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Development and evaluation of low-cost walker with trunk support for senior citizen*

Desenvolvimento e avaliação de andador de baixo custo com suporte de tronco para idosos
Desarrollo y evaluación de andador de bajo costo con soporte de tronco para ancianos

Paloma Hohmann Poier[1], Francisco Godke[2], José Aguiomar Foggiatto[1], Leandra Ulbricht[3]

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[1] Universidade Tecnológica Federal do Paraná, Programa de Pós Graduação em Engenharia Mecânica e de Materiais, Curitiba, PR, Brazil.

[2] Universidade Tecnológica Federal do Paraná, Departamento de Mecânica, Curitiba, PR, Brazil.

[3] Universidade Tecnológica Federal do Paraná, Programa de Pós Graduação em Engenharia Biomédica, Curitiba, PR, Brazil.

ABSTRACT

Objective: Develop and evaluate a low-cost walker with trunk support for senior citizens. **Method:** Two-stage descriptive study: development of a walker with trunk support and evaluation with fourth age senior citizens. **Results:** Twenty-three fourth age senior citizens were selected. The evaluated criteria were the immediate influence of the walker on the static stabilometry with baropodometer and the evaluation of gait with accelerometers monitoring time and amplitude of the hip movement. There was a significant decrease in the body oscillation of senior citizens with the use of the developed walker, and there were changes in the joint amplitudes of the hip, but they were not significant. **Conclusion:** Using low-cost materials, it was possible to develop and equipment that met resistance and effectiveness requirements. The walker interfered in the balance of the senior citizens, reducing significantly the static body oscillation.

DESCRIPTORS

Walkers; Aged, 80 and over; Postural Balance; Low Cost Technology.

Corresponding author:
Paloma Hohmann Poier
Núcleo de Manufatura Aditiva e Ferramental
Rua Deputado Heitor Alencar
Furtado, 5000 – Ecoville
CEP 81280-340 – Curitiba, Paraná, Brazil.
palomahoh@gmail.com

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INTRODUCTION

The population group called fourth age, or very old senior citizens, is formed by people aged 80 or more[1]. This plot is growing and, according to demographic projections, they will be 30% of the Brazilian population in 2050[2]. In spite of this growth deriving from the improvement of basic life conditions, functionality cannot follow the passing of time[3-4]. Therefore, senior citizens are a heterogeneous group as for the independence in completing activities of interest and in the quality of life[2,5].

Among the possible difficulties related to the age increase, there are balance and gait alterations, known as Postural Instability. With the decline of the sensorial capacities and the decrease of biomechanical skills, senior citizens tend to present unbalances and difficulties to maintain orthostatism and, consequently, an independent gait[6]. The most dangerous consequence of these alterations is falling, which may cause fractures and immobilization[4,7]. In these cases, there may be a decrease in the bone mass, reduction of the blood circulation, alterations in the respiratory function, appearance of pressure ulcers, urinary incontinence and intestinal constipation[8]. In addition, falls are the main mortality and morbidity cause among older senior citizens[9]. The occurrence of falling episodes increases with the age, since around 30% of the individuals aged more than 65 falls at least once a year; above 74, this index increases to 35% and after 85 years old, it goes up to 51%[10].

With the intent to stimulate mobility, independence and functionality in senior citizens, it is possible to introduce gait or locomotion helping devices in their routine[11]. Depending on the damage level, it is possible to recommend the use of walking sticks, walkers, wheel walkers or, in extreme cases, wheelchairs. Walkers are used to help balance and totally or partially reduce the weight support of the lower limbs[12-13]. In addition to common walkers, locomotion trainings based on the partial weight support provide positive results in the static and dynamic balance and help performing the functional gait[12]. Other benefits from body support are the psychological repercussions in the reduction of the fear of falling[12]. In spite of the benefits, there are studies explaining that the use of a gait helping device may cause falls in case it is poorly designed, wrongly recommended or wrongly used[14-15]. This shows the importance of evaluating the interference of these resources on the balance and mobility of senior citizens, due to the growing number of users that motivates studies investigating effectiveness and influence[15]. In this context, health evaluation technologies may be investigation tools. Knowing and monitoring the activities performed by senior citizens may help health professionals in possible interventions, creating feedback on their evaluation[16]. Movement sensors allow measuring the intensity of a performed activity, the step quantity or standing time, as well as other variables[16]. These health technologies may be also used to create information about the influence of using walkers with trunk support on senior citizens[15]. The evaluation of these gait helping devices is an essential factor to avoid possible harms.

