IMMEDIATE EFFECT OF AN ORTHOSTATIC DEVICE IN AMPUTEES WHO PRACTICE PHYSICAL ACTIVITY

ORIGINAL ARTICLE
ARTIGO ORIGINAL
ARTÍCULO ORIGINAL

EFEITO IMEDIATO DE UM DISPOSITIVO ORTOSTÁTICO EM AMPUTADOS PRATICANTES DE ATIVIDADE FÍSICA

EFECTO INMEDIATO DE UN DISPOSITIVO ORTOSTÁTICO EN AMPUTADOS QUE PRACTICAN ACTIVIDAD FÍSICA

Gabriella Coelho Vieira de Melo Alves[1] (Physiotherapist)
Gisele Harumi Hotta[1,2] (Physiotherapist)
Débora Pinheiro Aguiar[1] (Physiotherapist)
Liana Praça Oliveira[1,3] (Physiotherapist)
Marie Aquino Melo de Leopoldino[3] (Physiotherapy Student)
Jefferson Pacheco Amaral Fortes[4] (Physiotherapist)
Francisco Carlos de Mattos Brito Oliveira[1,4] (Computational Scientist)
Francisco Fleury Uchoa Santos Júnior[1,2,5] (Physiotherapist)

1. Centro de Pesquisa, Desenvolvimento e Inovação da Dell, Dell Lead, Fortaleza, Ceará, Brazil.
2. Universidade de São Paulo, Faculdade de Medicina de Ribeirão Preto, Department of Health Sciences, Ribeirão Preto, São Paulo, Brazil.
3. Centro Universitário Estácio do Ceará, Department of Physiotherapy, Fortaleza, Ceará, Brazil.
4. Department of Computational Sciences, Universidade Estadual do Ceará, Fortaleza, Ceará, Brazil.
5. Centro Universitário Fametro, Department of Physiotherapy, Fortaleza, Ceará, Brazil

Correspondence:
Francisco Fleury Uchoa Santos Junior
R. Jaime Pinheiro, 36 Patriolino Ribeiro, Fortaleza, CE, Brasil. 60810-250.
drfleuryjr@gmail.com

ABSTRACT

Introduction: Lower limb amputation affects mainly economically active young adults, causing great socio-economic impact due to impaired work capacity, socialization, and quality of life. Thus, the use of orthostatic devices could make reintegration of the individual back into the work environment possible. Objective: To evaluate the immediate effect of using a postural elevation device on physiological parameters and plantar pressure levels in amputees who practice physical activity. Methods: Sociodemographic and perceived sleep quality data were collected from 14 adults of both sexes with lower limb amputations, who practice physical activity. The participants were placed in postural elevation equipment for a period of 90 minutes with monitoring of physiological parameters such as blood pressure, heart rate, and oxygen saturation. Parameters related to the autonomic nervous system and plantar pressure levels were also evaluated. Data were also collected during recovery at 15- and 30-minute intervals after using the device. Data analysis was performed using two-way ANOVA or a mixed-effects model with Sidak's multiple comparisons test. Results: For all cardiovascular parameters ($p>0.05$) analyzed, the activation level of the autonomic nervous system ($p>0.05$), and plantar pressure ($p>0.05$), no evidence of differences was observed during use of the orthostatic device in all evaluated periods. Conclusion: The use of postural elevation equipment for 90 minutes does not generate, as an immediate effect, changes in physiological parameters and postural control in amputees who practice physical activity. ***Level of evidence II; Therapeutic studies – investigation of treatment results. Clinical relevance statement.***

Keywords: Amputees; Autonomic nervous system; Biomechanical phenomena.

RESUMO

Introdução: A amputação de membros inferiores afeta em sua maioria adultos jovens economicamente ativos, o que ocasiona grande impacto socioeconômico devido ao comprometimento da capacidade laboral, socialização e qualidade de vida. Desta forma, as utilizações de dispositivos ortostáticos possibilitariam a reinserção do indivíduo no ambiente de trabalho. Objetivo: Avaliar o efeito imediato da utilização de um dispositivo de elevação postural nos parâmetros fisiológicos e nos níveis da pressão plantar de amputados praticantes de atividade física. Métodos: Foram coletados os dados sociodemográficos e a percepção da qualidade do sono de 14 adultos de ambos os sexos com amputações de membro inferior que praticam atividade física. Os participantes foram colocados em um equipamento de elevação postural durante 90 minutos com monitorização dos parâmetros fisiológicos como pressão arterial, frequência cardíaca, saturação e sistema nervoso autônomo, além dos níveis da pressão plantar. Os dados também foram coletados durante a recuperação (15 e 30 minutos depois do uso do dispositivo). A análise dos dados foi realizada pela ANOVA two-way ou modelo de efeitos mistos com teste de comparações múltiplas de Sidak, $p < 0,05$. Resultados: Para todos os parâmetros cardiovasculares ($p > 0,05$) analisados, nível de ativação sistema nervoso autônomo ($p > 0,05$) e pressão plantar ($p > 0,05$) não foram observadas diferenças ao longo do uso do dispositivo ortostático em todos os períodos avaliados. Conclusão: A utilização do equipamento de elevação postural por 90 minutos não gera como efeito imediato, alterações nos parâmetros fisiológicos e no controle postural de amputados praticantes de atividade física. ***Nível de evidência II; Estudos terapêuticos: investigação dos resultados dos tratamentos Declaração de relevância clínica.***

