The effect of short orthosis for rhizarthrosis on grip and pinch force: a single-case study

ORIGINAL ARTICLE

O efeito da órtese curta para rizartrose na força de preensão e força de pinça: estudo de caso único

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ABSTRACT: Objectives: to document the impact of ventral and dorsal short orthosis for rhizarthrosis on grip and pinch force. Methodology: an AB design, single-case, experimental study was performed. Phase A, lasting 4 weeks, consisted of traditional occupational therapy intervention. Phase B, lasting 6 weeks, included the use of ventral or dorsal short orthosis for rhizarthrosis. Two women with rhizarthrosis participated in the study and grip and pinch force (lateral, tripod and pulp) were evaluated weekly. The Celeration Line and the Two Standard Deviation Band statistical methods, as well as Visual Analysis, were used for data analysis. Results: the use of ventral short orthosis on dominant hand led to an increase in grip, tripod pinch and pulp pinch force, as well as force reduction in lateral pinch. The use of dorsal short orthosis on non-dominant hand led to a decrease in lateral, tripod, and pulp pinch force, with no change in handgrip strength. Conclusion: the results of the study suggest that the use of ventral and dorsal short orthosis on rhizarthrosis interfere with the grip and pinch force. This information can be useful to occupational therapists and other hand rehabilitation professionals that work with these patients to define the type and time of use of the orthosis, minimizing its impact on grip force.

KEYWORDS: Orthopedic devices; Joint prosthesis; Finger joint/physiopathology; Occupational Therapy.

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RESUMO: Os objetivos deste trabalho consistiram em documentar o impacto da órtese curta, ventral e dorsal, para a rizartrose na força de preensão e força de pinça. Quanto à metodologia, foi realizado um estudo experimental de caso-único do tipo AB. A fase A, com duração de quatro semanas, consistiu em intervenção tradicional de terapia ocupacional. A fase B, com duração de seis semanas, incluiu o uso de órtese curta ventral ou dorsal para rizartrose. Duas mulheres com rizartrose participaram do estudo e foram avaliadas semanalmente quanto à força de preensão e pinça (lateral, trípode e polpa-a-polpa). Empregaram-se na análise dos dados os métodos estatísticos *Celeration Line* e Banda de Dois Desvios-Padrão, assim como da Análise Visual. Os resultados foram: o uso de órtese curta ventral em mão dominante levou a um aumento na força de preensão, pinça trípode e pinça polpa-a-polpa, bem como redução da força de pinça lateral. Já o uso da órtese curta dorsal em mão não dominante levou à diminuição da força de pinça lateral, trípode e polpa-a-polpa, não havendo alteração na força de preensão manual. Com os resultados do estudo, conclui-se que o uso de órtese curta ventral e dorsal na rizartrose interfere na força de preensão e força de pinça. Essa informação pode ser útil aos terapeutas ocupacionais e demais profissionais de reabilitação da mão que trabalham com essa clientela na definição do tipo e tempo de uso da órtese, minimizando seu impacto na força de preensão.

DESCRITORES: Aparelhos ortopédicos; Prótese articular; Articulações dos dedos/fisiopatologia; Terapia Ocupacional.

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INTRODUCTION

The thumb accounts for 45% of the hand functions and its carpometacarpal joint (CMC) presents great mobility, also being subject to a significant stress during the clamp grip activities.[1] The rizarthrosis is a degenerative joint disease that affects the CMC joint, also known as trapeziometacarpal joint.[2]

In Brazil, rizarthrosis affects from 6% to 12% of the adult population and has prevalence in women after menopause.[3] Its incidence is smaller in individuals younger than 40 years old, and it progressively increases with age.[4] It is believed that the main factor of predisposition of this clinical condition is ligament laxity, associated to mechanical stress and the heavy loads put on the joint, as occurs in some activities that requires gripping, clamping and grasping, leading to subluxation, swelling and eventual degeneration.[5] The main complaints of individuals that present rizarthrosis are severe pain[6] and stiffness[7], with consequent limitation in the function[6], such as in the case of writing, brushing teeth, opening a tap, sewing, turning the door knob activities, among others[7]. The deformities that involve adduction and extension of the thumb, present in rizarthrosis, may generate biomechanical and kinematic alterations during the accomplishment of certain activities that involve gripping force, such as opening a jar. Given that, to accomplish a task, it may be required to perform some compensatory movements that involve the wrist, elbow, shoulder and other thumb articulations. These movements, associated with pain, may demand longer time for the execution of the task when compared to the movements necessary during the performance for individuals that do not have rizarthrosis.

