IMPACT OF A DYNAMIC ORTHOSIS ON MANUAL DEXTERITY IN PARKINSON'S DISEASE. A RANDOMISED TRAIL (Author´s final version – Accepted Manuscript)

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Running title: Dynamic upper limb orthosis in Parkinson

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Abstract

Importance: Dynamic elastomeric fabric orthosis (DEFO) could be a novel non-pharmacological treatment for motor symptoms in Parkinson´s Disease. **Objective:** To evaluate the efficacy of the orthoses in manual dexterity in Parkinson´s Disease. **Design:** A randomized trial with 20 participants in the control group and 40 in the experimental group (N=60). Manual dexterity was assessed in ON/OFF states of the disease with and without the orthosis. **Setting:** Burgos University Hospital. **Participants:** Consecutive non-probabilistic sampling. Inclusion criteria: patients diagnosed with Parkinson´s Disease, with motor symptoms in at least one upper limb, and attending the neurology department of the Hospital. Age between 48 to 89, with an average disease duration of 5.38 ± 4.23 years. Exclusion criteria: tremor due to another neurological disease and/or Montreal Cognitive Assessment score lower than 26. **Intervention:** Implementation of the orthosis on the most affected upper limb for two months, control group participants did not receive the orthosis. **Outcomes and Measures:** Manual dexterity was measured with the Purdue Pegboard Test, Minnesota Manual Dexterity Test, and Square Test. The paired t-test for related samples and ANCOVA tests were used. **Results:** Improvements in some items of manual dexterity were observed while wearing the orthosis. However, the improvement was not sustained when the orthosis was removed after two months of use. **Conclusions and Relevance:** This orthosis may improve certain aspects of manual dexterity in people with PD and the patient´s functionality, but only while it is worn. **What this article adds**: A dynamic orthosis can reduce the motor symptoms of Parkinson's Disease and improves upper limb functionality.

Keywords: Parkinson's Disease; non-pharmacological treatment; dynamic elastomeric fabric orthosis; motor symptoms; manual dexterity.

1. Introduction

Parkinson's Disease (PD) common motor symptoms such as muscle rigidity, tremors, bradykinesia and impairments in manual dexterity, significantly impact the patient's ability to perform activities of daily living (ADL) requiring fine motor skills and the quality of life (QoL) (Bloem et al. 2021a).

A decline in manual dexterity, defined as the skill and precision in hands and fingers fine and coordinated movements, impacts the functional use of the upper limb (UL) in tasks like reaching, grabbing, and manipulating objects (Heffner & Masterton, 1983; Poirier, 1988). Manual dexterity serves as a strong predictor of the levels of functional independence for PD patients (Bloem et al., 2021b; Poewe et al., 2017).

The primary approach to motor symptoms in PD is pharmacological, primarily with levodopa and dopamine agonists. Although medication temporarily improves symptoms, there is currently no cure for PD (Connolly & Lang, 2014). Over time, patients often develop motor complications such as dyskinesia and fluctuations in medication response, limiting the long-term effectiveness (Choi et al., 2017).

In most cases, PD treatment is multifaceted, combining pharmacological treatment with other non-pharmacological approaches to improve the patient's QoL. Various non-pharmacological interventions such as exercise, acupuncture, and physiotherapy, among others have been developed, with exercise especially showing improvements in QoL (Ahn et al., 2017; Van de Weijer, Hommel et al., 2018).

Innovative non-pharmacological therapies, such as Motor Imagery, Action Observation, Dual Therapy, Virtual Reality, and Robot-Assisted Therapy, are emerging in PD to address functional issues, though there remains a lack of studies and uncertainty regarding the optimal intervention dosage for effectiveness (Fusco et al., 2019; Righi et al., 2022; Ryan et al., 2021; Strouwen et al., 2015; B. Wang et al., 2019). While some orthoses have proven effective in reducing motor symptoms in the UL, existing devices are often bulky and heavy, resulting in low treatment adherence (Fromme, Camenzind, Riener, & Rossi, 2019).