Descritores: *Amputados; Sistema nervoso autônomo; Biomecânica.*

RESUMEN

Introducción: La amputación de miembros inferiores afecta mayoritariamente a jóvenes adultos económicamente activos, lo que provoca un gran impacto socioeconómico debido al compromiso de la capacidad laboral, la socialización y la calidad de vida. Así, el uso de dispositivos ortostáticos permitiría la reinserción del individuo en el entorno laboral. Objetivo: Evaluar el efecto inmediato del uso de un dispositivo de elevación postural en los parámetros fisiológicos y en los niveles de presión plantar de amputados que practican actividad física. Métodos: Se recogieron datos sociodemográficos y la percepción de la calidad del sueño de 14 adultos de ambos sexos con amputaciones de miembros inferiores, practicantes de actividad física. Los participantes fueron colocados en equipos de elevación postural durante 90 minutos con monitoreo de parámetros fisiológicos como presión arterial, frecuencia cardíaca, saturación y sistema nervioso autónomo, además de los niveles de presión plantar. También se recopilaron datos

Associate Editor responsible for the review process: Julia Maria D'andrea Greve

durante la recuperación a intervalos de 15 y 30 minutos después de usar el dispositivo. El análisis de datos se realizó mediante ANOVA two-way o un modelo de efectos mixtos con la prueba de comparaciones múltiples de Sidak, p < 0,05. Resultados: Para todos los parámetros cardiovasculares (p> 0,05) analizados, el nivel de activación del sistema nervioso autónomo (p> 0,05) y la presión plantar (p> 0,05), no se observaron diferencias a lo largo del uso del dispositivo ortostático en todos los períodos evaluados. Conclusión: El uso del equipo de elevación postural durante 90 minutos no genera, como efecto inmediato, cambios en los parámetros fisiológicos y en el control postural de los amputados que practican actividades físicas. ***Nivel de evidencia II; Estudios terapéuticos: investigación de los resultados de los tratamientos. Declaración de relevancia clínica.***

Descriptores: *Amputados; Sistema nervioso autónomo;* Fenómenos biomecánicos.

DOI: http://dx.doi.org/10.1590/1517-8692202329012021_0304 Article received on 06/28/2021 accepted on 02/15/2022

INTRODUCTION

Limb amputation is a widely used resource in cases of injuries involving nerves, arteries, soft tissues, and bones[1,2] and those that may be related to traumatic processes, tumors, thromboses, and infections.[1,2] Its high prevalence has mainly been associated with military conflicts, but is currently related to trauma resulting from traffic accidents, work accidents, the presence of and complications from chronic diseases such as diabetes mellitus, and urban violence.[1,2] It affects mostly young, economically active adults, which can have a significant socioeconomic impact due to the loss of work capacity, socialization, and consequently of the quality of life.[1,3] In Brazil, in 2020 alone, 25,198 lower limb amputation surgeries were performed, generating an annual cost to the Brazilian healthcare system of over R$64 million, with the Southeast and Northeast regions accounting for the highest costs for this resourse.[3]

Amputation of the lower limbs leads to important hemodynamic, physical, and psychological changes.[4] In addition, possible adverse consequences to the cardiovascular system include high coagulability, changes in blood pressure, and insulin resistance.[5] Thus, amputees seem likely to present a functional imbalance in the autonomic nervous system as compared to healthy and non-amputee individuals, with higher heart rate, blood pressure, plasma norepinephrine, and sympathetic nerve activity values.[5,6] Furthermore, limb amputation contributes to psychosocial alterations, leading to increased consumption of alcohol, smoking, and reduced physical activity, with obesity as a possible consequence.[7]

The physical changes occur mainly due to the asymmetry caused by the absence of the sustaining limb, the dependence on an artificial limb (prosthesis) to help support the body, and muscle control, activation, and strength deficiencies that can lead to compensatory hip, pelvis, and trunk movements.[8,9] Thus, changes in postural balance are identified in amputees and the essential performance capacity of the body to maintain daily functions and to engage, for example, in sports and high demand activities becomes impaired.[10] Therefore, although it is a challenge, amputees should be encouraged to live physically active lives,[11,12] aiming to reduce post-amputation physical and hemodynamic problems, in addition to promoting social inclusion, improved self-esteem, and independence, leveraging the rehabilitation process.[13]

