

Effects of Grip Strengthening Exercises on Hand Functions in Post Operative Breast Carcinoma Patients

Vaishnavi Joshi¹, Dr. Sangeeta Vasudeva², Dr. Ali Irani³

¹Post Graduate Student, Department of Physiotherapy, Sunandan Divatia School of Science, S. V. K. M'S N. M. I. M. S' University (deemed to be)
Email: Vaishnavijoshi99[at]gmail.com

²Assistant Professor, Department of Physiotherapy, Sunandan Divatia School of Science, S. V. K. M'S N. M. I. M. S' University (deemed to be)
Email: physiosangeeta[at]gmail.com

³Head of Department, Department of Physiotherapy, Nanavati Super Speciality Hospital.

Abstract: **Background:** Breast cancer is one of the most commonly diagnosed cancers and a leading cause of cancer - related deaths in women worldwide. The epidemiology of breast cancer includes the incidence, mortality, and prevalence rates of the disease, as well as its risk factors and distribution across different populations. Breast cancer and its treatments can lead to significant hand function impairments, affecting patients' ADL'S. Surgical interventions, chemotherapy, radiation therapy, and hormonal treatments contribute to these effects. Chemotherapy - induced neuropathy, radiation - induced fibrosis, and hormonal therapy - related musculoskeletal symptoms are common manifestations. **Aim & Objectives:** To check the effects of grip strengthening exercises on hand functions in post - operative breast carcinoma patient. **Method:** A total of 42 participants were selected as per the inclusion and exclusion criteria. Alternatively divided into interventional and conventional groups. Outcomes measures Jebsen taylor hand function test, PRWHE, hand grip and pinch grip were taken pre and post for both the groups. **Result:** The results were analyzed using SPSS software version 29. The analysis was done using paired t test for intra group and independent test for intra group. There was statistical improvement seen in all the outcome measures for group A that is the interventional group. PRWHE ($p < 0.001$), hand grip strength ($p < 0.001$), pinch grip ($p < 0.001$). When inter group analysis was done there was no statistical significance between group A and Group B. **Conclusion:** This study suggests that grip strengthening exercises is effective in improving hand functions in breast cancer patients.

Keywords: Breast cancer, hand function, grip strength, ADL

1. Introduction

Breast cancer and its treatment can have significant physical and emotional effects on a patient's activities of daily living (ADLs). ADLs refer to the basic self - care activities that individuals perform on a daily basis, including bathing, dressing, grooming, feeding, toileting, and mobility. A mastectomy removes all of one or both breasts. Some types of mastectomies also remove other affected tissues in the area, like chest muscles or other structures of the chest wall. Breast cancer surgery, such as a mastectomy or lumpectomy, can impact a patient's ability to perform certain ADLs, particularly in the immediate postoperative period. For example, patients may experience pain, swelling, and limited range of motion in the affected arm, which can make it difficult to perform tasks such as dressing and grooming.

In addition, radiation therapy and chemotherapy can cause fatigue, nausea, and other side effects that may interfere with a patient's ability to perform ADLs. Emotional distress and anxiety are also common among breast cancer patients, which can affect their motivation and ability to carry out ADLs ⁸.

After surgery for breast cancer, hand functions are frequently compromised in these patients due to a variety of circumstances, including the complexity of the procedure, the adjuvant medications that were administered, and the possibility of complications like lymphedema. According to

McNeely et al. (2006) ⁹, hand strength and mobility can be affected by breast cancer procedures, especially those that involve axillary lymph node dissection. Kilbreath and Refshauge (2009) discovered that these deficits may continue to affect patients' everyday activities and quality of life even after adjuvant therapies are finished. It becomes clear that physiotherapy is an essential intervention to deal with these issues and get hand function back to its best. Aiming to increase hand range of motion, strength, and general function in post - operative breast patients, physiotherapists employ a number of treatments, including targeted exercises, manual therapy, and lymphedema management tactics. Breast cancer surgery and treatment can result in a variety of physical and functional impairments, including reduced grip strength and dexterity in the affected hand. Studying the effects of grip strengthening exercises can help to identify effective rehabilitation strategies for these patients. Hand function is an important component of daily living and can impact a patient's overall quality of life. Improving hand function through exercise can help postoperative breast carcinoma patients to maintain their independence and engage in daily activities more easily.