Dynamic Elastomeric Fabric Orthoses (DEFO) are custom-made Lycra garments individually designed that provide traction forces, aligning the limb biomechanically, leading to reduced muscle tone and edema; and improved proprioception (Betts, 2015; González-Bernal et al., 2017). They can be crafted as individual gloves or sleeves, full-body suits, vests, or ankle-foot wraps (Betts, 2015; Powell et al., 2021). While DEFO has proven effective in conditions like stroke, pediatric cerebral palsy, multiple sclerosis, and complex regional pain syndrome, with positive results in motor function, muscle strength, manual dexterity, and reach (Alexander et al., 2022; Giray et al., 2020; Miller et al., 2016), its effectiveness in PD remains uncertain.

The main goal of Occupational Therapy (OT) is to promote and enable meaningful contextual occupational performance. The impairment in fine motor skills in PD leads to a decline in the patient's ADL performance and independence. Therefore, due to the lack of devices or treatments and the promising research on DEFO in other neurological conditions, the aim of this study is to assess the effectiveness of this device on manual dexterity in the UL of PD patients.

2. Method

2.1. Participants

A longitudinal study was undertaken involving a control group (CG) and an experimental group (EG). Recruitment of patients diagnosed with PD at any stage and experiencing motor symptoms in at least one UL took place between September and October 2021 through consecutive non-probabilistic sampling at the neurology department of the University Hospital of Burgos. Exclusion criteria comprised tremor resulting from another neurological disease and/or a Montreal Cognitive Assessment (MoCA) score equal to or lower than 26 (Postuma et al., 2015a).

PD diagnosis was based on criteria established by the International Parkinson and Movement Disorder Society, requiring the presence of bradykinesia along with rigidity, resting tremor, or both. Additionally, at least two out of four supportive criteria (dramatic improvement from dopaminergic therapy, dyskinesias or loss of smell, resting tremor, or cardiac sympathetic denervation on myocardial scintigraphy) needed to be met (Armstrong & Okun, 2020; Postuma et al., 2015b).

The study adhered to ethical principles outlined in the Helsinki Declaration, and participants provided informed consent. It was approved by the Clinical Research Ethics Committee of the Health Area of Burgos and Soria (Spain) with reference CEIM-2119/2019; and registered on ClinicalTrials.gov under the test number NCT04815382.

2.2. Procedure

The sample size calculation was based on the improvement in rigidity and tremor as the main variables. With an alpha risk of 0.05 and a beta risk of 0.20, using a two-tailed test, it was estimated that 40 participants (20 each group) would be needed to detect a minimum difference of 0.50 in rigidity and tremor of the most affected UL using Part III of the Motor Subscale of the Unified Parkinson's Disease Rating Scale (UPDRS) (Winter et al., 2022). Finally, due to the availability and interest of participants, the number of participants in the EG was increased to 40, leaving a total sample size of N=60 (EG=40, CG=20).

In the first visit, participants who met the established criteria signed the informed consent. The sociodemographic and clinical data were collected by occupational therapists. One month prior to DEFO implementation, exact measurements of UL were taken by an occupational therapist (that was also a physical therapist) to be fitted for the personalized customization of the orthosis. The professionals who carry it out must be specifically trained to do so.