According to Eaton and Littler[8], rizarthrosis may be classified in 4 stages. Stage I is characterized by the presence of the regular joint shape and by the beginning of the reduction of the joint space of the CMC. Stage II is known for the reduction of the joint space at the CMC with sclerosis of the subchondral bone. In both stages, severe pain can be felt[5]. In stage III, there is a significant decrease in the joint space with cystic alterations, bone sclerosis, dorsal luxation and presence of osteophytes. At last, stage IV involves the additional compromise of the scaphotrapezio-trapezoidal joint. In stages III and IV, clinical symptoms may yet be absent[5], and surgical treatment is recommended[8], while stages I and II are eligible for the conservative treatment[8]. Occupational Therapists are involved in the conservative treatment of this health condition through special programs that focus on functionality and on occupational performance[9]. In the case of rizarthrosis, the restoration of the function is mainly related to use the thumb without pain.

During the rehabilitation process, the use of orthoses is recommended to provide rest, immobilization of the joint involved and stability during the performance of everyday activities, which contributes to decreasing pain. For the stabilization of the CMC thumb joint, reduction of pain and increase of manual function, the short orthosis for the thumb is recommended[10]. Among its advantages, can be highlighted: it does not hinder the manipulation of objects and eliminates the possibility of atrophy due do muscles disuse[3]. There are two short orthoses' models for the thumb: dorsal and ventral[2]. The dorsal model is modeled on the back, in the thenar and hypothenar eminence of the hand[2]; the ventral model, proposed by Colditz[11] is modeled on the palm of the hand and on the radial and ulnar aspects of the back of the hand. Both orthoses' designs increase the capacity of the use of the hands, since they stabilize only the thumb CMC joint and it does not impede the full-range of movement of the wrist and fingers[2].

Given that the manual force may be reduced during the gripping and clamping activities with rizarthrosis and that the utilization of the orthosis aids the return to the everyday occupations and activities, several studies investigated the effects of the use of the orthosis (ventral and dorsal) for rizarthrosis regarding gripping and clamping forces. Among them, there are those that did not indicate differences, like the study by Buurke et al.[12], that correlated three types of orthosis according to its material for four weeks each. The controlled and randomized study of Wajon and Ada[13], compared the use of two short orthoses for six weeks each: one that immobilized the CMC and the metacarpophalangeal joint (MCF) of the thumb and the other immobilized only the CMC, associated with an exercise program, and also did not indicate any difference between groups regarding strength.

In the study by Carreira et al.[4], only a single model of dorsal short orthosis was made, immobilizing both the CMC and the MCF. Its use was compared in two groups with different length utilization, the experimental group used the orthosis during everyday activities for 180 days and the control group used it only on the last 90 days. The authors believed that the orthosis, as it stabilized the thumb, would reduce pain, but they were afraid that the immobilization could lead to muscle atrophy with a consequent reduction of strength. The results did not indicate a change in the gripping strength, regardless of the time the orthosis was used. Regardless of the time that the orthosis was utilized, there were no changes in the gripping

force, according to the results of the study. A statistically significant reduction of the strength was observed only in the lateral pinch in the experimental group.

In the study by Weiss et al.[14], it was noted that the strength of the clamping was a little greater with the short orthosis when compared to the long one, that also immobilized the wrist's articulation and is done with the same material. Other studies[5], such as Weiss et al.[15], compared a precast orthosis with a neoprene tailor-made orthosis based on the Colditz[11] model. After one week of use of the splint, a 0.3kg in the strength of the clamp was noted for those that used the precast orthosis[5].

Therefore, controversial results can be observed regarding the best indication for the short orthosis for the treatment of rizarthrosis, considering its impact in the gripping force. The objective of this study was to investigate what is the impact of the use of the ventral and dorsal short orthoses in the strength of the gripping and of the clamping in individuals with rizarthrosis.

METHODS

In this study, an experimental drawing of a single case of the AB type was utilized, that allows a systemic comparison between the baseline (A) and the intervention (B) phases. The baseline phase consisted in gathering data during a period without intervention (occupational therapy service without use of the orthosis). The B phase was based on the utilization of the orthosis for rizarthrosis, associated to traditional Occupational Therapy care.