Reintegration of the amputee into the social and work environments as the final goal of rehabilitation is considered one of the greatest challenges faced, since it requires adaptation of the environment and the work routines.[12,14] Thus, in relation to social policies in Brazil that involve the health and social security of the worker, the reinstatement of the disabled individual is currently supported by Law 13146/2015, called the Brazilian Law for the Inclusion of Disabled Persons (Disabled Persons Statute), which guarantees disabled persons the right to free choice of employment and acceptance, in an accessible and inclusive environment, with opportunities equal to those of the other people.[12] It is estimated that approximately 66% of individuals who have undergone lower limb amputations return to the work environment, however the context depends on the level of disability resulting from the amputation. Other problems with reintegration, like adaptation to the prosthesis, restrictions on mobility, and difficulties performing work activities are also reported and need to be the focus of studies that aim to minimize and even eliminate this barrier to the execution of work activities.[12,15] In this way, the use of devices that help amputees to return safely to activities in the work environment ensures not only individual rights, but also equal opportunities and improved quality of life.

Considering the changes related to the process of lower limb amputation and the difficulty of reintegration into the work environment with safety, comfort, and adaptability, the objective of the study was to evaluate the immediate effect of using a postural elevation device on the physiological parameters and the plantar pressure levels of amputees who engage in physical activity.

METHODS

Description of the study subjects

This was a longitudinal experimental study, approved by the Research Ethics Committee of the Centro Universitário Estácio do Ceará, as CAAE number 07192819.6.0000.5038. Fourteen individuals, predominantly males (n=8), with a mean age of 31, participated in the study. The sample had a mean weight of 70.16 (± 14.73) kg, a mean height of 67 (± 0.09) cm, a mean body mass index (BMI) of 25.20 kg/m^2. The individuals played physical/ sports activities, such as soccer, handball, and track and field activities in adapted form, with hour-long training sessions twice a week (Table 1).

Eligibility criteria

Individuals of both sexes with unilateral lower limb amputations at the transtibial, femoral, or hip level, who had been using a prosthesis for at least six months (in order to avoid lower limb prosthesis adaption process issues) were included. They also had to be between 18 and 50 years of age, between 1.55 and 1.75 meters tall, with a maximum weight of 100 kg, due to the ergonomic conditions of the postural elevation equipment.

Individuals with uncontrolled blood pressure and associated vascular alterations (coagulation disorders, decompensated diabetes, a history of thrombosis diagnosed after lower limb amputation surgery by the

Table 1. Characterization of the study sample (N=14)

	Amputees
Sex (Male)	8
	SD
Age (Years)	31 (6.21)
Weight (kg)	70.16 (14.73)
Height (cm)	1.67 (0.09)
BMI (kg/m2)	25.20 (5.34)
Sleep quality (0-10)	8.18 (1.20)

SD: Standard Deviation

physician) were excluded. Those who had any severe cognitive/psychological dysfunction that could interfere with the test performance, such as panic syndrome, depression, or anxiety attacks during evaluation, or individuals with any relevant speech disorder that could hinder communication during the tests were also excluded.

Equipment Description

The equipment, an orthostatic elevation device with automated ankle movements (circulatory support system) was designed, developed, and built by the engineering team of the proposing university in partnership with Dell Computers®. The structure of this device was constructed using AISI 409 stainless steel tubes, 28 mm in diameter and 0.7 mm in thickness, with joints and articulated connections that allow the movement of the seats and backs to the vertical position. In addition, custom upholstery and special straps with pressure adjustments were developed and installed to provide a better anthropomorphic fit between the user and the equipment (Figure 1).

Parameter descriptors

Heart rate variability (HRV) data was collected using the Inner Balance® sensor and application. The neurocardiac measurement was evaluated by the RR interval through a sensor positioned on the earlobe, which is considered a reliable, valid, and non-invasive method.[16] The data were synchronized to the EmWave Pro software and the generated files were submitted to the Kubios HRV® Standard version 2.1 software for data conversion and HRV analysis, where they were transformed into the following variables: parasympathetic nervous system (PNS), sympathetic nervous system (SNS), mean distance between the RR waves of the QRS complex (RR), and mean heart rate variability (HRV).