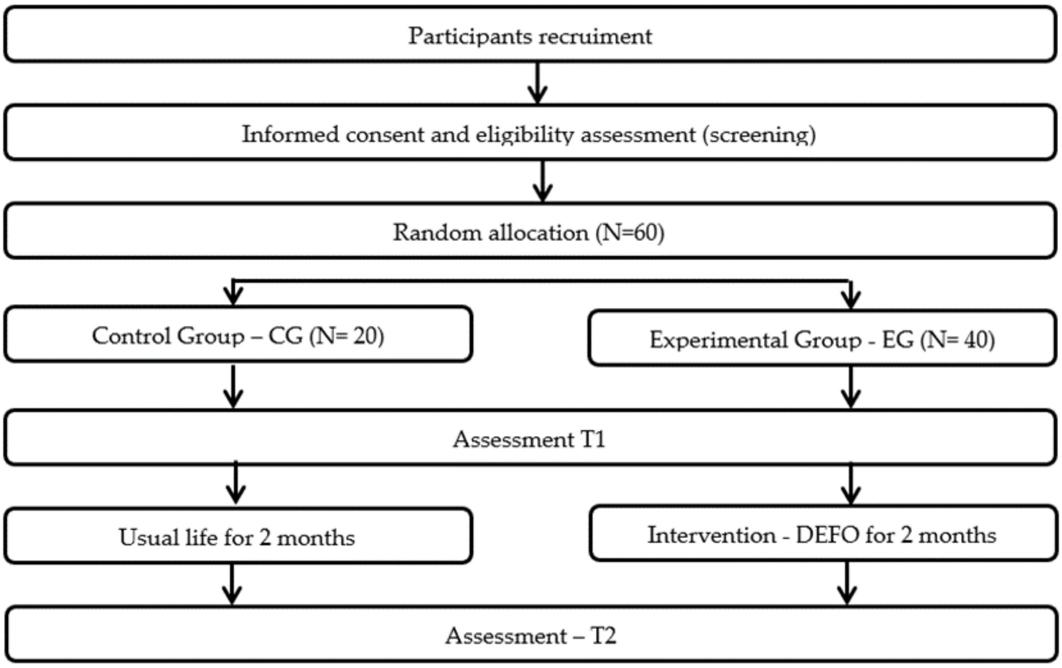
The orthosis used in this study is an UL limb DEFO that covers the entire arm and therefore acts on the entire UL providing proprioceptive stimulation. Since tremor in people with PD subsides with activity, muscle contraction and support; the orthosis aims to activate the finger extensors, wrist extensors, radial deviators, supinators and external rotators, thus, the UL limb is positioned with the musculature in contraction as when the UL is placed in a support and load position. For its manufacturing, CADCAM technology is used combined with traditional manufacturing techniques to guarantee that each product matches the exact measurements of the patient. The power net reinforcement panels are strategically placed to position the upper limb in better postural alignment(Supplementary material 3).

Participants were randomly assigned to control group (CG) or experimental group (EG) with Epidat 4.2 program. The treatment protocol involved implementing the DEFO on the most affected UL along two months, while participants in the CG continued with their usual daily activities. The EG participants had to wear the orthosis from the moment they got up until they went back to bed. They only had to take it off to sleep and shower. They were instructed to use it in all the activities they usually did and to try to carry out those activities that they had stopped doing due to their motor symptoms, such as fishing, sewing or planting. All patients continued with their usual pharmacological treatment. The effects were evaluated both during the ON state (under the effects of levodopa) and OFF state (1 hour before the next levodopa dose) as there are significant fluctuations in PD's motor symptoms (Martin, Suchowersky, Kovacs Burns, & Jonsson, 2010). The ON state refers to periods when medication is effective, and patients experience significant improvement in their motor function. On the contrary, the "off" state refers to periods when medication is not effective, and Parkinson's motor symptoms reappear or worsen significantly, with patients experiencing increased rigidity, bradykinesia, and tremors. In this research, it is considered important to evaluate the effect of the DEFO in both states due to the significant difference in motor symptomatology between them.

During the two months of treatment, scheduled calls were made to participants, one after one week and one after one month of wearing the orthosis, to obtain information about adherence to treatment; in the two-month evaluation, they were also asked about this. All participants reported that they have worn the orthosis for the amount of time indicated.

Motor assessments were conducted by occupational therapists at two time points (T1, T2), immediately prior and following the 2-month intervention window. At both times, two assessments were performed, one before and one after placing the DEFO, to check for its immediate effects and its potential long-term benefits (Figure 1). The results were analyzed by occupational therapists. Neither participants nor evaluators were blinded.

Figure 1. Study flow chart. DEFO: dynamic elastomeric fabric orthoses.



Manual dexterity assessment was made following standard testing procedures with three different tests: The Purdue Pegboard Test (PPT), the abbreviated version of the Minnesota Manual Dexterity Test (MMDT), and the Square Test (ST).