For the selection of the participants in the study, the criteria for eligibility were: clinical and radiological diagnosis of stage II of rizarthrosis, present in the dominant hand or in the non-dominant hand, age above 40, women, perception and cognitive capability in order to respond to the scale of pain and to accomplish the study's tests. Exclusion criteria were: to be undergoing other treatments during the period of study, associated pathologies (diabetes, rheumatoid arthritis, among others), having undergone hand surgery in the last 6 months, allergy to the orthosis materials and alterations in usage of medicines in the last 3 months.

The eligible candidates were sent to the Occupational Therapy Service – at the Bias Fortes ambulatory, part of the Complex of the Hospital das Clínicas of the Federal University of Minas Gerais, Brazil, for them to start their treatment. They were directed to the participation in the study, which was done in the same location, through the signature of a free and informed consent form. The research project was approved by the Ethics Commission in Research of the Federal University of Minas Gerais (Protocol no. 89,405, CAAE 02635912.1.0000.5149).

The participants filled an identification questionnaire on: their age, place of birth, gender, marital status, schooling, family constitution, profession and performance in any given job during the research period. After that, they were submitted to the treatment proposed by the research, with a total duration of 10 weeks. In the baseline phase (4 weeks), it was chosen, as a control condition, the traditional occupational therapy treatment, which consisted in therapeutic exercises and techniques of joint protection. The treatment sessions occurred twice a week for 40 minutes, and were directed according to stage II of rizarthrosis that has as priority to preserve the 1st interdigital space, pain relieve and preservation of the thumb's movement. In the B phase (6 weeks), the same frequency and duration of the traditional occupational therapy was preserved, with the addition of the dorsal or ventral orthosis for rizarthrosis as a therapeutic procedure.

One of the participants (P1) used the short ventral orthosis on the right dominant hand and the other (P2) used the short dorsal orthosis on the left, non-dominant hand. The orthosis were made with a thermically moldable material (Ezeform®), tailor-made for each patient. In the B phase, the participants were oriented about the use, conservation and maintenance of the orthosis, highlighting the need for its constant use, the orthosis only being taken out for hygienization. Necessary adjustments were made on the orthosis with the intention of avoiding pressure points and to provide the preservation of the adequate posture for the function.

The assessment of the gripping forces, of the lateral clamp, of the tripod clamp and of the pulp clamp was conducted weekly during phases A and B. The measurement of the gripping force was taken with the Jamar® dynamometer. This instrument contains a closed hydraulic system that measures the quantity of force produced by an isometric contraction applied on the handles and the gripping force is registered in kilograms or pounds[16]. The utilization of this instrument, which has good levels of validity and reliability[16], followed the recommendations of the American Society of Hand Therapists (ASHT)[17], and the participants were placed sitting, with their shoulder forward, elbow flexed at 90º, forearm in a neutral position and the wrist between 0º and 30º of extension. They were also instructed to press the dynamometer as hard as they could, three times in a row, with a 2-3 minutes rest between the attempts, in which the same voice volume was used not to interfere on the obtained results, as suggested by Figueiredo et al.[16] For the

calculation of the manual gripping force, the final measure was the arithmetic average between the three trials[18].

The clamping strength was measured by the Preston Pinch Gauge following the standardization recommended by the ASHT[17]. Three clamping were assessed for being involved in the efficient accomplishment of occupational tasks and other activities: lateral, tripod and pulp. For the three types of clamping, three attempts were made, with resting between each of them in order to avoid fatigue, and then the average of the three consecutive measurements was calculated[18].

In a single-case experimental study, the careful analysis of both intra- and interphases measures was necessary to determine whether there were changes in behavior in the intervention phase, and if these can be associated to the proposed treatment. In this study, the statistical methods used to analyze the data related to the gripping and clamping force were the Celeration Line and a Two Standard Deviations Band. The Celeration Line was used to demonstrate, through a trend line, the direction of change (acceleration, deceleration or stabilization) of the data of a given phase in relation to the following phase. The effect of this measure was assessed comparing, between the two phases, the proportion of data above and below the trend line. The statistical significance was determined by the binomial test, considering the level of significance of $\alpha=0.05$[21].