The cardiovascular parameters were monitored by systolic blood pressure (SBP), diastolic blood pressure (DBP), heart rate (HR), and oxygen saturation (SaO_2), before, during, and after using the equipment. Blood pressure was measured using a digital sphygmomanometer (BIC™), and oxygen saturation and heart rate using an oximeter (BIC™). All data were collected prior to, during, and after the tests with the participants in orthostatism. Subjects were weighed on a Renpho® digital scale and they remained barefoot for the plantar area and plantar pressure (mean and maximum) analysis. The measurements were taken via baropodometry, using the Medicapteurs® T-Plate instrument, with a 50-second collection time. Data collection was repeated at each evaluation.

Data Collection and Procedures

All procedures and data collection were explained to the participants who read and signed the Free and Informed Consent Form. First, the participants answered a form developed by the researchers to collect personal data for sample characterization. Then height and weight were measured with a metric tape measure and digital scale. Because of the influence of sleep on cardiac parameters and the autonomic nervous system, sleep quality was evaluated according to the individual's perception using a Likert scale from 0 to 10, with higher values corresponding to better sleep quality. After the initial collection of demographic data and physiological parameters (HR, BP, SaO_2, and HRV) the participant was positioned on the postural elevation device and the safety straps were secured by the researchers in the chest, hip, thigh, and leg regions. The participant was oriented on how chest straps work and how to adjust them if necessary. The individual was seated on the device and remained at rest for five minutes before the first heart rate frequency variability evaluation was performed using the short duration protocol (5 minutes) of the Inner Balance™ with the sensor positioned on the earlobe.[17–19] With the participant still in the pre-test resting position, oxygen saturation and heart rate were measured.

The device was then elevated to the orthostatic position (Figure 2). While the participant remained in this condition without performing any specific task for 90 minutes, the SaO_2, BP, and HR parameters were collected at 15-minute intervals. The measurement of the ANS and baropodometry were conducted every 30 minutes. The baropodometric analysis of the plantar area was collected at times 0, 30, 60, and 90 minutes of device elevation and the mean and maximum pressure were collected for 50 seconds at each time. After the 90-minute period, the device was adjusted to the resting position allowing the participant to remain in a sitting position. The SaO_2, BP, and HR parameters were also collected 15 and 30 minutes after the end of the experiment to verify the return to resting conditions and as a control. Thus, the participants completed a total of 10 evaluations.

Data analysis

The data were analyzed using Graphpad Prism 9.0 statistical software. The Shapiro-Wilks normality tests were applied, followed by two-way ANOVA or the mixed-effects model with Sidak multiple comparison test ($p < 0.05$). The data were expressed as mean ± standard deviation and/or CI 95% (confidence interval).

The normality values considered were systolic blood pressure (SBP) and diastolic blood pressure (DBP) of 120/80 mmHg,[20,21] heart rate lower than 100bpm, and oxygen saturation above 95%.[21]

RESULTS

The cardiovascular parameters evaluated in this study are presented in Table 2. No evidence of differences was observed for any of the parameters collected and evaluated before, during, or after the use of

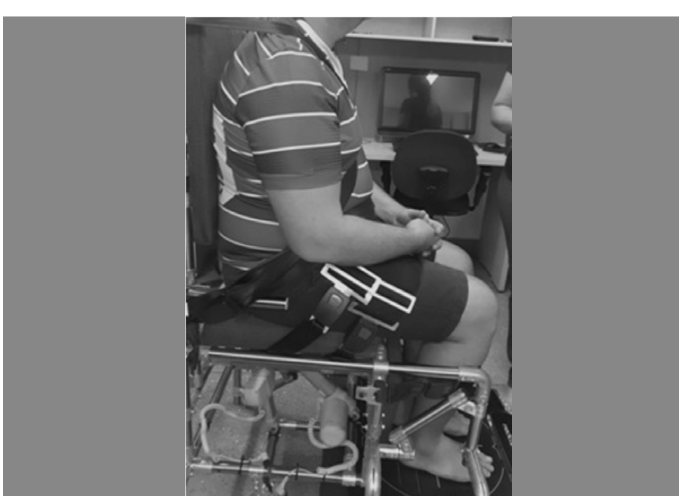

Figure 1. Orthostatic elevation device.

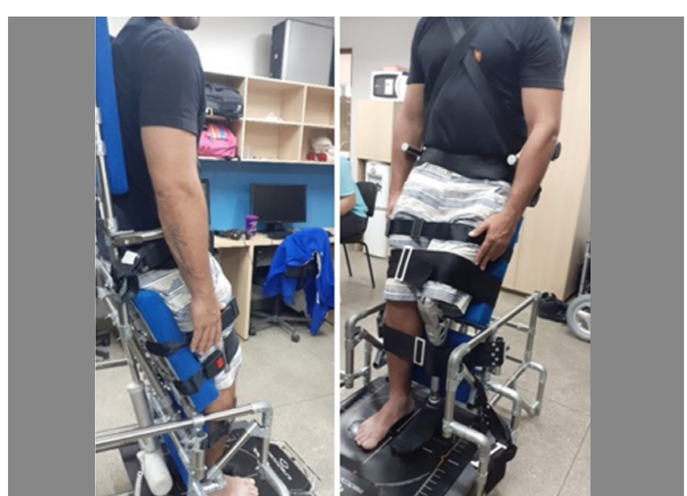

Figure 2. Elevated device. Stabilization straps on the hip, thigh, and leg region.

