Pressure pain threshold in people with amputation submitted to the use of postural lifting equipment: crossover experimental study

Limiar de dor por pressão em pessoas com amputação submetidas ao uso de equipamento de elevação postural: estudo experimental cruzado

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ABSTRACT

BACKGROUND AND OBJECTIVES: Amputation is an event that has consequences that can affect daily life, including pain, enhancing changes, whether in sleep or in quality of life. The objective of this study was to evaluate the pressure pain threshold (PPT) in people with amputations submitted to the use of different postural elevation equipment.

METHODS: Experimental crossover study, carried out from September to October 2022, with people with lower limb amputation (n=15) and people without amputation (n=15). PPT in four regions (T12-L1, L5-S1, anterior tuberosity of the tibia and calcaneus) were evaluated before and after the use of different versions (A and B) of an equipment for postural elevation, gravity and pain interference. Presence of signs and symptoms of central sensitization (CS) and sleep quality.

RESULTS: The groups did not present PPT alterations when compared between the different versions of the equipment ($p<0.05$) in the four locations analyzed. Furthermore, the groups did not show differences in relation to the evaluation days or among themselves regarding the severity and interference of pain and the presence of signs and symptoms of CS. The control group indicated poor sleep quality ($p=0.0173$) and remained worse than people with amputation.

CONCLUSION: The versions of the equipment did not change PPT in the analyzed areas. The groups did not differ between themselves, suggesting that the equipment promoted similar responses, that is, no change in sensitivity was evidenced in the analyzed regions which have greater contact with stabilization elements and weight discharge of the equipment.

Keywords: Amputees, Disabled people, Pain, Wheelchair.

RESUMO

JUSTIFICATIVA E OBJETIVOS: A amputação é um evento que acarreta consequências que podem afetar o cotidiano, entre elas a dor, potencializando alterações, seja no sono ou na qualidade de vida. O objetivo deste estudo foi avaliar o limiar de dor por pressão (LDP) em pessoas com amputação submetidas ao uso de diferentes equipamentos de elevação postural.

MÉTODOS: Estudo experimental cruzado, realizado de setembro a outubro de 2022, com pessoas com amputação no membro inferior (n=15) e pessoas sem amputação (n=15). Foram avaliados o LDP em quatro regiões (T12-L1, L5-S1, tuberosidade anterior da tíbia e calcâneo) pré e pós uso de distintas versões (A e B) de um equipamento de elevação postural, gravidade e interferência da dor. Presença de sinais e sintomas de sensibilização central (SC) e qualidade do sono.

RESULTADOS: Os grupos não apresentaram alterações no LDP quando comparados em relação às diferentes versões do equipamento ($p<0,05$) nos quatro locais analisados. Além disso, os grupos não mostraram diferenças em relação aos dias de avaliação ou entre si quanto a severidade e interferência de dor e presença de sinais e sintomas de SC. O grupo controle indicou uma qualidade de sono ruim ($p=0,0173$) e manteve-se pior que as pessoas com amputação.

CONCLUSÃO: As versões do equipamento não alteraram o LDP nas áreas analisadas. Os grupos não apresentaram diferença entre si, sugerindo que o equipamento promoveu respostas semelhantes, ou seja, não foi evidenciada uma alteração de sensibilidade nas regiões que possuem maior contato com elementos de estabilização e descarga de peso dos equipamentos.

Descritores: Amputados, Cadeiras de roda, Dor, Pessoas com deficiência.

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HIGHLIGHTS

- Pressure pain threshold was measured in people with unilateral lower limb amputation.
- The use of the postural elevation equipment did not cause a change in the pressure pain threshold between the groups, control and people with amputation.
- The types of equipment did not show differences in pressure pain threshold in any of the groups.

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INTRODUCTION

In Brazil, 23% of the population has some type of disability, one of which is amputation. Traffic accidents, firearm injuries, diabetes, neoplasms, and circulatory system diseases are identified as the main causes of this event[1,2]. Limb amputation generates functional disability by compromising the performance of individuals' activities[3-5].

After an amputation, the individual suffers consequences that last throughout life, such as loss of functionality[6], pain report[7] and phantom limb sensation[8], which potentiates alterations and contributes to the generation of disorders, among them sleep and quality of life disorders[9].

After amputation surgery, with the removal of a body segment, a reorganization of the sensory and motor maps takes place and the area of representation referring to the amputated limb in the somatosensory cortices does not remain inactive, but is altered, starting to relate to neighboring cortical areas[10-12].