The method of the Two Standard Deviations Band involved the calculation of the average and of the standard deviations of the data in the baseline (A) phase. The bands were drawn roughly with two standard deviations in relation to the average obtained during the baseline phase, which are extended to the subsequent phase. The statistical significance is based on the premise that the data are independent and that they are normally distributed. It was considered that the changes are statistically significant when at least two consecutive points in the intervention phase are found outside the Two Standard Deviation Band, provided that the possibility of such event to occur is smaller than 0.05[21].

In the case of a disagreement between the two statistical methods, the visual analysis was utilized in addition to the statistical methods for the decision regarding the result. In the visual analysis, the data are described according to the level and direction of the changes, as well as the slope level of the trend line. Changes in the level refer to the value of the dependent variable or the magnitude of the performance at the intervention point. The level is assessed by the comparison between the last value obtained from the target behavior on phase I and the first value obtained on the following phase. The change in level can also be described by the comparison of the average behavior value obtained in each phase[21].

Regarding the trend, it refers to the change in direction in each phase. It can be described as acceleration, deceleration or stabilization. The slope of the trend refers to the angle or percentage of change between the data. The slope can be determined by a linear trend line. When the angle of the slope is greater at the intervention phase, it is considered that the percentage of change in the target behavior increases when the treatment is started[21].

RESULTS

Two women participated in the study, with an average age of 58.5 years, both withdrawn from work. Participant P1 used the ventral orthosis in the dominant hand in the intervention phase (B), and participant P2 used the dorsal orthosis in the non-dominant hand.

The results and analysis of the Celeration Line and Two Standard Deviations Band methods in the gripping force and pulp clamp tests are presented in Figures 1 and 2, and in Table 1. In Figures 1 and 2, it can be observed, respectively, the evolution of the gripping force and of the pulp clamp of the two participants of the study in the baseline phase (B1-B4) and in the intervention phases (I1-I6).

An increase in the gripping force can be noted, in the tripod clamp and in the pulp clamp, and a reduction in the lateral clamp with the use of the ventral orthosis. The use of the dorsal orthosis implied in a decrease on the lateral, tripod and pulp clamp, and in the stabilization of the gripping force. The analysis of the data reveals that the use of ventral or dorsal orthosis (intervention phase) had a significant statistical effect in the gripping force according to the Celeration Line, reflecting a great change between phases.

Concerning the gripping force with the use of the ventral orthosis, both statistical methods revealed significant results, however with opposite meanings. On one hand, the Two Standard Deviations Band identified a significant amount of gripping force, while the Celeration Line identified a significant decrease. However, the visual analysis points to a change of level between the baseline phase (average in pounds: 38.35) and the intervention phase (average in pounds: 43.88); the trend of acceleration is kept in both phases, but the slope of the trend line is slightly higher in phase B, which corroborates the results of the Two Standard Deviations Band. Regarding the gripping force, when the dorsal orthosis is used, while the Celeration Line evidenced a significant increase, the Two

Standard Deviations Band did not identify a significant increase in the gripping force. The visual analysis also indicates that there is a level stability between the baseline phase (average in pounds: 10.07) and the intervention phase (average in pounds: 10.61) which corroborates the results of the Two Standard Deviations Band.

As far as the use of the ventral orthosis is concerned, the two statistical methods showed significant results regarding the reduction of the force of the lateral clamp in the intervention phase. For the tripod clamp, a significant change regarding the increase in this force was observed. For the pulp clamp force, the Celeration Line indicated a significant increase, whereas the Two Standard Deviations Band did not indicate a significant change. In this case, the visual analysis presents a level change between the baseline phase (average in pounds: 7.5) and the intervention phase (average in pounds: 8.98); however the deceleration trend that was observed in phase A is inverted in phase B (acceleration), which corroborates the results of the Celeration Line.

Regarding the use of the dorsal orthosis, both statistical methods indicated a significant reduction in the lateral and pulp clamp forces. For the pulp clamp force, the Celeration Line showed a significant increase in the force while the Two Standard Deviations Band indicated a significant decrease. However, the visual analysis points to a significant change in level between the baseline phase (average in pounds: 6.77) and the intervention phase (average in pounds: 5.22). The deceleration trend kept in both phases, which confirms the results of the Two Standard Deviations Band.

The information in Table 1 demonstrates that there was a 62.5% concordance between the two statistical methods in all related variables that were assessed. The concordance between the two statistical tests was determined by the division of the number of results in which both tests produced similar results by the total number of results assessed by both tests, multiplied by 100.