Table 2. Comparison of the evolution of cardiovascular parameters during 90 minutes of maintaining the orthostatic position

	Amputees (N=14)		
	Mean (SD)	p value	Mean Difference (CI 95%)
Systolic Blood Pressure (mmHg)			
Baseline	113.6 (11.51)	---	---
Time 0	115.0 (14.54)	>0.9999	-1.43(-8.78 to 5.93)
Time 15 minutes	117.1 (11.39)	>0.9999	-3.57 (-14.76 to 7.61)
Time 30 minutes	120.7 (17.74)	0.9514	-7.14 (-21.85 to 7.57)
Time 45 minutes	117.1 (13.26)	>0.9999	-3.57 (-14.76 to 7.61)
Time 60 minutes	119.3 (14.92)	0.9839	-5.71 (-18.56 to 7.13)
Time 75 minutes	119.3 (15.92)	0.9968	-5.71 (-19.96 to 8.53)
Time 90 minutes	120.7 (15.92)	0.8734	-7.14 (-20.50 to 6.22)
Recovery 15 minutes	114.4 (10.85)	>0.9999	-0.86 (-9.85 to 8.13)
Recovery 30 minutes	116.0 (10.76)	>0.9999	-2.43 (-11.05 to 6.19)
Diastolic Blood Pressure (mmHg)			
Baseline	77.14 (10.69	---	---
Time 0	80.71 (12.07)	0.9998	-3.57 (-13.88 to 6.73)
Time 15 minutes	77.86 (11.22)	>0.9999	-0.71 (-11.78 to 10.35)
Time 30 minutes	79.29 (10.72)	>0.9999	-2.14 (-12.05 to 7.76)
Time 45 minutes	80.00 (8.771)	>0.9999	-2.86 (-12.01 to 6.30)
Time 60 minutes	81.43 (12.92)	>0.9999	-4.29 (-17.13 to 8.56)
Time 75 minutes	82.86 (12.67)	0.9928	-5.71 (-19.28 to 7.85)
Time 90 minutes	80.71 (9.972)	>0.9999	-3.57 (-16.34 to 9.19)
Recovery 15 minutes	75.71 (11.58)	>0.9999	1.43 (-9.97 to 12.82)
Recovery 30 minutes	77.14 (9.139)	>0.9999	0.000 (-9.73 to 9.73)
Heart Rate (bpm)			
Baseline	75.93 (11.12)	---	---
Time 0	75.29 (12.84)	>0.9999	0.64 (-12.36 to 13.64)
Time 15 minutes	78.93 (11.44)	>0.9999	-3.00 (-14.25 to 8.25)
Time 30 minutes	78.64 (17.98)	>0.9999	-2.71 (-25.73 to 20.30)
Time 45 minutes	78.71 (11.91)	>0.9999	-2.79 (-19.92 to 14.35)
Time 60 minutes	79.36 (13.17)	>0.9999	-3.43 (-18.29 to 11.43)
Time 75 minutes	79.07 (14.47)	>0.9999	-3.14 (-19.87 to 13.59)
Time 90 minutes	77.86 (13.42)	>0.9999	-1.93 (-15.39 to 11.54)
Recovery 15 minutes	69.43 (12.80)	0.9218	6.50 (-6.30 to 19.30)
Recovery 30 minutes	70.36 (13.22)	0.9973	5.57 (-8.45 to 19.59)
Oxygen Saturation (%)			
Baseline	98.00 (1.47)	---	---
Time 0	97.93 (1.07)	>0.9999	0.07 (-2.04 to 2.18)
Time 15 minutes	97.21 (1.58)	0.9922	0.78 (-1.07 to 2.64)
Time 30 minutes	97.50 (1.34)	>0.9999	0.50 (-1.75 to 2.75)
Time 45 minutes	97.43 (0.94)	>0.9999	0.57 (-1.15 to 2.30)
Time 60 minutes	97.14 (1.66)	0.9988	0.86 (-1.40 to 3.11)
Time 75 minutes	97.21 (1.58)	>0.9999	0.78 (-1.64 to 3.21)
Time 90 minutes	97.50 (1.09)	>0.9999	0.50 (-1.05 to 2.05)
Recovery 15 minutes	97.71 (1.38)	>0.9999	0.28 (-1.99 to 2.56)
Recovery 30 minutes	97.86 (1.23)	>0.9999	0.14 (-1.98 to 2.27)

SD: Standard Deviation, CI: Confidence Interval

the orthostatic elevation device (p>0.05), indicating constancy of the vital signs evaluated during the experiment within the parameters of normality considered in the present study.