Another important aspect in recommending a walker is the financial factor. Models with trunk support systems present an approximate cost of R$ 2,500.00[a], and are not made in Brazil. In this context, the intent of this research was to develop a walker with partial body support system, but with a low cost. Subsequently, the goal was to evaluate the immediate interference of the walker on the body oscillation and the gait of fourth age senior citizens with postural instability. Finally, the device capacity to promote orthostatism and safe walking were observed.

METHOD

It is a descriptive research divided into two steps: development of the walker and evaluation with senior citizens. Each step will be presented hereinafter.

Development of the walker and trunk support system

In order to define the essential characteristics of the walker and the trunk support system, a study about commercial walkers was conducted and, at the same time, the needs and suggestions of health professionals working with the senior population were collected. This study occurred through a semi-structured interview, where the possible functional activities that could be helped by the use of support equipment for orthostatism and walking were questioned. In this context, it was possible to observe that walkers should allow getting closer to tables and shelves and help moving to toilets or chairs. The raw material of the structure should be easily found, low-cost, have high mechanical resistance and allow simple assembling. PVC 50 mm, used in the composition of hydraulic networks, was the selected material to meet these requirements. Considering that the walker could be manipulated inside houses whose doors, generally speaking, are 70 cm wide and 210 cm tall, it was established that sides and height should not exceed these measures. In order to define the maximum height of the walker, researches about anthropometric data of the senior population were searched for. Studies indicate a height range between 130 cm and 180 cm[17]. As for rotations, the commercially called "gel wheels" were chosen, measuring 10 cm, which provide easy steering because of their small friction coefficient. In order to define the length, the extension of senior citizens' steps was considered, which varies between 70 and 82 cm[18-19], and 30 cm were added in order to help fitting toilets or chairs. The handhold diameter was based in the International Technical Standard ISO 11199-1, called "Walking AIDS manipulated by both arms – Requirements and test methods", of common walkers[20]. According to this standard, the diameter must be between 20 mm and 50 mm. In order to make the support system and vest, there was a research about high resistance and durability fabrics, and the polyester tape, able to support up to 800 kgf according to the manufacturer certification, was selected to compose the support system. Likewise, the adjusting belts were made of

[a] Price in US$: 790. It refers to December 2016, in a research conducted in specialized stores and websites.

polyester rope, used to make the safety belts. The vest was made of polyamide synthetic fabric (nylon) with high durability and resistance to traction or tear[21]. The used clips and locks were made of plastic and duralumin. The vest should be adjustable, in order to meet the various anthropometric patterns of senior citizens.

In order to evaluate the carrying capacity of the walker when submitted to different loads, the test proposed by the International Technical Standard ISO 11199-1 was conducted. According to the standard, a force above 525 N ± 2% must be applied gradually during a period of at least 2 seconds until maximum strength. The maximum strength must be applied for at least 5 seconds. After that, the existence of cracks should be observed, indicating their presence, location and potential danger. For the load simulation, a linear pneumatic actuator was used, placed in the central part of the equipment, as determined by the standard. Loads were simulated varying the pressure values applied on the cylinder. Five loads were applied, namely: 444.53 N; 889.07 N; 1,333.70 N; 1,778.23 N; and 2,222.77 N. Later, with the support system and the vest already assembled, usage tests were conducted with a young non-disabled individual, with the goal to evaluate the dynamic behavior of the walker during gait. In these tests, the stability and performance of the support structure were observed in falling simulations of the user.