Firstly, the PPT consists of a wooden board with 50 holes in two parallel columns, a set of pegs, washers, and collars placed in four cups at the top of the board. It has four subtests that evaluate the use of the right hand, left hand, alternating movements and the combination of both. The score for each subtest is the result of the sum of the pieces placed. All subtests were performed three times, and the total score was the average of them. Higher scores indicate greater manual dexterity. It is a test with high test-retest reliability, with an intraclass correlation coefficient (ICC) of ≥ 0.90 (Lo et al., 2022; Proud et al., 2019).

The MMDT consists of a rectangular board with 60 holes in 15 columns and 4 rows, with 60 circular pieces with one side red and other black. It has got two subtests: displacement and rotation (supplementary material 1 and 2), that are performed four times, with the total score being the average of them. The less time taken in the tests, the better the manual dexterity. It is a reliable and valid measure, with high test-retest reliability, an intraclass correlation coefficient (ICC) of 0.88, and a 95% confidence interval (Rane et al., 2017; Y. C. Wang et al., 2018).

The ST, which consists of a sheet of paper with four printed grids that consist of 20 squares. The patient is given 30 seconds to make a mark with a pen inside as many squares as possible. The score is the result of the sum of the marks made without touching the lines. A higher number indicates better manual dexterity. This is a reliable and valid test with excellent test-retest reliability for both hands (ICC ≥ 0.93) (Soke et al., 2019).

2.3. Statistical Analysis

The data was analyzed using SPSS V28 program considering a p-value < 0.05 as statistically significant. Mean and standard deviation (SD) were calculated for quantitative variables, while frequency distribution and percentages for categorical variables. To analyze the differences between not wearing and wearing the orthosis both in T1 and T2 in the EG, the paired t-test for related samples was employed; adding in this case a Bonferroni correction, in order to control for the family-wise error rate (FWER); for which 4 tests were taken into account as adjustment (2 time points and 2 medication conditions) the corrected p-value obtained was 0.0125 (0.05/4). To analyze the differences between CG and EG after two months wearing the DAFO, means between the two groups were compared using ANCOVA, with the group (CG or EG) as a fixed factor; differential scores of the analyzed variables as dependent variables, and the pretest scores of each one as covariate. This ANCOVA was performed without wearing the orthosis. Both t-student test and ANCOVA were performed in ON and OFF states.

3. Results

3.1.Baseline Sociodemographic Characteristics of Participants

Sample was composed of 60 individuals with a mean age was 71 years old. 87.5% of the participants lived with someone (N=53), 10% lived alone in their homes (N=6), and one person in a religious community. Other sociodemographic data are shown in table 1.

Table 1. Baseline characteristics

Variables	Total (n= 60)	CG (n= 20)	EP (n = 40)
Age (years)	70.67 ± 10.37	69.94 ± 12.90	70.97 ± 9.32
Gender			
Male	45	14	31
Female	15	5	10
Most affected UL			
Right	35	21	14
Left	25	5	20
Years of desease evolution	4.78 ± 3.83	3.75 ± 2.79	5.21 ± 4.14
Current non-pharmacological treatment			
Physiotherapy	2	0	2
Occupational therapy	0	0	0
Spech therapy	1	1	0
All	1	1	0
None	55	25	30
Others	1	1	0

Abbreviations: CG: Control Group; EP: Experimental Group; UL: Upper limb

Table 2 shows the observed differences in the comparative analysis of motor dexterity assessments (PPT, MMDT, and ST) at baseline (T1) with and without the orthosis in both ON and OFF states.

