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Keywords: Breast cancer; disability; motor disorders; sensation disorders; quality of health care

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Article

Functionality of the Upper Limb in Women with Breast Cancer

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Abstract: Objectives: To analyze differences in affected upper limb functionality (grip strength, digital pinch grip, sensitivity, and manual dexterity) in a population with breast cancer, and the prediction of these factors in perceived disability. **Methods**: Cross-sectional, quantitative, non-randomized, descriptive study. A total of 42 women diagnosed with breast cancer, with neuropathic symptoms in the upper limb after receiving chemotherapy, radiotherapy, or hormone therapy in Eurovillas Physiotherapy and Pilates Clinic, Specialty Center of Torrejón de Ardoz, in Madrid; and Rosae, an association of women affected by breast cancer, in Valdepeñas, Spain. A 40-minute assessment, including the collection of sociodemographic data and administration of the following scales: dynamometry, Spanish Nottingham Somatosensory Assessment Stereognosis Scale, Moberg Pick-up Test, Jebsen & Taylor Hand Function Test, Disability and Shoulder Pain Index (SPADI), pinch dynamometry. The statistical analysis was performed with SPSS 29.0 software. Student's t-tests were used for the group comparison, and the effect size (Cohen's d) was analyzed. An analysis of variance was employed for the linear regression analysis between disability and functionality of the upper limb, considering $p<0.05$ as statistically significant. **Results**: The comparison by age, work status, and years of surgery showed significant differences in the mean dynamometry of the affected hand ($F=11.23$; $D=-0.232$) between the group of women ≤50 years and those >50 years ($p=0.002$). Significant differences were also found in total affected hand disability ($F=6.472$; $D=-0.534$) between the group of active and passive women ($p=0.015$) and in total SPADI time ($p=0.026$), as well as in mean digital pinch grip ($F=5.419$; $D=.467$) between the group of women with surgery ≤4 years and women with surgery >4 years previously ($p=0.027$). Regression analysis revealed that grip strength, digital pinch strength, hand function, and surface sensitivity are predictor variables in 25.7% of perceived shoulder pain and disability cases. **Conclusions**: Breast cancer causes motor and sensory disorders in the affected upper limb and in the daily life of those with the disease, triggering disability and reduced quality of life.

Keywords: breast cancer; disability; motor disorders; sensation disorders; quality of health care

1. Introduction

Cancer is a disease that causes a vast number of health problems and is the second leading cause of death in Spain. Breast cancer is one of the most common types of cancer, together with lung, uterine, and colon-rectum cancer [1,2], occurring a hundred times more frequently in women than in men [3]. Although over the years survival has also increased, reaching 86% in women between 2008 and 2013 [4,5]; in recent years, there has been an increase in its incidence, with 34,750 new cases in 2022 [6,7]. The probability of a woman having breast cancer at some point in her life is 1 in 8, with many cases diagnosed between 45 and 65 years of age [5].

Among the risk factors are female sex, alcohol and tobacco consumption, obesity, family history, genetic mutations, hormonal changes due to menopause, taking oral contraceptives, exposure to pollution, and sedentary lifestyle [4–6,8,9]. The characteristic signs and symptoms of this disease

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include the appearance of lumps in the breast or armpit, skin changes (such as redness, retraction or orange-peel appearance of the breast), abnormal nipple discharge, nipple retraction, eczema, and swelling of the arm [10].

The most frequent secondary symptoms are loss of strength, limited mobility and joint range, pain, and lymphedema [11]. Its impact on the functional level has been proven in a qualitative manner [12,13], with the possibility that the involvement and limitations of the upper limb could lead to future disabilities [14]. Occupational therapy has proven to be a necessary for this group to perform from the early stages, to improve cognitive and functional components, and to enable a return to driving or to incorporate into workplace activity [15]; however, no occupational therapy research has yet analyzed upper limb functionality.

Therefore, this research project aimed to analyze the differences in functionality of the affected upper limb (grip strength, digital grip, sensitivity, and manual dexterity) in a Spanish population with breast cancer, and to determine the prediction of these factors in the disability perceived by these women.