Evaluation with senior citizens

Twenty-three fourth age senior citizens were selected, seven men and 16 women, from a long-stay institution for senior citizens. Inclusion criteria were: age above 75; family authorization; capacity of understanding simple requests and expressing possible problems during the evaluations; ability to maintain the orthostatic position, even with the need for support. Exclusion criteria were: traumas or falls during the last 3 months; bedridden senior citizens; senior citizens using only wheel chairs to move; presence of pressure ulcers. The project was submitted to the Research with Human Beings Ethics Committee via Plataforma Brasil and was approved under the decision number 243.208. The selected senior citizens participated voluntarily and signed an Informed Consent form. The evaluation location was a long-stay institution for senior citizens, which provided its staff for any eventuality.

The evaluation with senior citizens consisted in three steps. The first one was the application of the Functional Independence Measure (FIM), in order to divide them into three groups, according to the level of locomotion independence. The second one was the performance of the static stabilometry exam, under different conditions for each established group. The third step was the gait analysis with accelerometers, in order to observe the joint amplitude of the hip flexion and extension during gait. During this last step, there was a sample reduction, due to the complexity of the evaluation, as a safety measure for senior citizens in higher dependency conditions. Each evaluation protocol will be detailed hereinafter.

Step 1 – FIM application for group division: the goal was to evaluate which senior citizens from the sample would be potential users of the developed walker with trunk support. The senior citizens that were considered independent in performing gait composed a reference group, while the others formed to other groups according to the level of help dependency. FIM for locomotion[12] is used to define scores from 1 to 7, according to the need for locomotion assistance, being 1 totally dependent and 7 independent. Scores were defined starting from the observation of the dependency level of senior citizens in locomotion, together with information from health professionals of the institution about the presence of balance and gait alterations, regardless of their origin. Starting from FIM scores, senior citizens were divided into three groups (Figure 1).

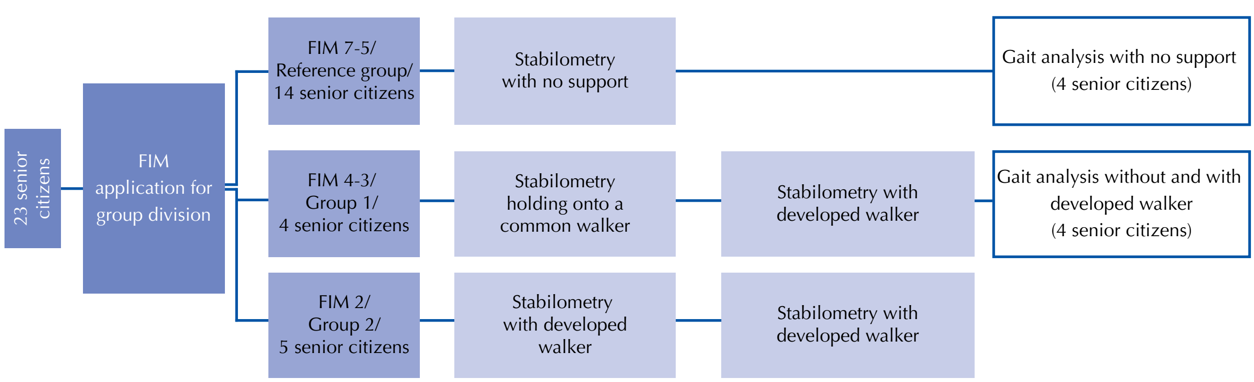


Figure 1 – Flowchart with group division starting from the application of FIM and the evaluations to which each group was submitted – Curitiba, Paraná, Brazil, 2013. Reference group – independent in gait performing, FIM scores between 7 and 5; Group 1 – needs moderate or minimum contact assistance, FIM scores between 4 and 3; Group 2 – maximum assistance, FIM score 2. The reference group was evaluated for comparative purposes and groups 1 and 2 were evaluated with the use of the developed walker. Source: Prepared by the authors.

Step 2 – Static stabilometry: it is the measurement of the body oscillations in the orthostatic posture, giving information about the individual balance[22], applied in order to verify possible stability changes caused by the use of the developed walker. Initially, the participants from the three groups were evaluated as for the habitual orthostatic position. Senior citizens from the reference group and group 1 had to remain still on the platform for 20 seconds, without any external support.