Table 2. Comparative analysis of motor dexterity assessment at baseline (T1) with and without the orthosis. Paired t-test for related samples (N=40)

Variables	State	Mean	SD	α	$\alpha_{corrected}$	p-value
PPT Subtest 1	OFF	.393	1.416	0.05	0.0125	.102
	ON	.606	1.368	0.05	0.0125	**.012**
PPT Subtest 2	OFF	-.007	1.404	0.05	0.0125	.975
	ON	.073	1.872	0.05	0.0125	.814
PPT Subtest 3	OFF	.024	.949	0.05	0.0125	.879
	ON	.565	1.412	0.05	0.0125	.022
PPT subtest 4	OFF	.042	2.477	0.05	0.0125	.918
	ON	.236	6.423	0.05	0.0125	.827
MMDT placing test	OFF	-6.901	11.305	0.05	0.0125	**.001**
	ON	-5.424	10.734	0.05	0.0125	**.005**
MMDT turning test	OFF	1.583	42.367	0.05	0.0125	.826
	ON	2.201	9.943	0.05	0.0125	.193
ST Right hand	OFF	-.971	7.278	0.05	0.0125	.435
	ON	-.417	6.29	0.05	0.0125	.693
ST Left hand	OFF	-.828	7.422	0.05	0.0125	.513
	ON	1.083	4.625	0.05	0.0125	.187

Mean: mean difference between the group with and without orthosis. ON: under levodopa effects; OFF: 1 hour before next levodopa dose; SD: Standard Deviation; PPT: The Purdue Pegboard Test; MMDT: Minnesota Manual Dexterity Test; ST: Square Test.

Table 3 presents the observed differences in the comparative analysis of motor dexterity assessments (PPT, MMDT, and ST) in the evaluation conducted 2 months after the implementation of the DEFO (T2), both with and without the orthosis in both ON and OFF states.

Table 3. Comparative analysis of motor dexterity assessments after 2 months of the implementation of the DEFO (T2), with and without the orthosis. Paired t-test for related samples (N=40)

Variables	State	Mean	SD	α	$\alpha_{corrected}$	p-value
PPT Subtest 1	OFF	.341	1.31	0.05	0.0125	.064
	ON	.441	1.168	0.05	0.0125	**.008**
PPT Subtest 2	OFF	-.05	1.053	0.05	0.0125	.733
	ON	.661	3.323	0.05	0.0125	.154
PPT Subtest 3	OFF	.066	1.455	0.05	0.0125	.740
	ON	.534	1.637	0.05	0.0125	.021
PPT subtest 4	OFF	-1.911	24.935	0.05	0.0125	.579
	ON	.887	7.749	0.05	0.0125	.409
MMDT placing test	OFF	-5.185	16.692	0.05	0.0125	.028
	ON	-3.638	13.248	0.05	0.0125	.051
MMDT turning test	OFF	-3.656	19.377	0.05	0.0125	.180
	ON	3.453	11.116	0.05	0.0125	.028
ST Right hand	OFF	2.019	16.056	0.05	0.0125	.369
	ON	-2.642	8.204	0.05	0.0125	.023
ST Left hand	OFF	-1.192	7.667	0.05	0.0125	.267
	ON	.170	6.100	0.05	0.0125	.064

Mean: mean difference between the group with and without orthosis. ON: under levodopa effects; OFF: 1 hour before next levodopa dose; SD: Standard Deviation; PPT: The Purdue Pegboard Test; MMDT: Minnesota Manual Dexterity Test; ST: Square Test

No differences were observed between the CG and the EG in the PPT, in the MMDT or in the ST without orthosis after the EG had worn the orthosis for two months (Supplementary material 4).

4. Discussion

The main results of this study indicate that improvements in certain aspects of motor dexterity occur when the patient wears the orthosis. However, after using the orthosis regularly for two months, no differences were observed in manual dexterity of the UL when the orthosis was removed.

Among motor symptoms, bradykinesia, rigidity, resting tremor, and impaired motor dexterity are prominent and can manifest themselves in varying degrees as the disease progresses, but they are highly bothersome and disabling, impacting performance in ADL and QoL (Bloem et al., 2021b; Postuma et al., 2015a).

In recent years, the effectiveness of these devices has been tested in other conditions. Jen et al. explored their implementation in stroke patients, observing an improvement in function and dexterity in the UL and promotion of participation in repetitive activities (Alexander et al., 2021). Studies conducted in cases of cerebral palsy have demonstrated their effectiveness in improving manual dexterity (Giray et al., 2020; Pavão et al., 2018), functionality and alignment of the affected UL (Yasukawa & Uronis, 2014).