Studies conducted with people with amputations have shown that sensory dysfunctions occur both in the amputated limb and in the residual limb[13]. In addition, studies also provide information that, by predisposing a person with amputation to loads and efforts, their pain threshold and tolerance may be altered, bringing consequences not only to the stump, but also to other body regions such as the lumbar region and the residual limb[14,15]. A tool capable of evaluating these somatosensory changes is algometry, which has the capacity to quantify the pressure pain threshold (PPT)[16].

Pressure algometry is used to measure individual's perception and tolerance to pain through pressure stimulation[17], and has already been used as a sensory examination in a study carried out in people with lower limb amputation, whose objective was to quantify and compare mechanical sensitivity in the pre- and postoperative limb[18]. The pressure algometer can be used in research[19], as well as in clinical settings, it is efficient and low cost, in addition to being reliable and validated[16,20].

It is known that the report of pain in remaining regions of people with amputation is an event that alters individual's brain connectivity, causing changes that may even involve the reduction of brain electrical activity in a selective way[7].

As a social inclusion strategy, the use of prostheses and devices to assist walking and locomotion have been tested in people with amputation to increase functional capacity, activity and social participation[21], but without tests to verify the impact of the use of these tools on PPT. This is a relevant aspect, since people with amputation may be subjected to loads and efforts in the tested conditions, which could predispose to changes in sensitivity and the presence of musculoskeletal pain. It is worth noting that one of the clinical manifestations after amputation, in addition to pain, is the reduction of the pain threshold (hyperalgesia due to mechanical stimulation)[22], which may lead to greater difficulty in the prosthetization process.

In this context, studies that deepen and/or promote the investigation of specific conditions of people with amputation allow an expansion of the perception of the functional adaptations that this population needs to make for a greater integration into society. This study aims to evaluate PPT in people with amputation submitted to the use of different postural lifting equipment.

METHODS

This is a cross-over experimental study, carried out at the Dell Research, Development and Innovation Center, from September to October 2022, with approval of the Ethics Committee, No. 60219322.8.0000.5534, Opinion Number 5,647,355.

Participants were recruited by convenience from private clinics and parathelete associations in the state of Ceará. They were contacted by telephone and invited to participate in the research. This study was composed of people with unilateral lower limb amputation, using or not using prosthesis, as well as people without physical disability, called in this study "control". Adults aged between 18 and 50 years of both sexes, without associated vascular diseases, e.g. coagulation disorders and decompensated diabetes, were included.

The blood pressure of those included in the study was classified as normotensive (120/80 mmHg or ≤139/89 mmHg)[23]. The amputee group included patients with lower limb amputations who had been using prostheses for at least six months and were no longer in the process of adapting to prosthesis use.

Individuals with symptoms of dizziness were excluded, as well as associated neuropathological brain disorders such as stroke, Parkinson's, Alzheimer's and recent head trauma with cognitive impairment. Also excluded were all individuals with any cognitive alteration reported by medical diagnosis and/or self-reported, which would compromise the objectives of the study and the performance of the tests, such as panic syndrome, anxiety attacks or major depression during the evaluation, as well as individuals with relevant speech impairments that would make it impossible for them to communicate during the tests.

Study variables

Primary outcome

Pressure pain threshold

It consists of gradually applying a pressure by means of an algometer (MED.DOR Ltda.*, Brazil; maximum compression = 50 kgf, accuracy = 0.1 kgf, 3-digit display), perpendicular to a given body region, the pain threshold being the minimum amount of pressure that causes the sensation of pain reported by the patient, distinct from the sensation of pressure or discomfort. Measurement is usually performed in kilograms (kg). The validity and intra-rater internal consistency of the equipment range from 0.84 to 0.99, while the inter-rater reliability results were moderate, Cronbach's α = 0.71-0.75[20].

Three repetitions were performed at intervals of 15 to 30 seconds and then the mean was calculated. The room temperature was controlled to a comfortable level (21-24°C) and the same measurement settings were used between assessments and reassessments20,24. For the study, PDL was measured at specific points of increased pressure during the use of Steve. These points are: the interspinous ligament between the 12th

thoracic vertebra (T12) and the first lumbar vertebra (L1); the interspinous ligament between the 5th lumbar vertebra (L5) and the first sacral vertebra (S1); the anterior tibial tuberosity (ATT) and the lower central region of the heel. In control patients, both legs were considered for these measurements, while in amputated patients the remaining leg was considered, and structures such as ATT and heel in the limb that had been amputated, if they still remained (Figure 1).