On the other hand, senior citizens from group 2 remained on the platform for the same time, but due to the dependency level, they held onto a common walker. This exam provides different variables for the analysis, but in this study it was decided to analyze only the elliptic area formed starting from the record of the movement route of the center of mass. For the evaluation, the Platform IST Footwork® (575x450x25 mm) and the software Footwork 3.6.3.0 were used.

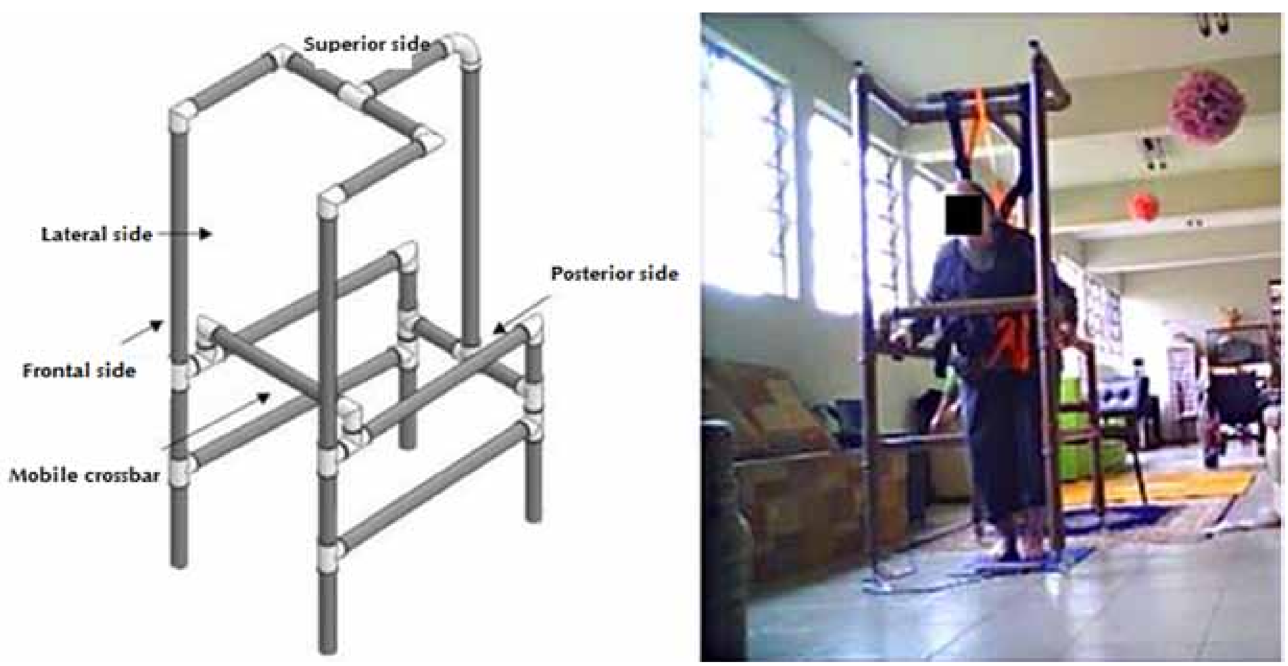
Later, in order to evaluate stabilometry with the developed walker, senior citizens from group 1 were evaluated, remaining in the orthostatic position, still, with their arms along their body. In group 2, conditions were similar, but the senior citizens held onto the developed walker.

Step 3 – Gait evaluation: this step was performed to observe the influence of using the developed walker on the gait biomechanics of senior citizens. It was decided to evaluate two variables: movement amplitude of the hip joint during gait and the time to cover a certain distance. This analysis was performed with the Biofeed® equipment, which uses accelerometers fixed on the body segment to be evaluated and records movements via radiofrequency. For the evaluation with senior citizens, two accelerometers, placed on each thigh, and the software BiosmartBiofeed Version f4.6 were used. The evaluation protocol started with the sitting senior citizen. After standing up, they had to cover a predefined distance (6 meters) and go back to the origin point (sitting). Gait evaluation was performed with four senior citizens from the reference group and four senior citizens from group 1. The reference senior citizens was evaluated performing gait without any support, and senior citizens from group 2 were evaluated with and without the use of the developed walker.