These results partially align with those obtained in the present study as an immediate effect of the orthosis was observed in some subtests both in T1 and T2. Therefore, improvements in certain aspects of motor dexterity are observed when the orthosis is being used. However, after using the orthosis for 2 months, no differences were observed between CG and EG when the tests are performed without the orthosis, which may be explained, in part, because while PD is a degenerative condition, stroke and cerebral palsy are not.

Various orthoses tested have shown positive effects on reducing involuntary movement, but they were also heavy and unattractive, leading to reluctance in their use (Fromme et al., 2019; Mo & Priefer, 2021). Therefore, there is a need to design lighter and appealing to the patient orthosis, while also providing an improvement in manual dexterity.

This research must be considered in the context of their strengths and limitations. DEFOs have proven to be easily implementable and adherent devices, resulting in improvements in some aspects of manual dexterity, both the ON and OFF states of the disease. Although no differences were found after removing the orthosis in manual dexterity, improvements were obtained in occupational performance with the orthosis on. Furthermore, they represent a non-pharmacological treatment without any contraindications for the patient.

In the results, there is a tendency for greater differences to appear between wearing or not wearing the orthosis in the ON state; however, they lack statistical significance after applying the Bonferroni correction. At first glance, there does not seem to be an obvious reason for the medication state to interact with the use of the orthosis in this way; however, the role of medication state and its interactions with findings should be addressed more deeply in future research. Understanding the orthosis response in both states allows for optimizing its use, adjusting the timing to maximize its benefits during ON periods and minimize symptoms during OFF periods.

The observational nature of the study, and not having blinded evaluators or patients are limitations for this study. Additionally, due to the limited duration of the study, it was not possible to ascertain whether longer-term treatment might lead to further improvements or if it could slow down the progressive deterioration of the disease. On the other hand, although participants reported that they had worn the orthosis for the amount of time indicated since they were able to perform their activities better, and they did not have as much tremor; these devices do not include a sensor that allows obtaining objective data on their adherence, and despite having obtained this information in the telephone calls made during the intervention period as well as in the evaluation after two months, it would be interesting to obtain objective data about both adherence and participation.

The use of the Bonferroni correction itself has some advantages and disadvantages to consider. It is easy to apply and understand, and minimizes the risk of false positive errors, as well as being a robust and conservative adjustment that does not depend on the nature or distribution of the data or tests and works for any number of tests. On the other hand, it may be too conservative, reducing the power of each test and increasing the risk of false negative errors; it is also not flexible, as it does not take into account the dependence or correlation between tests. All of this must be taken into account when interpreting the results obtained in this research, since when applying the corrected α value, some results that would be positive at a significance level of 0.05 are lost; this is something that will have to be addressed in future research.

Furthermore, this orthosis was implemented during the winter months in a city with a cold climate, so it did not give heat to the participants, however it would be interesting to manufacture it with a breathable material so that heat would not be a problem and could maintain its adhesion in other warmer climates.

Currently, there is a lack of effective orthopedic devices that can be implemented as a non-pharmacological treatment in PD. The results obtained in the present study can be a starting point to continue researching these devices in PD or encourage the development of new ones that are easy to implement, lightweight, and with patient adherence, in order to improve manual dexterity and thus allow greater participation in ADLs, improving their functionality and quality of life. Given that no effects were found when the device was removed, in a future, for a longer implementation of the orthosis for months, it could be interesting to wear it only while performing those activities that are relevant to the patient. Furthermore, given that the biggest problem with current orthoses is their lack of adherence because they are heavy, it would be interesting to implement a sensor that allows checking the adherence in this orthosis and having objective data about it.

Although no differences were found in manual dexterity after removal of the orthosis, it is possible that differences could occur in other variables not studied such as occupational performance, daily use of the arm and hand, etc., which would be interesting variables for future research.

5. Implications for Occupational Therapy Practice

Currently, PD´s fundamental treatment is pharmacological; however, OT is of great relevance for the patient´s occupational performance and QoL. Studies such as this one can encourage greater involvement of occupational therapy in this and other populations. This research shows an alternative non-pharmacological treatment that could reduce the motor symptoms, improve patients' functionality, and increase their QoL without adverse side effects.