2. Materials and Methods

2.1. Study Design and Samplig

A descriptive cross-sectional study was performed. The participants were recruited under a non-probabilistic convenience sampling from the Eurovillas Physiotherapy and Pilates clinic of the Torrejón Specialties Center (Madrid), and from Rosea, the Valdepeñas association of women affected by breast cancer (Ciudad Real).The inclusion criteria were as follows: (a) women who had undergone surgery for unilateral breast cancer; (b) presence of neuropathic symptoms in the affected upper limb; and (c) having received treatment with chemotherapy, radiotherapy or hormone therapy. The exclusion criteria were (a) having had bilateral breast cancer; (b) having had unilateral breast cancer with locoregional recurrence; (c) having had any other type of carcinoma; (d) having neuropathies associated with systemic, metabolic, or infectious diseases (e.g., diabetes, rheumatoid arthritis, myelomas); (e) neuropathic difficulties associated with systemic, metabolic, or infectious diseases (e.g., diabetes, rheumatoid arthritis, myelomas); (e) language comprehension difficulties that prevented the participant from following test instructions and communicating with the evaluators; or (f) having presented symptoms of neuropathy or neurogenic pain in the regions evaluated prior to treatment.

2.2. Data Collection

The evaluation was performed in a 40-minute session. Six tests were administered in the following sequence:

1. **Dynamometry.** Employing a Jamar® hydraulic hand-held dynamometer, while seated, with both feet touching the floor and the upper limb performing the grip, positioning the shoulder in abduction, the elbow in flexion, and the forearm and wrist in neutral position [16], each participant performed 3 maximal isometric contractions, with 1 minute of rest between them. The mean value of the 3 measurements was then calculated. Both hands were evaluated. This tool presents good intra- and inter-rater reliability (r=0.83 to 0.96) [17] and is recommended for the evaluation of this study population [18].
2. **Stereognosis scale of Nottingham Sensory Assessment in its Spanish version.** This is a test that assesses functional sensitivity, specifically of the median nerve, when picking up and carrying objects with tridigital forceps. Each of the 11 everyday objects was actively recognized through touch without the use of vision. The test was timed, and the total time in seconds was recorded. Only the hand ipsilateral to the affected breast was evaluated. The tool has excellent psychometric data in terms of internal consistency, with an α-Cronbach = 0.91 (95% CI), test-retest reliability (rho=0.915; p<0.01) and inter-rater reliability (k=0.792) [19].
3. **Moberg Pick-up Test.** Participants were instructed to reach for the small test objects placed on the table using tridigital forceps and transport them to the container in the shortest possible time, first with eyes open and then with eyes closed. The total time was measured in seconds. Only the hand ipsilateral to the affected breast was evaluated. It is a simple test, quick to administer, easy to replicate, inexpensive, and with acceptable inter-rater reliability [20].

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4. **Jebsen & Taylor Hand Function Test.** A test that evaluates manipulative dexterity, in which participants were instructed to perform each subtest in the shortest possible time. This test was administered first with the non-dominant hand, followed by the dominant hand. Each subtest was timed and recorded in seconds. It is a valid and reliable test to assess hand function (intraclass correlation coefficient=0.84 to 0.97) [21].
5. **Shoulder Pain and Disability Index.** A questionnaire on shoulder pain and affected upper limb, in addition to the disability index during the performance of various activities of daily living (ADLs). The user must score on a scale of 1 to 10 the pain perceived in the affected MS during the previous week. The Spanish version is reliable and valid for shoulder symptomatology and quality of life in Spanish women after breast cancer treatment (r=0.30 to 0.40) [22].
6. **Pinch dynamometry.** A JAMAR hydraulic clamp meter was used. Each participant performed 3 maximal contractions with a subterminolateral clamp, with 30 seconds of rest between each contraction. The mean value of the 3 measurements was calculated and compared with normative reference data. Both hands were evaluated. This test has excellent intra- and inter-rater reliability (r=0.66 to 0.82) [23].