In Table 3, the values related to the distribution characteristics of the plantar area and pressure captured by the baropodometer are presented. No differences were observed before or during the use of the orthostatic elevation device for the variables area, mean pressure, and maximum pressure (p>0.05).

No difference was observed between the HRV values measured before and during the use of the orthostatic elevation device (p>0.05) (Table 4). In addition, sleep quality had a score of 8.18 (± 1.20), indicating good quality reported by the study participants.

DISCUSSION

The objective of the study was to evaluate the immediate effect of using a postural elevation device on the physiological parameters and

Table 3. Kinetic variables of the participants.

	Amputees (N=14)			
	Mean	(SD)	p value	Mean difference (CI 95%)
Area				
baseline	132.9	31.7	---	---
Time (30)	124.2	35.4	0.9999	1.14 (-41.07 to 43.35)
Time (60)	122.5	40.9	0.9998	1.21 (-41.00 to 43.43)
Time (90)	126.2	41.4	>0.9999	-0.71 (-42.93 to 41.50)
Mean pressure				
baseline	433.8	77.52	---	---
Time (30)	458.6	104.8	0.9348	-24.86 (-136.7 to 87.03)
Time (60)	474.3	125.4	0.7722	-40.50 (-152.4 to 71.39)
Time (90)	460.3	130.5	0.9224	-26.50 (-138.4 to 85.39)
Maximum pressure				
baseline	1091	220.6	---	---
Time (30)	1200	352.8	0.7910	-108.9 (-421.1 to 203.2)
Time (60)	1266	321.3	0.4502	-175.4 (-487.5 to 136.8)
Time (90)	1245	333.1	0.5594	-154.4 (-466.5 to 157.8)

SD: Standard Deviation, CI: Confidence Interval

Table 4. Functional analysis of the autonomic nervous system (N=14).

	Amputees (N=14)			
	Mean	(SD)	p value	Mean difference (CI 95%)
PNS index				
Time (0)	1.49	1.61	---	---
Time (30)	0.26	1.02	0.19	1.22 (-0.32 to 2.77)
Time (60)	0.01	0.93	0.13	1.48 (-0.25 to 3.21)
Time (90)	0.16	0.83	0.28	1.32 (-0.49 to 3.14)
SNS index				
Time (0)	-0.05	0.67	---	---
Time (30)	0.53	0.84	0.15	-0.58 (-1.28 to 0.12)
Time (60)	0.64	1.00	0.48	-0.69 (-1.78 to 0.41)
Time (90)	0.53	0.65	0.16	-0.57 (-1.27 to 0.12)
Mean PNS RR				
Time (0)	799.5	101.3	---	---
Time (30)	770.4	111.1	0.99	29.07 (-63.87 to 122.0)
Time (60)	761.6	115.8	0.96	37.93 (-60.74 to 136.6)
Time (90)	755.6	113.0	0.97	43.86 (-73.90 to 161.6)
Mean SNS HR				
Time (0)	76.21	9.58	---	---
Time (30)	79.50	10.98	0.98	-3.29 (-12.84 to 6.27)
Time (60)	80.43	11.77	0.92	-4.21 (-14.27 to 5.84)
Time (90)	81.00	11.13	0.94	-4.79 (-16.64 to 7.07)

PNS: Parasympathetic Nervous System, SNS: Sympathetic Nervous System, SD: Standard Deviation

the postural balance control of amputees who practice physical activity. The results demonstrate that for this population the use of the device for 90 minutes did not influence the parameters evaluated, and the amputees remained clinically stable. Considering that the individuals included practice physical activity, the parameters evaluated such as BP, HR, SaO_2, and HRV were stable and without statistically significant differences after the use of the orthostatic elevation device.

It is known that practicing physical activity generates benefits such as reduced mortality in healthy individuals and/or in those with heart diseases[23] and leads to an increase in cardiorespiratory fitness, preventing cardiovascular and chronic diseases.[24] The SBP and DBP values remained unchanged throughout the monitoring, demonstrating that the use of postural elevation support does not alter parameters considered important in amputees who practice physical activity, maintaining physiological homeostasis. Although this relationship is not yet well established, the loss of metabolic activity in the tissues can contribute to an increase in insulin and hyperlipidemia in the blood, and the increased blood pressure associated with the increase in sympathetic activity, especially during activities in which there is elevated pressure in the stump region (for example, during gait or standing) can lead to an increase in risk factors related to cardiovascular diseases.[25] The present study sample does not include diagnoses of diabetes and the participants practice physical activities, which may have contributed to the stability of the analyzed variables.