In clinical practice, the implications of implementing DEFO could lead to a reduction in bothersome motor symptoms like tremors and rigidity, thereby enhancing functionality fostering greater autonomy for patients in their daily lives. Moreover, such interventions have the potential to substantially improve the quality of life (QoL) for patients, fostering a positive self-image and reducing embarrassment and insecurity associated with symptoms like tremors. By enabling individuals to participate more fully in social activities and group outings without fear of functional limitations, these interventions could enhance social integration and rekindle interest in activities that patients may have previously abandoned. This, in turn, could bolster motivation to explore new activities and experiences without the burden of apprehension or the fear of failure, ultimately promoting a more fulfilling and enriching lifestyle for patients.

5. Conclusions

The DEFO is an easy-to-implement device that may improve manipulative dexterity when worn, and therefore may be a non-pharmacological adjunct to standard treatment to improve the motor aspects of the disease.

As few studies have been conducted with the DEFO in PD, further research is needed to verify its efficacy in PD as well as to see if these possible improvements in manipulative dexterity translate into improvements in occupational performance and participation. Also, including treatment adherence variables in future research would also be of interest.

Author Contributions

Conceptualization, J.G.-S., E.C., M.J.-B. and J.M.T.G.-G.; methodology, J.G.-B. and M.J.-B. ; software, J.G.-B. and J.M.T.G.-G.; validation, E.C. and J.M.T.G.-G.; formal analysis, M.J.-B., M.S.-P. and J.G.-B.; investigation, M.J.-B., C.C.-R. and M.S.-P.; resources, M.J.A.M., C.C.-R. and M.S.-P.; data curation, J.G.-B., C.C.-R. and M.S.-P.; writing—original draft preparation, M.J.-B.; writing—review and editing, J.G.-S., J.G.-B., M.J.A.M. and C.C.-R.; visualization, M.J.-B., J.G.-B., M.S.-P., C.C.-R., E.C., J.M.T.G.-G, M.J.A.M. and J.G.-S.; supervision, E.C., M.J.A.M., J.G.-B. and J.G.-S.; project administration, J.G.-B.; funding acquisition, J.G.-B. All authors have read and agreed to the published version of the manuscript.

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Institutional Review Board Statement

The study was conducted in accordance with the Declaration of Helsinki and approved by Clinical Research Ethics Committee of the Health Area of Burgos and Soria (Spain), with reference number CEIM-2119/2019 before participating in the present study on 25 March 2021 (ClinicalTrials.gov test number: NCT04815382).

Informed Consent Statement

Informed consent was obtained from all subjects involved in the study.

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Supplementary material 1.

Supplementary figure 1. Patient performing the displacement subtest with the DEFO. Own-made source

Supplementary material 2.

Supplementary figure 2. Patient performing the rotation subtest with the DEFO. Own-made source

Supplementary material 3. DEFO FABRICATION OVERVIEW

Dynamic elastomeric fabric orthoses (DEFO) are used to address the physical symptoms associated with neurological, genetic, and musculoskeletal disorders. These orthoses employ a soft, flexible, and durable compression fabric aimed at realigning the affected body segment and influencing muscle tone and the proprioceptive system. Custom-made for a precise fit, each orthosis applies pressure to the affected areas via strategically positioned powernet reinforcement panels.

DEFO are garments that integrate an elastic material with biomechanical reinforcement panels, serving two main functions:

1- They enhance proprioception by stimulating the body's sensory systems.
2- The reinforcement panels realign the body and provide stability at a biomechanical level.

For movement control, appropriate stimuli are required (tremor in Parkinson's disease is an example of involuntary movements in the extrapyramidal pathway). DEFO stimulate the somatosensory system through the proprioceptors in the musculoskeletal system. This sensory information is processed by the cerebellum to adjust movements and posture, influence muscle tone, and provide proximal stability. Different regions of the cerebral cortex then interpret these sensations in meaningful ways, leading to improved movement. Consequently, DEFO can be utilized in both neurophysiological and biomechanical therapies.