2.3. Data Analysis

Data were presented as means, standard deviations, and proportions. For the data analysis, a 95% confidence interval was used, and a p value <0.05 was considered statistically significant. In the bivariate analysis of the quantitative variables, the parametric Student's t-test was used. The effect size (Cohen's d) was calculated, considering the effect size as small (0.20 to 0.49), medium (0.50 to 0.79), or large (> 0.80). Lastly, a regression analysis was performed to explore and quantify the relationship between the disability variable and the independent variables affected (hand strength, digital gripper strength, sensitivity, and manual dexterity). A regression model observed by the R-squared value was obtained with an analysis of variance (ANOVA). All statistical analyses were performed with the IBM SPSS v.29 program.

2.4. Ethical Aspects

The study was approved by the Ethics Committee of the La Salle University Center for Advanced Studies in Madrid and registered under registration number CSEULS-PI-009/2019. All participants voluntarily agreed to participate, and signed a written informed consent. This research was conducted in accordance with the principles of good clinical practice in research involving human subjects in accordance with the Declaration of Helsinki.

3. Results

The total sample consisted of 42 participants, whose mean age was 55.9 years. Fifty percent of the women were affected on the dominant side, corresponding mostly to the right side (52.4%). With respect to employment status, they were mainly active, with a manual labor job, compared with 23.8% who were unemployed or 21.4% retired. As for the treatment received, breast surgery and radiotherapy predominated. The description of the participants' characteristics is shown in **Table 1**.

Table 1. Sociodemographic characteristics.

Age	**55.9 ± 10.62 (35-89)**
Body mass index	25.84 ± 3.94 (16.99-37.17)
Months since surgery	85.90 ± 67.26 (10-300)
Affected dominant limb	
Yes	21 (50)
No	21 (50)
Dominant hand	
Right	35(83.3)

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Left	6 (14.3)
Ambidextrous	1 (2.4)
Affected limb	
Right	22 (52.4)
Left	20 (47.6)
Work environment	
Active work	21 (50)
Unemployed	10 (23.8)
Retired	9 (21.4)
Disabled	1 (2.4)
Type of work	
Manual	28 (66.7)
Cognitive	12 (28.6)
Breast surgery	
Yes	41 (97.6)
No	1 (2.4)
Underarm surgery	
Yes	34 (81)
No	8 (19)
Chemotherapy	
Yes	30 (71.4)
No	12 (28.6)
Radiotherapy	
Yes	37 (88.1)
No	4 (9.5)
Hormonal therapy	
Yes	28 (66.7)
No	13 (31)

Mean ± standard deviation (minimum - maximum)
Frequency (Percentage)

Table 2 shows the outcome variables of the tests administered.

There were notable results in standard deviation for dynamometry (16.59 on the dominant hand and 16.09 on the non-dominant hand) and pincerometry (2.30 on the dominant hand and 2.92 on the non-dominant hand). A remarkable standard deviation was also observed in the total Nottingham Somatosensory Assessment time (22.63). In the pain and disability tests, disparate results were observed among the participants.

Table 2. Result variables. n=42.

Dynamometry (Dominant Hand)	25.21 ± 16.59 (1-63.00)
Dynamometry (Non-dominant Hand)	22.55 ± 16.09 (0.50-63.00)
Pinch dynamometry (Dominant Hand)	2.51 ± 2.30 (0.10-9.67)
Pinch dynamometry (Non-dominant Hand)	2.86 ± 2.92 (0.07-14.50)
Total NSA Time (Stereognosis)	59 ± 22.63 (31.35-153.45)
Total NSA Score (Stereognosis)	20.40 ± 1.17 (8.06-20.08)
Moberg O-E (Dominant Hand)	12.72 ± 2.79

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	(8.06-20.08)
Moberg O-E (Non-dominant Hand)	14.68 ± 9.14 (7.83-68.89)
Moberg C-E (Dominant Hand)	23.73 ± 8.17 (13.36-43.79)
Moberg C-E (Non-dominant Hand)	25.77 ± 6.73 (14.95-39.55)
Total JTHFT Time (Dominant Hand)	48.09 ± 11.70 (32.08-95.17)
Total JTHFT Score (Non-dominant Hand)	70.29 ± 20.74 (39.34-149.37)
Total Pain (SPADI)	17.93 ± 15.32 (0-44)
Total Disability (SPADI)	25.86 ± 22.81 (0-69)
Total SPADI Score	43.79 ± 37.29 (0-111)

Mean ± standard deviation (minimum - maximum)

JTHFT: Jebsen Taylor Hand Function Test; NSA: Nottingham Somatosensory Assessment; O-E: Open Eyes; C-E: Closed Eyes; SPADI: Shoulder Pain and Disability Index.