For data analysis, the descriptive statistics was applied, with position (mean) and dispersion (standard deviation and variability) measures. After verifying sample normality with the Anderson-Darling test, the Student's t test was also applied ($p<0.05$), in order to measure the statistic significance of the difference between the evaluations. All calculations were performed in the Excel® program.

RESULTS

The walker was designed with an upper part to assemble the vest and support system, the front part with a movable crossbar to allow the user access, the back part designed to help fitting on toilets and chairs, and an open side part to help getting closer to tables, cupboards or shelves. The final height measure was 190 cm, the frontal width was 68 cm and the back width was 60 cm. It was decided to reduce the back width in order to improve the chair and toilet fit. The geometric modeling result of the developed walker may be seen in Figure 2(a). Figure 2(b) shows the walker while being used by a senior citizen.

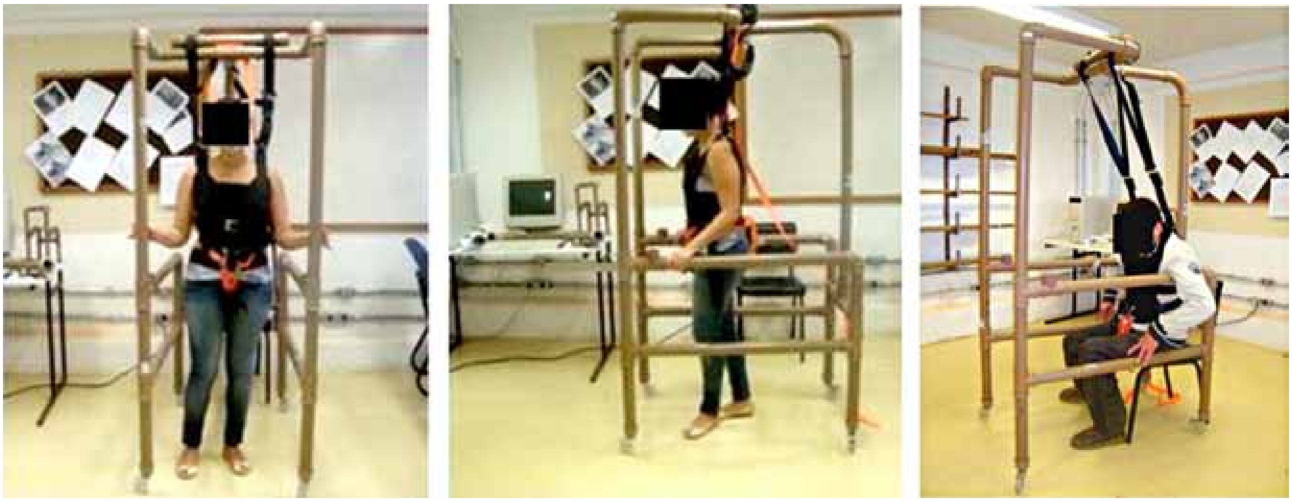


(a) (b)

Figure 2 – (a) Geometric modeling of the developed walker – Curitiba, Paraná, Brazil, 2013. (b) Senior citizen using the developed walker and vest. Source: Prepared by the authors.

As for the evaluation of the capacity to support loads, the developed walker supported a 2,222.77 N load, equivalent to 226.66 kgf, without the occurrence of cracks. In the evaluation with a young, healthy individual (Figure 3 a-b) it was possible to observe that the support system was effective in a simulation of falling and it was considered light to carry. During this test, it was possible to observe that the walker was stable to be used in plan or slightly uneven environments, and its stability to perform transfers from the sitting to the orthostatic position and vice-versa appeared proper, without the occurrence of falls.