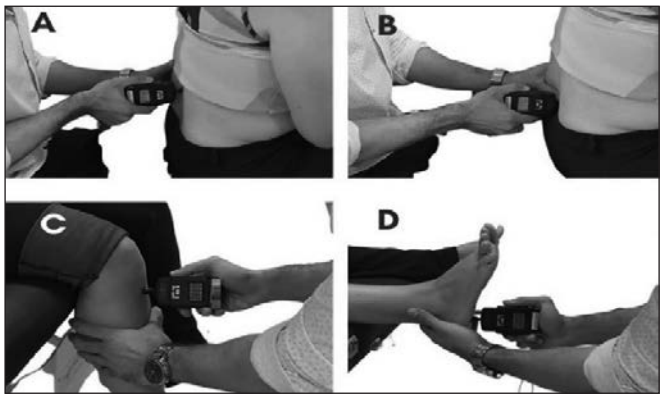

Figure 1. Location of points where pressure algometry was performed on study participants

A = interspinous ligament between the 12th thoracic vertebra (T12) and the first lumbar vertebra (L1); B = interspinous ligament between the 5th lumbar vertebra (L5) and the first sacral vertebra (S1); C = anterior tibial tuberosity (ATT); D = lower central region of the heel.

Secondary outcome

Sociodemographic aspects

An anamnesis form was used to collect personal information such as gender, age (years), information about the amputation (time, cause and lateralization), weight (kg), height (m) and body mass index (BMI), using the weight/height formula[2]. The following cut-off points were used to classify the anthropometric status of participants: BMI<18.5 kg/m^2 (underweight); BMI>18.5 to 24.9 kg/m^2 (eutrophy); BMI≥25 to 29.9 kg/m^2 (overweight); and BMI>30.0 kg/m^2 (obesity).

Brief Pain Inventory - BPI

The BPI consists of nine items arranged in two dimensions: pain intensity/severity (items 3 to 6) and pain interference (impact) on the patient's life (items 9a to 9g). The BPI asks patients to rate their pain severity and pain interference (with general activities, mood, ability to walk, normal work, relationships with others, sleep, and enjoyment of life) on an 11-point scale ranging from 0 (no pain/no interference) to 10 (as bad as possible). In addition, BPI also includes a body diagram to assess the location of pain (item 2), measures the percentage of pain relief (item 8), and asks patients to describe which treatments are being used to control pain. Scores for the two dimensions range from 0 to 10 and are calculated using the average of the total items. A high score represents a high severity or interference of pain. Confirmatory factor analysis confirmed two underlying dimensions, pain severity and pain interference, with Cronbach's α of 0.91 and 0.87, respectively[25].

Central Sensitization Inventory - CSI

It allows the identification and screening of symptoms associated with CS and consists of two parts: A and B. Part A contains 25 questions related to current health symptoms. Each item is measured with five response options, with the following numerical rating scale: Never (0), Rarely (1), Sometimes (2), Often (3) and Always (4). The score is cumulative and ranges from 0 to 100. In part B, the instrument identifies whether the patient has been diagnosed with other syndromes that occur with central sensitization[26], using a cut-off point of 35 points in part A, with a sensitivity of 0.98 and specificity of 0.9, with an AUC (area under the curve) of 0.8 (95%CI - 0.76-0.86).

These findings showed that, according to the cut-off point, the CSI was correctly classified (i.e. specificity) in more than 90% of those who had conditions of signs and symptoms of central sensitization[27].

Pittsburgh Sleep Quality Index - PSQI

PSQI is a self-administered questionnaire that assesses sleep quality, as well as possible disturbances in the last month. It was developed[28] and validated in Brazil in an adult population[29]. It consists of 19 questions that address sleep quality and sleep disorders in the last month. The evaluation occurs through the analysis of seven sleep components: subjective quality, sleep latency, sleep duration, sleep efficiency, sleep disorders, medication use and daily dysfunction. For each component, there is a score that ranges from zero to 3, and can reach a maximum score of 21 points. Scores above 5 indicate poor sleep quality[30].