The comparative analysis by age, work status, and years after surgery is shown. Significant differences were found in the mean dynamometry of the affected hand (F=11.23; D=−0.232) between the group of women aged ≤50 years and women aged >50 years (p=0.002) (**Table 3**).

Table 3. Age-matched comparative analysis.

Variables	*≤50 years N=13*	*>50 years N=29*	*(F) p*	*Cohen's D*
Dynamometry in affected hand	19.98±6.44	23.84±19.47	(11.23) 0.002	−0.232
Pinch dynamometry in affected hand	2.21±1.70	2.35±3.03	(0.872) 0.356	−0.052
Total NSA Time (Stereognosis)	54.02±19.79	62.13±23.13	(0) 0.993	−0.366
Moberg O-E in affected hand	11.84±2.49	13.58±3.02	(0.097) 0.757	0.603
Moberg C-O in affected hand	25.53±8.50	25.26±6.56	(0.668) 0.419	0.037
Total JTHFT Time in affected hand	57.27±14.53	59.23±18.53	(1.029) 0.317	−0.113
Total Pain (SPADI)	20.69±16.52	16.79±14.78	(0.776) 0.384	0.254
Total Disability (SPADI)	28±23.42	25.66±22.39	(0.162) 0.690	0.103
Total Score (SPADI)	48.69±39.11	42.45±36.21	(0.345) 0.560	0.168

Median ± standard deviation

(F): Student's T; JTHFT: Jebsen Taylor Hand Function Test; NSA: Nottingham Somatosensory Assessment; O-E: Open Eyes; C-E: Closed Eyes; p: p-value; SPADI: Shoulder Pain and Disability Index.

Statistically significant differences were found in the total disability of the affected hand (F=6.472; D=−0.534) between the group of working women and the group of non-working women (p=0.015); significant differences were also found in the total SPADI time between the group of active women and the group of passive women (p=0.026) (**Table 4**).

Table 4. Comparative analysis matched by employment status groups.

Variables	*Working N=21*	*Non Working N=21*	*(F) p*	*Cohen's D*

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Dynamometry in affected hand	22.9±16.03	22.40±17.47	(0.100) 0.754	0.030
Pinch dynamometry in affected hand	2.38± 1.80	2.23±3.37	(0.879) 0.354	0.055
Total NSA Time (Stereognosis)	59.30±16.84	49.94±27.02	(0.627) 0.433	−0.029
Moberg O-E in affected hand	12.99±3.43	13.09±2.45	(0.795) 0.378	−0.035
Moberg C-O in affected hand	24.96±7.64	25.73±6.75	(0.156) 0.695	−0.106
Total JTHFT Time in affected hand	55.33±15.11	61.92.4±18.92	(0.393) 0.535	−0.385
Total Pain (SPADI)	14.57±13.43	21.43±16.48	(2.586) 0.116	−0.456
Total Disability (SPADI)	20.52±17.66	32.24±25.48	(6.472) 0.015	−0.534
Total Score SPADI	35.10±30.16	53.67±40.99	(5.316) 0.026	−0.516

Mean ± standard deviation

(F): Student's T; JTHFT: Jebsen Taylor Hand Function Test; NSA: Nottingham Somatosensory Assessment; O-E: Open Eyes; C-E: Closed Eyes; p: p-value; SPADI: Shoulder Pain and Disability Index.

Statistically significant differences were found in mean pinch dynamometry in the hand affected (F=5.419; D=0.467) between the group of women with surgery ≤4 years previously and women with surgery >4 years previously (p=0.027) (**Table 5**).

Table 5. Comparative analysis of matched years of surgery.