The defined dimensions fulfilled the step and height measure of all the evaluated senior citizens, the passage through internal doors and the design of the back part allowed fitting on toilets and chairs (Figure 3c). Getting closer to benches and tables to perform activities remained limited; it was possible to do so only by the side part.



(a) (b) (c)

Figure 3 – (a) (b) Tests with an individual with no postural instability. (c) Walker with the back part fitting a chair, allowing the transfer to the sitting position – Curitiba, Paraná, Brazil, 2013. Source: Prepared by the authors.

The vest is similar to the ones used as safety equipments at height (Figure 4). The selected fabrics did not tear nor present flaws after their usage. It was chosen to include a foam mat to increase comfort and avoid pressure points. Clips and buckles, placed on the sides, upper part and lower part of the vest, allowed adjusting it to the different anthropometric patterns of the senior citizens. The cost of the walker, considering the raw material of the structure, vest and support system, as well as the vest manufacture, was approximately R$ 300.00

(a) (b)

Figure 4 – Developed vest. (a) Front (b) Back – Curitiba, Paraná, Brazil, 2013. Source: Prepared by the authors.

Result of the evaluations with senior citizens

The result of the FIM – Locomotion shows the heterogeneity of the functional abilities of the evaluated fourth age senior citizens, in spite of the average proximity of anthropometric characteristics and age. Fourteen senior citizens had scores between 7 and 5 and, therefore, composed the reference group. The age average of this group was 85.0 ± 4.6, the height average was 1.59 ± 0.15 m and the body mass average was 61.35 ± 13.63 kg. Four senior citizens presented score 4 or 3 and were framed in Group 1. They had an age average of 87 ± 3.2, height average of 1.54 ± 0.05 m and body mass average of 59.25 ± 17.03 kg. Finally, five senior citizens were considered with score 5 and formed group 2. In this group, the age average was 87 ± 9.7, the height average was 1.56 ± 0.09 m and the body mass average was 57.60 ± 16.27 kg.

The results of the stabilometry average values and standard deviations in the initial evaluation of the three groups and in the evaluation with the developed walker may be verified in Table 1. P^1 refers to the p value resulting from the comparison between data from the initial evaluation and the evaluation with the developed walker. P^2 refers to the p value resulting from the comparison between the evaluation with the developed walker and the reference group.

Results from the gait analysis using accelerometers are presented in Table 2, which refers to the average values and standard deviation of the amplitude of the hip flexion and extension movement. It also describe the time in necessary seconds to complete the distance.

Table 1 – Average result of the stabilometry initial evaluation of the three groups and with the developed walker for groups 1 and 2 – Curitiba, Paraná, Brazil, 2013.

Groups	Initial evaluation Average (cm^2)	With the developed walker Average (cm^2)	P^1	P^2
Reference group	2.981 ± 2.177	-	-	-
1	4.694 ±1.319	1.644 ± 1.249	0.048	0.277
2	14.780 ± 5.697	4.559 ± 2.730	0.042	0.724

Table 2 – Average result and standard deviation of the hip flexion and extension movement amplitude during gait performance and time in seconds to cover the 12 meter distance – Curitiba, Paraná, Brazil, 2013.

Variables	Reference group	Group 1 (whithout walker)	Group 1 (whit Walker)	P*
ADM Flexão - Q D	21.75º± 1.26	15.33º±4.16	20.67º±8.14	0.386
ADM Flexão - Q E	19.75º±1.71	17.00º±4.58	20.33º±6.51	0.508
ADM extensão - Q D	4.5º± 1.00	10.00º±5.00	7.33º±2.08	0.456
ADM extensão - Q E	5.25º± 1.26	11.33º±4.51	7.67º±5.03	0.400
Tempo p/12m (s)	24.5± 4.51	37±4.36	43±1.73	0.113

*: P value corresponding to the result of the t Student between the results of group 1 with and without the developed walker.

