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

Antonio Morais, Silvia Boschi, Luan Moura, Yasmim Moniz, Silvia Martini, Terigi Scardovelli and Alessandro Silva

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Usability validation of a parallel bar device with vibrating stimulus for neuropathologies treatment

A.V. Morais[1], S.R.M.S. Boschi[1], L.A. Moura[1], Y.F. Moniz[1], S.C. Martini[1], T.A. Scardovelli, A.P. Silva[1]

[1]Universidade de Mogi das Cruzes/Núcleo de Pesquisas Tecnológicas, Mogi das Cruzes, Brasil

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 order to verify the effectiveness of the retrofit 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.**

I. 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 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 [7]. This test is composed by ten questions that use the Likert scale for valuation and it can present. This test can present important criteria for evaluating the constructive and operational systems characteristics. After score calculate, the results are between 0 and 100, where 0 represents the worst usability and 100 the best usability.

II. MATERIALS AND METHODS

A. 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 [8].

B. Subjects

It was requested five physical therapists [9] to participate with their technical considerations.

C. 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.

D. Materials

-Retrofitted device

- SUS questionnaire.

E. 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 30s, rest time 20s, 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.

F. Usability test

To the device usability measurement, the usability test proposed by Brooke [8] 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 [10] statements where the score 1 means you totally disagree and 5 you totally agree. According to art. 1 of resolution 51/06 from National Health Council, public opinion polls with unidentified participants are not registered or evaluated by CEP/CONEP [11].

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:

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

Where:
U: Usability Device Index
p: processed values

After the Usability Device Index calculated, it is possible to classify the usability based on the proposed interval as shown in Table 2.

Table 2: SUS results definition

Range	Definition
0 – 20,5	Worst Imaginable
21 – 38,5	Poor
39 – 52,5	Average
53 – 73,5	Good
74 – 85,5	Excellent
86 – 100	Best Imaginable

III. Resuls

As previously presented, considering the device Usability evaluation by professionals, was requested for five physiotherapist and physical educators to use the equipment (Fig. 1) and afterwards to fill the SUS form.

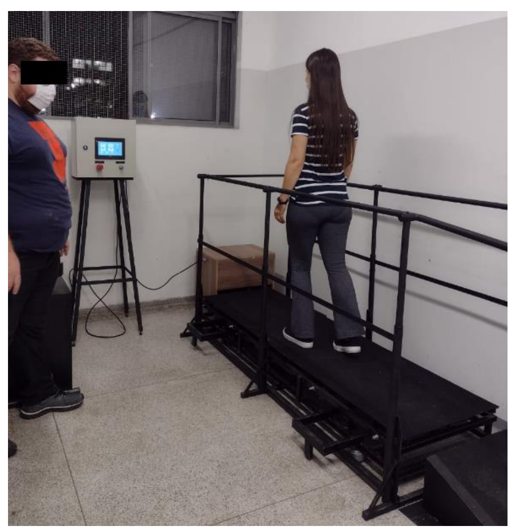

Fig. 1: Protocol execution

The Fig. 2 presents the five provided values average. Table 3 presents the summary of the obtained values.

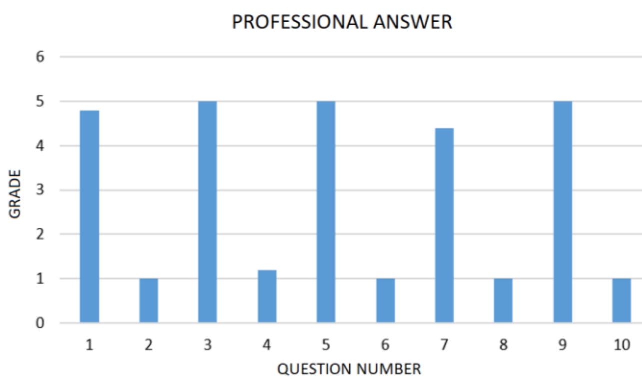

Fig. 2: SUS form answer

Table 3: SUS answer summary

Question	Score	Deviation
1	4,8	0,32
2	1	0
3	5	0
4	1,2	0,32
5	5	0
6	1	0
7	4,4	0,96
8	1	0
9	5	0
10	1	0

Based on the valuation table previously presented, the calculated SUS average is obtained (Fig. 3). Table 4 presents the data summary.

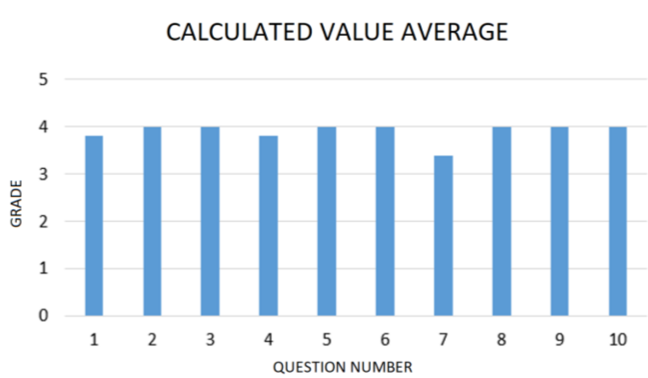

Fig. 3: Calculated SUS average

Table 4: Calculated SUS average summary

Question	Score	Deviation
1	3,8	0,32
2	4	0
3	4	0
4	3,8	0,32
5	4	0
6	4	0
7	3,4	0,96
8	4	0
9	4	0
10	4	0

In this way, according to SUS the Usability value obtained is 97,5, that suggest the Best Imaginable device classification.

IV. Discussion

Besides the engineering tests, the device usability based on SUS Scale was performed. This evaluation is fundamental aiming at ergonomics, safety and constructive improvements identification [12]. Usability testing is usually performed during the device development process, but it should be performed after the start use with a focus on user experience also [6].

Consideration of the interaction between user and equipment is fundamental in the device development process. Even though, among the engineering conditions tests performed, to ensure that the device works properly, the device interaction is an important parameter to be considered. The usability test application addresses aspects that aim to understand how the interface design affects the interactions between user and technology [13].

The tests were applied to the five professionals, including physical therapists and invited physical educators, using the SUS scale as a form of validation. Calculating the average score between the participants' scores, 97.5 points were obtained, pointing to the “Best Imaginable” classification [14].

In addition, the application of the HMI as a graphic resource for device configuration made its use simpler and more intuitive, arousing interest. This is an important factor since interest is one of the central components of the cognitive process [15]. Whereas the professionals quickly developed autonomy in the use of the equipment, it motivated the device grade attribution.

V. Conclusions

The equipment was analyzed in operation by a group of physiotherapists and its usability was considered satisfactory for the professional as well as the patient.

It is concluded that the execution of dynamic protocols is viable, since the control variables remain stable regardless of the load application point. As evaluated, the device can be used to perform treatment protocols for neuropathological patients.

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Conflict of interest

The authors declare that there isb no conflict of interest regarding the publication of this paper.

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Author: Antonio Vinícius de Morais
Institute: Universidade de Mogi das Cruzes
Street: Avenida Doutor Cândido Xavier de Almeida e Souza, 200
City: Mogi das Cruzes
Country: Brasil
Email: antonioviniciusm@yahoo.com.br