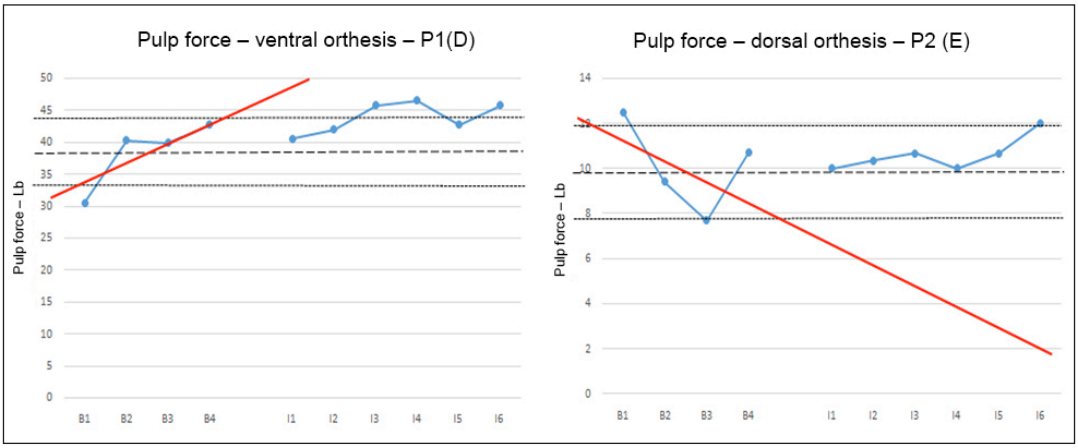

Figure 1 – Results of the Celeration Line and the two standard deviations band statistical methods, related to the gripping force of the dominant right hand with rizarthrosis in participant P1 – Ventral Orthosis and of the left non-dominant hand participant P2 – Dorsal Orthosis

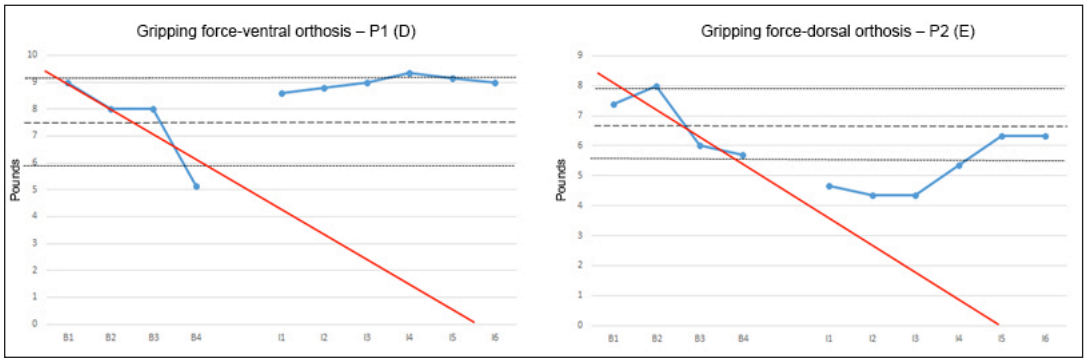

Figure 2 – Results of the Celeration Line and the two standard deviations band statistical methods, referring to the pulp clamp force of the dominant right hand with rizarthrosis of participant P1 – Ventral Orthosis and of the left non-dominant hand of participant P2 – Dorsal Orthosis

Table 1 – Analysis of the *Celeration Line* and Two Standard Deviations Band of the dependent variables

Dependent Cariables	Celeration Line*	Two Standard Deviation Band	Visual Analysis
Gripping force			
P1 (ventral)	S↓(0.016)	S↑	S
P2 (dorsal)	S↓(0.016)	NS	NS
Lateral clamp			
P1 (ventral)	S (0.016)	S	
P2 (dorsal)	S (0.016)	S	
Tripod clamp			
P1 (ventral)	S (0.016)	S	
P2 (dorsal)	S (0.016)	S	
Pulp clamp			
P1 (ventral)	S (0.016)	NS	S
P2 (dorsal)	S↑(0.016)	NS	S

*$p<0.05$; S= statistically significant result; S = statistically significant result in the opposite than expected sense; NS= statistically insignificant result.