Measurements are taken using specific forms that therapists learn to use during specialized training, ensuring the orthoses fit correctly without being too tight or too loose. These measurements are performed while the patient is seated, using a series of precise reference points on the upper limb.

The DEFO are created after taking precise measurements to design the base garment, in this case, an orthosis for the upper limb, always aiming for a functional position. From this position, measurements are taken for the necessary reinforcements, based on the desired outcome. In the context of reducing tremor in individuals with Parkinson's disease, the objective was to activate the finger extensors, wrist extensors, radial deviators, supinators, and external rotators. This approach positions the upper limb with muscles contracting as they would when the limb is supported and bearing weight.

The reinforcements designed to achieve this effect include:

- External rotation reinforcement: panel to sleeve used to correct internal rotation of the shoulder/arm.

- Radial side reinforcement: from the base of the thumb to correct ulnar deviation

- Arm tremor proximal reinforcement: designed to reduce forearm tremor by applying pressure to the deep muscles of the upper forearm

- Thumb abduction reinforcement: from the proximal thumb joint on the palmar aspect, across the posterior of the wrist, to the ulnar aspect of wrist joint; to correct excessive thumb adduction.

- Elbow flexion angle reinforcement: specifies the required degree of elbow flexion with the arm in the patient’s natural resting position.

Additional reinforcements can be applied to increase traction as needed. The prescribing professional determines which reinforcements are necessary for each case based on their training.

Imagen: Dynamic elastomeric fabric orthose (DEFO).

Supplementary material 4. Inter-group comparison of PPT, MMDT and ST differential score evaluation T2 without orthoses in ON and OFF state. ANCOVA

Variables		Group	Mean	SD	MS	F	*p-value*	η^2
PPT Subtest 1	ON – without orthoses	CG	.076	1.29	.489	.232	.632	.005
		EG	-.175	1.50				
	OFF – without orthoses	CG	.111	1.219	.976	.019	.890	.000
		EG	.189	1.803				
PPT Subtest 2	ON – without orthoses	CG	.446	1.258	2.458	.139	.711	.003
		EG	.934	5.317				
	OFF – without orthoses	CG	.40	1.57	.898	.416	.522	.008
		EG	.116	1.425				
PPT Subtest 3	ON – without orthoses	CG	.177	1.323	4.587	.507	.480	.010
		EG	.873	3.479				
	OFF – without orthoses	CG	.001	1.194	12.132	1.137	.291	.022
		EG	1.069	3.790				
PPT Subtest 4	ON-without orthoses	CG	-.1000	5.280	38.460	.410	.525	.008
		EG	1.793	11.674				
	OFF-without orthoses	CG	-.222	1.250	40.381	3.664	.061	.068
		EG	1.707	3.785				
MMDT Placing test	ON – without orthoses	CG	.347	27.380	2.171	.005	.943	.000
		EG	1.392	17.442				
	OFF – without orthoses	CG	3.256	24.600	365.771	.745	.392	.015
		EG	-2.574	20.840				
MMDT Turning test	ON – without orthoses	CG	-6.967	17.023	424.270	1.721	.196	.033
		EG	-.454	14.993				
	OFF – without orthoses	CG	.033	9.911	210.418	.313	.578	.006

		EG	-6.270	37.093				
ST Right hand	ON – without orthoses	CG	2.933	9.706	157.431	1.725	.195	.033
		EG	-1.132	9.416				
	OFF – without orthoses	CG	-.333	9.693	588.302	2.089	.155	.041
		EG	7.108	18.625				
ST Left hand	ON-without orthoses	CG	2.133	6.346	28.048	.365	.548	.007
		EG	-.026	9.774				
	OFF-without orthoses	CG	6.949	6.949	310.548	3.417	.071	.065
		EG	10.534	10..535				

PPT: Purdue Pegboard Test; MMDT: Minnesota Manual Dexterity Test; ST: Square Test; CG: Control group (n=20), EG: experimental group (n=40), SD: standard deviation, p value < .05