In humans, during rest, there seems to be a predominance of parasympathetic activity, while during stimuli, such as orthostatism, the sympathetic nervous system makes a greater contribution, explained, for example, by the fact that the system is preparing for situations of stress and effort.[25] These changes were described by Mahananto, Igasaki, and Murayama (2015), demonstrating that healthy individuals have an increase in sympathetic activity, and a decrease in parasympathetic and vagal activity when moving from a sitting to an upright posture.[26] Silva et al. (2019) evaluated amputees and observed that the active change in posture, from a sitting to a standing position, lead to an activation of autonomic and sympathetic modulation within the expected behavior of the individuals.[6] Our results showed that using the orthostatic device did not generate any interference in the sympathetic and parasympathetic nervous system parameters measured, indicating that the use of the device for 90 minutes did not influence the perception of stress or physical effort generated by the prolonged standing position beyond what was expected by the volunteers.

Multifactorial components such as biomechanical restrictions, movement and sensory strategies, orientation in space, control of dynamics, and the cognitive process seem to contribute to postural control in the presence of lower limb amputations.[10] The device used in the study features a system of straps that provides the participant with greater trunk and lower limb stability. Considering that, in a standing position, the baropodometry values could increase in the absence of stabilization, which would create harmful effects for the amputees, such as, for example, reduced blood flow, greater tissue pressure, and, consequently, a higher chance of tissue injury (pressure sores or blisters), the results demonstrate that the dynamic control strategy evaluated by means of mean plantar pressure and maximum pressure were not influenced by using the orthostatic position, suggesting that the equipment offered sufficient support to aid in bearing the individual's weight.

One participant reported mild edema during the orthostatic position, which was controlled by actioning the circulatory support system. This system allows mobilization of the ankle for the movements of dorsiflexion and plantar flexion, ranging between zero and five degrees, and was developed to minimize the presence of swelling due to overload and posture maintenance.

Study limitations and future directions

The fact that the study assessed the immediate effect of using the elevation device and was not able to extrapolate the data for continuous and long-term use is a limitation. The data indicate that using new assistive technologies can be considered since they do not generate harmful effects for the amputee. Thus, further studies should be conducted to evaluate the implications of long-term and work-environment use of this device.

CONCLUSION

Using the postural elevation device for 90 minutes did not cause an immediate effect of changes in the physiological parameters or in the postural control of amputees who practice physical activity.

The authors declare that Dell Computers provided financial support for the development of this study in the form of a research grant for each author. Declaration of Financial Support: This study is financed by Dell Computers and was developed at the Universidade Estadual do Ceará within the scope of the project titled "Technologies for job accessibility in the Brazilian electronic industry".

AUTHORS' CONTRIBUTIONS: Each author made significant individual contributions to this manuscript. GCVMA: writing and data collection; GHH and DPA: data analysis and writing; LPO, MAML, and JPAF: data collection and analysis; FCMBO: writing, review, and intellectual concept; FFUSJ: data collection, writing, statistical analysis, intellectual concept, and elaboration of the entire research project.