Postural elevation device (Steve)

Steve is an exoskeleton with a postural lifting function aimed at people with reduced mobility (paraplegics, amputees and people with musculoskeletal injuries in the lower limbs). The equipment is applicable for people with height between 1.63 and 1.73 m and body mass up to 125 kg. It has mechanisms that allow the user to work in jobs that require standing. The mechanism that performs the elevation to orthostatic position is called "stand up". In addition, it has an oscillating footrest to avoid variations in blood pressure and heart rate[21,31]. This support also functions as a platform for the stand up.

Steve A: in this version, tubular structures joined mostly by welding were used. Both the stand-up and the foot swing mechanism are present in this version. In addition, linear actuators are used so that the user can make ergonomic adjustments to the structures. These adjustments are backrest inclination and height, horizontal and vertical seat displacement, oscillation amplitude and footrest height.

Steve B: the main change compared to the previous version was the use of plates instead of tubular structures, due to which it was possible to obtain greater ranges of motion in the ergonomic adjustments. These changes aimed to adapt the project to the new constructive form, in addition to improving the ergonomics of Steve, based on feedback from previous versions.

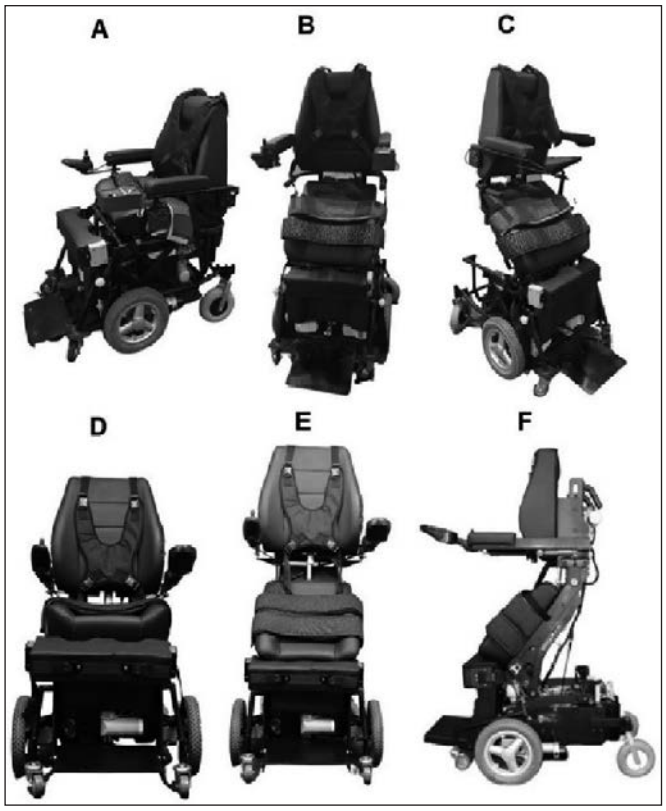

Figure 2. Steve postural elevation device

A = Steve A in initial position side view; B = Steve A in raised position front view; C = Steve A in raised position side view; D = Steve B in initial position front view; E = Steve B in raised position front view; F = Steve B in raised position side view.