DISCUSSION

The developed walker with trunk support was effective in creating stability and safety during the orthostatic position and to perform gait; it presented resistance to support loads, supporting up to 226 kgf, without any damage to the equipment. As for the functionality generated by the equipment in performing activities, it was possible to observe that it may help the safe transfer to chairs and toilets. However, to use tables and benches, there is the need for changes in the design, so that the user may get closer to these work surfaces in an effective way. Compared to commercial walkers, the final price may be considered low, corresponding to about 10% of the researched similar ones. This may facilitate its use, since senior citizens may experience financial limitations due to the fragility deriving from aging[23].

As for the evaluations with senior citizens, FIM – Locomotion was an effective tool to provide information about senior citizen functionality. The application of this instrument demonstrated the differences of the sample as for the independence in performing locomotion, in spite of the small average difference among ages. Similarly, other studies show this heterogeneity in aging. Researchers report that this difference is related to intrinsic factors, such as pathologies, as well as with life habits and socioeconomic aspects[24]. Practicing some physical activity, even with low intensity, is one of the main addressed factors, since its decrease is constantly related to the increase in the fragility and stillness of the senior citizen[25]. In this context, the use of the proposed walker with trunk support may help the performing low intensity physical activities, such as walks.

In the initial stabilometry exam, the averages of the groups were very different. In the reference group, the average body oscillation was 37% lower than the one from group 1 and 80% lower than the one from group 2. By using the developed walker, there was a reduction in the body oscillation for the two evaluated groups; the statistical difference was significant ($p<0.05$) between the initial and final evaluation. In group 1, there was a 66% decrease and in group 2, it was 70%. This result from the evaluation of the second group showed a relevant difference between the stability generated by a common walker compared to the walker with trunk support. The result of the t Student test, compared to the results of the evaluation among senior citizens using the developed walker and the reference senior citizens, showed an approximation of the stabilometry values. More than one third of the senior citizens aged over 65 presented difficulties in controlling their balance[26]. Evidences show that this instability is due to difficulties in adapting to the sensorial information and the swinging increase in the median-lateral and front-back direction in senior citizens compared to young people[26]. Thus, it is interesting to observe the decrease of this swinging with the use of the developed walker. It is possible to observe that, during the step in which senior citizens from group 2 were evaluated while holding onto a common walker, the area resulting from the body oscillation was 14.780 cm^2, raising a question about the frontal body movement required for its use. Different researches have pointed out risks related to the use of common walkers[27]. A study conducted in Holland concluded that the use of common wheel walkers may increase the risk of falling and cause high risk injuries[28]. One of the causes would be the curved and forwarded position deriving from the incorrect adjustment of the walker for the senior citizen's height[28]. In the case of the developed walker, the positioning and adjustment of the vest prevent forwarding and help the erect posture. The generated stability increase shows how the developed equipment may facilitate mobility and the consequent decrease of damages caused by bed or wheelchair restrictions. A research conducted with community senior citizens pointed out the need for investments in alternatives to provide support for caregivers of people with mobility restrictions, due to the specific cares provided to this public[29]. In this context, the use of the developed walker may reduce the effort of caregivers and health professionals in performing transfers and promote perambulation safety.

As for the gait analysis with accelerometers, it was possible to observe that, in the results with the use of the developed walker, there was a redistribution of the hip joint amplitude. It was possible to verify the decrease of four extension degree and a flexion increase of about five degrees; however, there was no increase in the total amplitude. In spite of the fact that these alterations did not have statistical significance, with the use of the developed walker, the joint amplitude values of group 1 got closer to the values from the reference group. As for the information about the gait speed observed through the relation between the average time needed to cover 12 meters, there was a six second increase with the use of the walker. The gait speed is also considered an indicator of the senior citizen functionality status[30]. A research conducted in China with 4 thousand people points out the relation between the senior citizen fragility and the speed to cover a determined distance[30]. The subjects covered a distance of six meters the usual way and also responded to a questionnaire about life habits and performing daily activities. Those who walked more quickly also reported greater independence in the daily activities and mentioned healthy life habits. This is supported, in this research, by the evaluation with the accelerometer sensors that showed similar results, where more independent senior citizens walked more quickly than the dependent ones[30]. The most dependent group presented longer time than the reference group to cover the distance and with the walker, on an average, there was a decrease in speed. The hypothesis for this change with the use of the walker is that the stability increase helps careless walking; however, it may also suggest that the use of the equipment limited the gait speed because it was a new element to be managed while walking. This shows the importance of evaluating the inclusion of these equipments in the routine of senior citizens, as well as the training to use gait helping devices.