DISCUSSION

This study presents longitudinal information for comparing the effect of the use of the short ventral orthosis on the dominant hand and of the dorsal orthosis on the non-dominant hand, regarding the gripping force and pinch, of two women with an average age of 58.5, diagnosed with stage II rizarthrosis.

The results of this single-case study suggest that the use of the short ventral and dorsal orthosis may interfere in the gripping and clamping forces in people with stage II rizarthrosis. The use of the short ventral orthosis led to an increase in the gripping force, tripod clamp and pulp clamp. Regarding the lateral clamp, both the use of the ventral orthosis and the dorsal orthosis led to its decrease, which corroborates the study of Carreira et al.[4], in which the use of the short dorsal orthosis led to the reduction of the force of the lateral clamp. Apart from the reduction of the force of the lateral clamp, the use of the short dorsal orthosis led to the decrease in the clamp force, tripod grip and pulp clamp, without alteration in the gripping manual force. Souza[2] determines the functions of the orthosis, as follows: to decrease the acute swelling so patients are able to return to their normal functioning level, to stop the development of deformities and to immobilize the joint, restricting the movement of the 1st metacarpal during the gripping clamp. As for immobilization, Colditz[11] defends that the positioning of the molding of the orthosis should be done on the volar face of the hand, given that the rigidity of the thermoplastic material favors the contention of the thenar muscles, which stabilizes the first metacarpal[22]. In this study, this orthosis molding, apart from containing the muscles and stabilizing the joint, led to a considerable force gain. This finding may suggest that the force applied during the clamp movements could be associated to the distal joint of the thumb.

Momose[23] concluded in his study that the MCF joint is more stable in the opposing position, and describes that the transmission of the compressive forces is greater, and it enables more force efficiency for the gripping clamp and for manual grasping. Boustedt et al.[9], in a controlled clinical experiment, stated that the use of the orthosis day and night, allied with exercises and joint protection techniques, leads to an expressive improvement in the gripping force and in the performance in everyday activities.

In this study, only the gain of significant gripping force in the patient that used the ventral orthosis was observed, which suggests that it is superior to the dorsal orthosis, that, in its turn, led to the decrease in the gripping force. It is believed that this difference is related to the direction and the way that the forces are applied by the two orthotic models: the ventral orthosis generates an extension force in the distal aspect of the metacarpal, from the palmar to the dorsal, which does not occur in the dorsal modal. Its direction is in flection, and the direction is from dorsal to palmar.

The result of gain of force for the patient that used the ventral orthosis in the dominant hand may also be related to lateral dominance: the use of the ventral orthosis in the dominant hand compared to the dorsal orthosis in the non-dominant hand. The results of the study by Nicolay and Walke[24] showed that, in relation to the peak of maximal force in women, the dominant

hand generally has a better performance. The effect of the dominance was also investigated by Armstrong and Oldham[25], that noticed that the differences found between the dominant and non-dominant hands of 83 people with ages between 18-72 are small (around 10%), but they state that the comparison between the dominant and the non-dominant hand should be carefully done according to the methodological outline of the clinical intervention or research.

The use of quantitative methods in single-case investigations is still a fairly recent practice. Although some researchers defend the use of these procedures replacing visual analysis, a question regarding which method is the best to be applied and another about the equivalence between different statistical procedures and of the advantages and limitations of each method remain without a definite answer. Due to that, only the results supported by visual analysis were considered, as recommended by Nourbakhsh e Ottenbacher[26] apud[21].

Although the single-case study allows the careful examination of the effects of the use of the orthosis with a considerable level of detail, its design limits the generalization of the results for an entire population. A randomized study involving a larger and more diverse sample is necessary to determine the effect of this device in the gripping and clamp forces.

CONCLUSION

The use of orthosis in women in stage II of rizarthrosis had a significant effect on the gripping and clamp forces. The use of the short ventral orthosis on the dominant hand led to an increase in the gripping force, tripod clamp and pulp clamp, while the use of the short dorsal orthosis in the non-dominant hand led to a considerable decrease on the lateral, tripod and pulp clamp, not causing alteration on the manual gripping force. This information may be useful for the occupational therapists and other hand rehabilitation professionals that work with this type of patients in defining how long and what type of orthosis should be used, minimizing its impact on the gripping force. However, the design of this study limits the generalization of results for a population, being necessary the conduction of randomized studies.

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