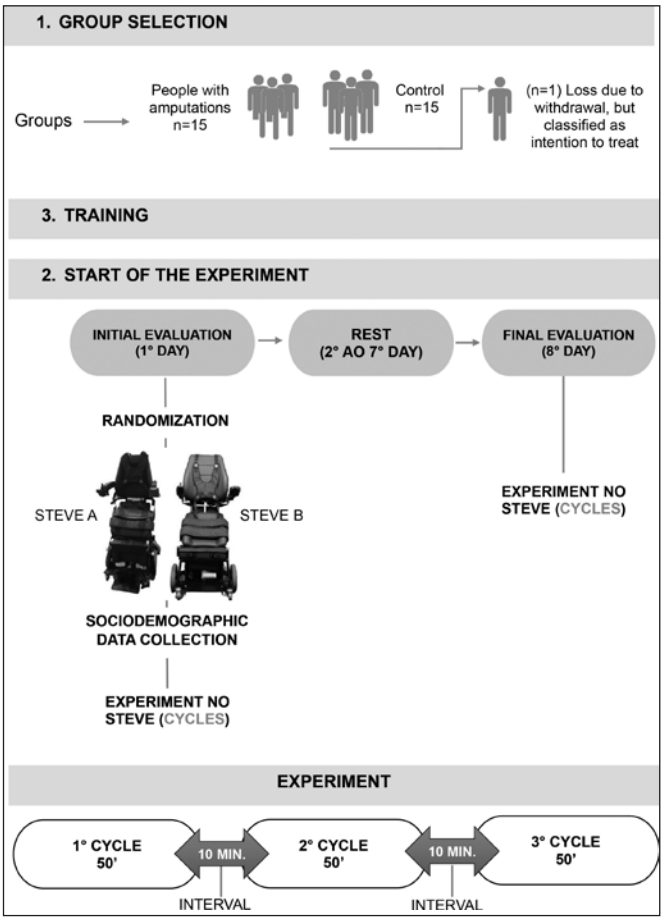

Figure 3. Study flowchart

A = region of the interspinous ligament between the 12th thoracic vertebra (T12) and the first lumbar vertebra (L1); B = region of the interspinous ligament between the 5th lumbar vertebra (L5) and the first sacral vertebra (S1); C = region of the anterior tibial tuberosity (ATT); D = lower central region of the heel.

Procedures

Individuals who met the requirements were invited to participate in the research and signed the Free and Informed Consent Term (FICT). Each participant was evaluated on two different days with a six-day interval between them, remaining on the equipment, each day, for three cycles of 50 minutes each in elevation (evaluation period), interspersed by 10 minutes (recovery period) of rest outside the equipment, sitting in a conventional chair or standing, according to the choice of the evaluated.

The equipment that each participant used first was defined by randomized draw (with opaque dark envelope), ratio 1:1, (Steve A and Steve B). PPT was measured at the beginning and at the end of the postural lifting equipment complete period of daily use, while the questionnaires were applied only at the beginning of each evaluation day (Figure 3).

Statistical analysis

To consider the PPT values, the comparative analysis of the difference (Delta = Final - Initial) of the first day values (using one type of equipment) in relation to the difference of the second day (using the other type of equipment) was performed. All body segments were assessed in the same way for algometry. Data were analyzed using descriptive statistics (mean and standard deviation) using the statistical software PRISMA 9.0® for IOS. Comparative tests were performed with ANOVA TWO-WAY or mixed effects model analysis, both with Bonferroni post-test, considering $p<0.05$, and presented with mean difference and 95% Confidence Interval.

RESULTS

Of the 30 individuals selected, 15 comprised the control group and 15 the amputation group. All individuals agreed to participate in the study and were thus submitted to the proposed experiment. One volunteer from control group performed the initial data collection but, for personal reasons, could not continue his participation in the study. In control group, three people were male, six practiced physical activity and obtained an average BMI classified as slightly overweight or overweight (from 25 to 29.9), with a total of 27 kg/m^2. In the group of people with amputation, 10 were male, 13 people regularly performed physical activity, BMI was classified as slightly above weight or overweight (from 25 to 29.9), with a total of 25 kg/m^2, and 10 individuals reported having phantom limb pain. Regarding the level of amputation, most of them were transfemoral type, and of the 15 volunteers, 11 presented this classification (Table 1).

Table 1. Characterization of the study sample (n=30)

Variables	Control (n=15)	Amputees (n=15)
	n	n
Gender (M)	3	10
	Mean (SD)	Mean (SD)
Age (years)	29 (9)	34 (7)
Height (m)	1.65 (0,05)	1.66 (0,07)
Weight (kg)	75 (13)	76 (12)
BMI (kg/m^2)	27 (4)	25 (7)
	n	n
Physical activity	6	13
Presence of phantom limb pain	-	10
	Level of amputation	
		n
Hip disarticulation		1
Transfemoral		11
Transtibial		3

SD = Standard Deviation; M = Male; m = meters; kg = kilograms; n: number; kg/m^2 = Kilogram per square meter; BMI = Body Mass Index.

Table 2. Brief Pain Inventory (BPI), Central Sensitization Inventory (CSI) and Pittsburgh Sleep Quality Questionnaire

	Control			Amputees		
CSI						
	Mean	SD	n	Mean	SD	n
Evaluation 1	27.4	15.96	15	19.33	8.91	15
Evaluation 2	27.2	16.26	14	18.13	7.38	15
			p=0.0729			
BPI Severity						
	Mean	SD	n	Mean	SD	n
Evaluation1	1.13	1.41	15	1.11	1.72	15
Evaluation 2	0.98	1.26	14	0.85	1.71	15
			p=0.8241			
BPI Interference						
	Mean	SD	n	Mean	SD	n
Evaluation 1	0.83	1.15	15	1.15	1.82	15
Evaluation 2	0.75	1.38	14	0.26	0.72	15
			p=0.8049			
Sleep						
	Mean	SD	n	Mean	SD	n
Evaluation 1*	7.2	2.93	15	4.86	2.38	15
Evaluation 2	6.57	3.43	14	4.46	1.92	15
			p=0.0173			

SD = Standard deviation; N: Numbers; CI = Confidence interval. BPI = Brief Pain Inventory, CSI = Central Sensitization Inventory. *TWO-WAY ANOVA with Bonferroni post-test, p<0.05.

