are between 0 and 100, where 0 represents the worst usability and 100 the best usability.

2 Materials and Methods

2.1 Tests with Professionals

In order to verify the device usability by physical therapists, a specific protocol was developed. It includes the device configuration and vibrational test exposure. Afterwards, the professionals submitted to the tests were asked to fill out a System Usability Scale questionnaire [7].

2.2 Subjects

It was requested five physical therapists [8] to participate with their technical considerations.

2.3 Data Collection Environment

All tests were conducted at the Virtual Environments and Assistive Technology Laboratory—LAVITA, on Technological Research Center—NPT of the Universidade de Mogi das Cruzes.

2.4 Materials

Retrofitted device and a SUS questionnaire.

2.5 Protocol

At first, the equipment was presented to the user. At the HMI, each functionality was individually exemplified and the professional invited to walk on the disconnected platform. Then, the user requested to configure the vibration parameters considering exposure time 30 s, rest time 20 s, repeating 3 cycles at 20Hz frequency. After configuration, the professional was asked for start the program to execute the protocol walking at low-intensity and regularly. The test can be interrupted at any time by pressing the emergency button.

2.6 Usability Test

To the device usability measurement, the usability test proposed by Brooke [7] was applied. The test is based on the SUS—System Usability Scale, which consists on a 10 questions form combining positive and negative statements regarding the use of the device. These questions are answered based on a five-point Likert scale [9] statements where the score 1 means you totally disagree and 5 you totally agree.

To calculate the score, the values assigned by the user must be processed so that, in odd-numbered questions, 1 point must be subtracted from the assigned value and, in questions with odd numbers, therefore, at even numbers, the value assigned must be subtracted by 5 (Table 1).

Table 1. SUS scale calculation

Question	Evaluation
1	$x - 1$
2	$5 - x$
3	$x - 1$
4	$5 - x$
5	$x - 1$
6	$5 - x$
7	$x - 1$
8	$5 - x$
9	$x - 1$
10	$5 - x$

Thereby, the maximum value calculated for each question is four. Then, the processed values were added up and this sum is multiplied by 2.5 as shown:

$$U = \left(\sum_{i=1}^{n=10} p_i \right) \times 2,5 \tag{1}$$

where