REFERENCES

1. Peixoto AM, Zimpel SA, Oliveira ACA de, Monteiro RLS, Carneiro TKG. Prevalência de amputações de membros superiores e inferiores no estado de Alagoas atendidos pelo SUS entre 2008 e 2015. Fisioter Pesqui. 2017;24(4):378–84.
2. Chamlian TR, Varanda R dos R, Pereira CL, Resende JM de, Faria CC de. Epidemiological profile of lower limb amputees patients assisted at the Lar Escola São Francisco between 2006 and 2012. Acta Fisiátr. 2013;20(4):219–23.
3. Ministério da Saúde. Diretrizes de atenção às pessoas submetidas a amputação Ministério da Saúde [Internet]. 2013. 38 p. Available from: www.saude.gov.br
4. Gabarra LM, Crepaldi MA. Aspectos psicológicos da cirurgia de amputação. Aletheia. 2009;(30):59–72.
5. Naschitz JE, Lenger R. Why traumatic leg amputees are at increased risk for cardiovascular diseases. QJM. 2008;101(4):251–9.
6. Silva ALG da, Peiter APD, Goulart C da L, Schneiders PB, San Martin EA, Trimer R, et al. Variabilidade Da Frequência Cardíaca Em Diferentes Posições Corporais E Durante Masr Em Amputado Unilateral De Membro Inferior. Saúde e Pesqui. 2019;12(1):77-84.
7. Magalhães P, Capingana DP, Silva ABT, Capunge IR, Gonçalves MAA. Arterial stiffness in lower limb amputees. Clin Med Insights Circ Respir Pulm Med. 2011;5(1):49–56.
8. Silva V de FA, Alves FRF, Martins CA, Monteiro HC, Barbosa D, Ferreira MB, et al. Analysis of static equilibrium in unilateral transfemoral amputation: a case report. Man Ther Posturology Rehabil J. 2018;(November):1–6.
9. Devan H, Carman A, Hendrick P, Hale L, Ribeiro DC. Spinal, pelvic, and hip movement asymmetries in people with lower-limb amputation: Systematic review. J Rehabil Res Dev. 2015;52(1):1–19.
10. Ku PX, Abu Osman NA, Wan Abas WAB. Balance control in lower extremity amputees during quiet standing: A systematic review. Gait Posture [Internet]. 2014;39(2):672–82. Available from: http://dx.doi.org/10.1016/j.gaitpost.2013.07.006
11. Borg I, Mizzi S, Formosa C. Plantar pressure distribution in patients with diabetic peripheral neuropathy and a first-ray amputation. J Am Podiatr Med Assoc. 2018;108(3):225–30.
12. de Carvalho-Freitas MN, Aparecida da Silva V, Pedrosa Gomes Tettea R, de Souza Veloso H, Costa Rocha P. Retorno às atividades laborais entre amputados: Qualidade de vida no trabalho, depressão e ansiedade. Rev Psicol Organ Trab. 2018;18(4):468–75.
13. Wilhite B, Shank J. In praise of sport: Promoting sport participation as a mechanism of health among persons with a disability. Disabil Health J [Internet]. 2009;2(3):116–27. Available from: http://dx.doi.org/10.1016/j.dhjo.2009.01.002
14. Fernandez A, Isusi I, Gomez M. Factors conditioning the return to work of upper limb amputees in Asturias, Spain. Prosthet Orthot Int. 2000;24(2):143–7.
15. Burger H, Marinček Č. Return to work after lower limb amputation. Disabil Rehabil. 2007;29(17):1323–9.
16. Behrmann E, Loerke J, Budkevich TV, Yamamoto K, Schmidt A, Penczek PA, et al. Structural snapshots of actively translating human ribosomes. Cell. 2015;161(4):845–57.
17. Correia B, Dias N, Costa P, Pêgo JM. Validation of a wireless bluetooth photoplethysmography sensor used on the earlobe for monitoring heart rate variability features during a stress-inducing mental task in healthy individuals. Sensors. 2020;20(14):3905.
18. Tarvainen MP, Laitinen TP, Lipponen JA, Cornforth DJ, Jelinek HF. Cardiac autonomic dysfunction in type 2 diabetes - effect of hyperglycemia and disease duration. Front Endocrinol (Lausanne). 2014;5:130.
19. Zhang Y, Weaver RG, Armstrong B, Burkart S, Zhang S, Beets MW. Validity of Wrist-Worn photoplethysmography devices to measure heart rate: A systematic review and meta-analysis [Internet]. J Sports Sci. 2020;38(17):2021–34. Available from: https://doi.org/10.1080/02640414.2020.1767348
20. Picone DS, Schultz MG, Otahal P, Aakhus S, Al-Jumaily AM, Black JA, et al. Accuracy of Cuff-Measured Blood Pressure: Systematic Reviews and Meta-Analyses. J Am Coll Cardiol. 2017;70(5):572–86.
21. Peterson BK. Vital Signs [Internet]. Physiscal Rehabilitation. 2007;598–624. Available from: http://dx.doi.org/10.1016/B978-0-7216-0361-2.50025-9
22. Mason JW, Ramseth DJ, Chanter DO, Moon TE, Goodman DB, Mendzelevski B. Electrocardiographic reference ranges derived from 79,743 ambulatory subjects. J Electrocardiol. 2007;40(3):228–34.
23. Jeong SW, Kim SH, Kang SH, Kim HJ, Yoon CH, Youn TJ, et al. Mortality reduction with physical activity in patients with and without cardiovascular disease. Eur Heart J. 2019;40(43):3547–55.
24. Lavie CJ, Ozemek C, Carbone S, Katzmarzyk PT, Blair SN. Sedentary Behavior, Exercise, and Cardiovascular Health. Circ Res. 2019;124(5):799–815.
25. Peles E, Akselrod S, Goldstein DS, Nitzan H, Azaria M, Almog S, et al. Insulin resistance and autonomic function in traumatic lower limb amputees. Clin Auton Res. 1995;5(5):279–88.
26. Mahananto F, Igasaki T, Murayama N. Potential force dynamics of heart rate variability reflect cardiac autonomic modulation with respect to posture, age, and breathing pattern. Comput Biol Med [Internet]. 2015;64:197–207. Available from: http://dx.doi.org/10.1016/j.compbiomed.2015.07.005.