Variables	*≤ 4 years N=16*	*> 4 years N=17*	*(F) p*	*Cohen's D*
Dynamometry in affected hand	16.88±8.42	14.06±6.66	(1.343) 0.225	0.373
Pinch dynamometry in affected hand	1.60±1.33	1.07±0.91	(5.419) 0.027	0.467
Total NSA Time (Stereognosis)	55.68±18	53.26±13.86	(0.253) 0.618	0.151
Moberg O-E in affected hand	13.32±3.63	13.33±2.83	(0.001) 0.976	−0.004
Moberg C-O in affected hand	26.04±8.73	24.02±5.72	(4.013) 0.054	−0.275
Total JTHFT Time	53.50±14.88	63.39±19.66	(2.024) 0.165	−0.565
Total Pain (SPADI)	17.13±15.54	23±14.87	(0.001) 0.973	−0.387
Total Disability (SPADI)	29.06±23.91	30.94±21.44	(0.205) 0.654	−0.083
Total SPADI Score	46.19±38.76	53.94±35.19	(0.345) 0.561	−0.210

Mean ± standard deviation

(F): Student's T; JTHFT: Jebsen Taylor Hand Function Test; NSA: Nottingham Somatosensory Assessment; O-E: Open Eyes; C-E: Closed Eyes; p: p-value; SPADI: Shoulder Pain and Disability Index.

A regression model observed by the R-squared value was obtained. This is the first information we obtained, which indicated the best fit or goodness of fit for the analysis. It is a standardized measure that takes values between 0 and 1 (0 when the variables are independent and 1 when there is a perfect relationship between them). In this case, the R-squared value was 0.257 (**Table 6**).

Table 6. Regressions.

Model	R	R-squared	R-squared Adjusted	Standard error of estimation
1	.507[a]	**.257**	.177	33.353

a. Predictor Variables: (Constant), Pinch dynamometry, Moberg Pick Up Test eyes closed in affected hand, Total time Jebsen Taylor Hand Function Test in affected hand and Dynamometry.

The p-value of the ANOVA was not significant; therefore, we found that the explanatory variables did not have a joint and linear influence on the dependent variable (**Table 7**).

Table 7. ANOVA test.

Model		Sum of squares	gl	Quadratic mean	F	Sig.
1	**Regression**	14273.511	4	3568.378	3.208	**.023[b]**
	Waste	41160.394	37	1112.443		
	Total	55433.905	41			

a. Predictor Variables: (Constant), Pinch dynamometry, Moberg Pick Up Test eyes closed in affected hand, Total time Jebsen Taylor Hand Function Test in affected hand, and Dynamometry.
b. Dependent variable: Total SPADI.

The regression analysis therefore revealed that grip and digital grip strength (measured by dynamometry and pinchometer, respectively), manual dexterity (measured by the JTHFT test), and combined cortical sensitivity (stereognosis, as measured by the Moberg Pick up Test), are predictor variables in 25.7% of perceived shoulder pain and disability, measured by the SPADI questionnaire.

4. Discussion

In the present study we set out to analyze the differences in affected upper limb functionality (grip strength, finger grip, sensitivity, and manual dexterity) in a Spanish population with breast cancer and to determine the prediction of these factors in the disability perceived by these women.

We found somatosensory alterations and deficits in the affected upper limb after breast cancer, including greater alteration in sensitivity and manipulative dexterity in the affected non-dominant upper limb and lower grip strength in the dominant. We also observed that a greater perceived disability index was an impediment to performing ADLs.

One of the most significant deficits was grip strength, which could be due to the type of treatment used. Surgery, chemotherapy, and radiotherapy have alterations in muscle strength as secondary effects, given that they not only act on damaged cells and tissues, but also on healthy cells and tissue [24–26], which could reduce some functions in the area where the treatment acts or is performed [27–31]. Loss of strength is also a factor consequent to increasing age [32,33], which is likewise a risk factor for breast cancer. After the age of 50 years, hormonal changes from the pre- and postmenopausal periods contribute to loss of strength [5,9,34], which could explain our results in the group of women over 50 years of age [35]. However, a loss of muscle strength has also been observed to begin before the menopausal period, around the age of 30 years [32,33,35], which could explain the results of the group of women under 50 [36].