When pain severity and interference were measured in the pre-test period, both groups showed no statistical changes, both in the pre-use of Steve A and in the pre-use of Steve B. The same occurred when the presence of CS signs and symptoms was analyzed. This information shows parity of these aspects before the analysis of the pressure pain threshold of those evaluated. However, in the sleep quality variable, there was a difference between control and people with amputation groups (p=0.0173), but not between the evaluation days within the same group (use of Steve A or B), p=0.2903 (Table 2).

PPT means and standard deviation of control and amputee groups, in the pre and post use of devices A and B, are presented in Table 3, showing no significant changes during the evaluations.

There was no statistical difference between the groups or between the equipment used at any of the measurement points in relation to PPT measured before and after the use of the two versions of the postural elevation equipment (Table 4).

Table 3. Descriptive analysis of pressure pain threshold in control and amputees using different versions of a postural elevation device

		Control			Amputees		
T12-L1							
		Mean	SD	N	Mean	SD	n
Steve A	Pre	5.27	2.09	15	6.52	1.87	15
	Post	5.48	2.31	15	6.46	1.75	15
Steve B	Pre	5.28	2.16	14	6.7	1.93	15
	Post	5.4	2.25	14	6.61	1.93	15
L5-S1							
		Mean	SD	N	Mean	SD	n
Steve A	Pre	5.17	2.2	15	6.93	1.83	15
	Post	5.06	2.02	15	7.25	1.83	15
Steve B	Pre	5.36	2.57	14	7.11	1.48	15
	Post	5.1	2.11	14	7.21	1.61	15
Anterior tibial tuberosity							
		Mean	SD	N	Mean	SD	n
Steve A	Pre	6.3	1.75	30	6.93	1.63	17
	Post	5.74	1.59	30	6.07	1.61	17
Steve B	Pre	6.1	1.4	28	6.42	1.69	17
	Post	6.13	1.62	28	5.94	1.78	17
Heel							
		Mean	SD	N	Mean	SD	n
Steve A	Pre	10.5	3.57	30	11.4	3.28	15
	Post	7.91	3.54	30	11.5	3.82	15
Steve B	Pre	10	3.5	28	11.8	4.02	15
	Post	9.75	3.52	28	11.3	3.64	15

SD = Standard Deviation; T12-L1 = Interspinous ligament between the 12th thoracic vertebra and the 1st lumbar vertebra; L5-S1 = Interspinous ligament between the 5th lumbar vertebra and the 1st sacral vertebra. *TWO-WAY ANOVA with Bonferroni post-test, p<0.05.

Table 4. Comparative analysis of the pressure pain threshold variation (final value - initial value) in control and amputees who used different versions of a postural elevation equipment

	Control (n=15)			Amputees (n=15)			Mean difference between groups (95%CI)
				T12-L1			
	Mean	SD	n	Mean	SD	n	
Δ Steve A	0.21	0.60	15	-0.05	0.64	15	0.2698 (-0.3016 a 0.8412)
Δ Steve B	0.11	0.67	14	-0.09	0.75	15	0.2159 (-0.3656 a 0.7974)
				L5-S1			
	Mean	SD	N	Mean	SD	n	
Δ Steve A	-0.11	0.68	15	0.31	0.60	15	-0.4253 (-1.1480 a 0.2975)
Δ Steve B	-0.25	0.86	14	0.10	1.16	15	-0.3612 (-1.0970 a 0.3744)
				Anterior tibial tuberosity			
	Mean	SD	N	Mean	SD	n	
Δ Steve A	-0.56	1.16	30	-0.48	1.01	17	0.0335 (-0.8005 a 0.8675)
Δ Steve B	0.03	1.15	28	-0.27	1.74	17	0.7757 (-0.0690 a 1.6200)
				Heel			
	Mean	SD	N	Mean	SD	n	
Δ Steve A	-0.23	1.16	30	0.04	0.96	15	0.2721 (-0.7530 a 1.2970)
Δ Steve B	-0.24	1.73	28	-0.29	0.79	15	-0.2688 (-1.3060 a 0.7685)

SD = Standard Deviation; T12-L1 = Interspinous ligament between the 12th thoracic vertebra and the 1st lumbar vertebra; L5-S1 = Interspinous ligament between the 5th lumbar vertebra and the 1st sacral vertebra. Δ: Variation (final value - initial value). 95%IC: 95% confidence interval.