CONCLUSION

The developed walker showed potential to be used as an orthostatic facilitator and to walk safely. The mechanical tests to which the equipment was submitted supported the hypothesis that it is safe to be used by senior citizens with postural instability. Moreover, the chosen materials for its assemble and the low mechanization applied gave it the desired low cost.

FIM was a proper instrument for the group division and provided a reliable picture about the functionality of senior citizens. The use of stabilometry to evaluate the walker highlighted that it helped controlling the orthostatic posture, so that the body oscillation of the analyzed senior citizens reached values that were close to the ones that perform independent walking. This aspect helped the safety and quality of walking and demonstrates a potential use as a stabilizer. The developed walker may provide safe walking, preventing the total immobilization of senior citizens with postural instability in bed or on a wheelchair. Even if the biomechanical alterations of gait with and without the use of the walker are not statistically expressive, it was possible to observe a growth in flexion, without practicing exercise or training with this intent. Even if the evaluated sample was limited, the research suggests that fourth age senior citizens, using gait helping devices, may experience alterations in gait and balance patterns right after their insertion. Another observation in this study referred to the complexity and the difficulties of conducting a research with fourth age people. The research was only possible through the support of the long-stay institution.

It is worth suggesting, for future studies, to perform additional tests about the safety generated by the equipment, in order to validate its use as a resource for gait rehabilitation. Another aspect to be evaluated is the opinion of senior citizens about the safe or unsafe sensation experienced with the use of the developed walker. Finally, another possibility is to follow, in a longitudinal study, users of the equipment in order to evaluate changes in the gait patterns and decreases in episodes of falling.

RESUMO

Objetivo: Desenvolver e avaliar um andador de baixo custo com sustentação de tronco para idosos. **Método:** Estudo descritivo de duas fases: desenvolvimento de um andador com suporte de tronco e avaliação com idosos de quarta idade. **Resultados:** Foram selecionados 23 idosos de quarta idade. Os critérios avaliados foram a influência imediata do andador na estabilometria estática com baropodômetro e avaliação da marcha com acelerômetros monitorando tempo e amplitude de movimento de quadril. Houve diminuição significativa da oscilação corporal dos idosos com a colocação do andador desenvolvido e mudanças nas amplitudes articulares do quadril, porém estas não foram significativas. **Conclusão:** Utilizando materiais de baixo custo, foi possível desenvolver um equipamento que atendeu aos requisitos de resistência e eficácia. O andador interferiu no equilíbrio dos idosos, diminuindo significativamente a oscilação corporal estática.

DESCRITORES

Andadores; Idoso de 80 Anos ou mais; Equilíbrio Postural; Tecnologia de Baixo Custo.

RESUMEN

Objetivo: Desarrollar y evaluar un andador de bajo costo con sustentación de tronco para ancianos. **Método:** Estudio descriptivo de dos fases: desarrollo de un andador con soporte de tronco y evaluación con ancianos de la cuarta edad. **Resultados:** Fueron seleccionados 23 personas mayores de la cuarta edad. Los criterios evaluados fueron la influencia inmediata del andador en la estabilometría estática con baropodómetro y evaluación de la marcha con acelerómetros monitoreando tiempo y amplitud de movimiento de cadera. Hubo disminución significativa de la oscilación corporal de los ancianos con la colocación del andador desarrollado y cambios en las amplitudes articulares de la cadera, pero esas no fueron significativas. **Conclusión:** Utilizando materiales de bajo costo, fue posible desarrollar un equipo que atendió a los requisitos de residencia y eficacia. El andador interfirió en el equilibrio de los ancianos, reduciendo significativamente la oscilación corporal estática.

DESCRIPTORES

Andadores; Anciano de 80 o más Años; Balance Postural; Tecnología de Bajo Costo.

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