It has been shown that when grip strength decreases, digital pincer strength also decreases, which would explain why having a deficit in one of the fingers, in this case the thumb, causes some type of added problem in the hand, creating a deficiency of between 14% and 35% in grip strength [37].

On the other hand, the limitation of hand and finger strength could be associated with pain and disability, because the lack of muscle strength can cause algesia in manipulative activities that require resistance, preventing the performance of ADLs and generating disability in daily life [14,38]. Furthermore, the loss of strength after breast cancer would explain the perceived disability, given that, as corroborated by our results, the decrease in strength after this disease causes between 17% and 43% of disability in women with the disease [37]. Likewise, several studies have determined that strength training on upper limbs after breast cancer could be beneficial for recovery [39]. Given that strength level is directly related to pain, quality of life, and upper limb function, the greater the strength, the less pain and the greater the function and quality of life [14,37]. This also suggests that the loss of strength together with other sequelae, such as loss of mobility, sensitivity, and manual dexterity, generate pain and disability, affecting work performance [14,38].

Peripheral neuropathies, often secondary to aggressive cancer treatments (e.g., chemotherapy, radiotherapy, surgery) could be responsible for somatosensory disturbances of the upper extremity. This nervous alteration in turn causes loss of muscle mass and strength [42,43], which could explain why these variables were related in our results. We also found an association between sensitivity and manual dexterity. Similar findings are described in the scientific literature, showing that sensitivity is a predictor of manual dexterity [44].

Despite the fact that grip and gripper strength, manual dexterity, and functional sensitivity determine 25.7% of the risk of developing a disability, many articles have reported that these deficits limit the life of women with breast cancer, both in terms of ADLs and in terms of participation in and quality of life [14,37,38].

Numerous articles have confirmed that a deficit in the functionality of the upper limb implies a decrease in the quality of life, influencing or hindering social participation and performance of daily activities [14,31,45]. However, quality of life is not only diminished by the disability generated by functional limitations on the affected side. The psychological repercussions of having breast cancer and the disorders that many women experience are often overlooked, thus favoring the failure of rehabilitation and subsequent recovery [14,46,47].

Therefore, the creation of specific programs for people who have had breast cancer could be an optimal solution to treat the functional, performance, and quality of life problems associated with this pathology. Several studies have already investigated beneficial physical exercise programs adapted to this pathology [37,41]. In addition, there is evidence that performing it in the early stages of the disease can be beneficial for preventing a decrease in upper limb strength and improving mobility [48]. Occupational therapy programs have also been observed to work for specific rehabilitation, to improve participation in daily life and the quality of life of these people [49–51].

This study has some limitations with respect to the sample size and heterogeneity of the selected sample, as well as measurement biases, given that the assessment tools used were validated in a population different from the study sample. It should be noted that the current scientific literature on the subject is scarce; thus, it was difficult to find similar studies or studies in which all the variables that we used have been evaluated.

5. Conclusions

Half of the women had greater impairment of somatosensory function, strength, and manipulative dexterity in the affected upper extremity after breast cancer. The results showed significant differences in dynamometry of the affected hand between women younger and older than 50 years and between active and passive women in the shoulder disability index.

Grip and pincer strength, along with manual function and tenderness, were predictor variables for shoulder pain and disability.

6. Patents

Author Contributions: Conceptualization, MG.C-N, C.C-G and BD.Z-R.; methodology, MG.C-N, C.C-G and BD.Z-R; software, BD.Z-R and MG.C-N; validation, BD.Z-R and MG.C-N; formal analysis, BD.Z-R and M.G-M, investigation, MG.C-N, V.A-A; resources, BD.Z-R and MG.C-N.; data curation, MG.C-N, C.C-G, M.G-M and BD.Z-R; writing – original draft preparation, MG.C-N and V.A-A; writing – review & editing, MG.C-N, C.C-G, M.G-M and BD.Z-R; visualization, MG.C-N, C.C-G, V.A-A and BD.Z-R.; supervision, MG.C-N, C.C-G and BD.Z-R, project administration, BD.Z-R and MG.C-N.

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

Data Availability Statement: Data is available by contacting the authors.

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