DISCUSSION

This study assessed PPT in people with unilateral lower limb amputations and the control group who used two different versions of a postural lifting device. No significant change was evidenced between the groups or between the equipment used. Pain severity and interference, as well as signs and symptoms of CS were similar between the groups at the pre-assessment of the postural elevation devices. Sleep quality of the control group was worse than that of the people with amputation in all assessments performed.

The use of straps and the contact of users with the Steve equipment are points of careful need for analysis, therefore the present study brought this point to question by evaluating PPT at its main contact sites. The results showed no significant variation in sensitivity after three cycles of use with 50 minutes each. The postural lifting devices used have ergonomic measures that preserve the safety and anatomical and functional integrity of the user[21,31]. Among these structures, the spine was a point of care when using the equipment, corroborating public policy recommendations that aim at the well-being of the individual through measures that provide care for the spine, including in people with disabilities[32]. PPT has already been performed in people without disabilities to investigate pain sensitivity through pressure stimulation in the face of somatosensory abnormalities[33] and in people with lower limb amputations in the pre and postoperative stump[18]. Regarding pain, in the present study the severity and interference domains remained at the same level when comparing the pre- and post-use versions of the equipment in the two groups evaluated. Results with a low level of pain intensity, such as this one, have already been found in people with amputation, associated with functional changes in the central nervous system (CNS) of people with amputation and reports of musculoskeletal pain[7].

Another factor that did not change was the presence of signs and symptoms of CS. For clinical purposes, CS is defined as an amplification of neural signaling in CNS that causes increased pain sensitivity, particularly dynamic tactile allodynia, secondary punctiform or pressure hyperalgesia[34]. CNS alterations in sensory areas have been previously reported[35], which prompted further clarification of the description of the patients assessed for CS signs and symptoms.

PPT reflects the analysis of pressure-related pain in amputee patients and control, and the fact that no changes in this threshold were evidenced reinforces the constitution of data without the influence of an amplification coming from other clinical conditions such as CS.

Regarding sleep quality, although amputation may evoke functional changes such as sleep disorders[36], this research observed that people with amputation may also have favorable reports regarding sleep quality[21]. Although studies have indicated that sleep alterations increase the likelihood of developing pain, especially chronic pain[37,38], in the present study it was observed that, although the control group showed evidence of poor sleep quality, this result did not affect individuals in relation to pain perception, either in intensity or interference.

This study is the first to analyze PPT in people with lower limb amputations before and after the use of a postural lifting device, as far as is known. Considering also that this evaluation was performed in different body regions, the results found bring favorable perspectives on the use of assistive technologies for patients with amputation in several areas, such as reintegration into the labor market[39], clinical use for

rehabilitation[32] and in the individual's daily life. However, the time of use of the equipment in the present experiment was short, compared to the time that can be demanded during usual work routines.

CONCLUSION

The two different versions of the postural elevation equipment did not alter the pressure pain threshold in the areas analyzed (T12-L1, L5-S1, ATT and calcaneus), both in the group of people with amputation and in the control group. This response is relevant and favorable to the use of the equipment, since no change in sensitivity was evidenced in the analyzed regions, which have greater contact with stabilization elements and weight discharge of the equipment. In addition, this finding allows new and broader studies, involving long-term adaptations to the use of the equipment, to be carried out.

AUTHORS' CONTRIBUTIONS

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Data Collection, Conceptualization, Resource Management, Research, Methodology, Writing - Preparation of the Original, Visualization
Gabriella Coelho Vieira de Melo Alves
Data Collection, Research
Gisele Harumi Hotta
Conceptualization, Methodology, Writing - Review and Editing, Validation
Liana Praça Oliveira
Data Collection, Resource Management, Research
Francisco Carlos de Mattos Brito Oliveira
Funding Acquisition, Project Management, Supervision
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Statistical Analysis, Conceptualization, Resource Management, Project Management, Methodology, Writing - Review and Editing, Supervision, Validation, Visualization

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