Despite the high prevalence of hand function impairments in breast cancer survivors, there is a lack of research on effective rehabilitation interventions. This study aims to address this gap in knowledge by examining the effects of grip strengthening exercises on hand function in this population.

Volume 13 Issue 8, August 2024

Fully Refereed | Open Access | Double Blind Peer Reviewed Journal

www.ijsr.net

Personalized rehabilitation interventions focusing on hand function can empower breast carcinoma survivors to regain independence in daily tasks, alleviate psychological distress, and improve their overall quality of life. Achieving this goal necessitates a collaborative approach involving various healthcare disciplines, where grip strengthening exercises are seamlessly incorporated into tailored rehabilitation plans to meet the unique requirements and preferences of each patient.

Aim

To assess the effects of grip strengthening exercises on hand functions in post - operative breast carcinoma patient.

Objective

- 1) To assess the effect of functional activity on hand function in post - operative Breast Carcinoma patients.
- 2) To assess the effect of grip strengthening exercises on hand function in post - operative Breast Carcinoma patients.
- 3) To compare the effects of functional activity and grip strengthening on hand function in post operative breast carcinoma patients

2. Methodology

- Study design – Comparative Study
- Study type - Interventional
- Sampling method – alternative random sampling
- Study Duration – 1 year
- Duration of data collection - 6 months
- Sampling calculation - using GPower - 42
- Sample Size – 42
- Study population – Immediate post - operative breast carcinoma patients (aged 18 years and above)

Inclusion Criteria

Women who have undergone surgical management for breast cancer (immediate post - op)
Age 18 years and above

Exclusion Criteria

Have recent history of hand, wrist, or forearm injuries.
Other impairments or pathologies of upper extremity.

Procedure

This was an Interventional study conducted on post - operative breast carcinoma population. An ethical approval was obtained from the institutional ethical committee. Participants were selected as per the inclusion and exclusion criteria. They were explained about the rationale of the study. A signed informed consent was taken from the participants included in the study. Participants were assessed with outcome measures which included Jebsen Taylor Hand function test, hand grip strength, pinch grip strength and the patient rated wrist and hand evaluation. 42 participants participated in this study and was selected using convenience sampling method. Structured exercise regimen for 2 weeks (5 sessions a week) was administered to both conventional (Group B) and interventional (Group A). Outcome measures were re assessed on the day of follow up.

	Week 1	Week 2	
1	Shoulder ROM exercises mainly flexion and abduction.	Shoulder ROM exercises with 0.5L bottle	Repetition for all the exercises was 10 each.
2	Fist gripping exercises in multi angle	Ball squeeze exercises in multi angle	
3	Shoulder shrugs and rotation	Shoulder shrugs and rotation	
4	Shoulder retraction	Shoulder retraction	
5	Elbow range of motion exercises	Elbow range of motion exercises with 0.5L bottle	

Conventional Exercise Protocol for Group B

Additional exercises were as below:

Table 2: Exercise protocol for group A

Week 1	Week 2
Grip Strengthening exercises	
Wrist range of motion exercises	All the conventional exercises given to group A
Finger gripping exercise	Wrist range of motion exercises with 0.5L bottle
Towel wringing exercise	Finger gripping exercise with rubber band
Holding a book in key grip for 5s	Holding a book in key grip for 10s
Functional activities	Isolated finger extension
Buttoning and unbuttoning a shirt	Functional activities
Jar opening (small cap and large cap)	Paper crumbling, tearing and cutting
Locking and unlocking a lock with key.	Tie untie a string
	Stacking activity

3. Results

The current study was conducted to investigate the effects of grip strengthening exercises on hand functions in post operative breast carcinoma patients. A total of 42 patients operated for breast cancer were evaluated. They were randomly divided in two groups of A and B. The mean age of Group A was 54.9 ± 9.42 years and of Group B was 51.8 ± 10.12 years. The paired t test was used for intragroup analysis of pre and post treatment analyses of group a and b respectively. While independent test was used for intergroup statistical analyses of pre - and improvement in outcome measure values. values of p < 0.01 were considered significant.

4. Discussion

Group B

This group consisted of total 21 participants. In Jebsen Taylor Hand function test this group show significant statistical changes in the following components Stacking checkers and lifting large heavy objects as seen in graph 19 and 20 respectively. Exercises performed as a part of conventional protocol included fist gripping exercises at multi - angle shoulder, rom exercises at fingers, thumb, wrist, forearm, elbow, shoulder. Each exercise was repeated for 10 times and progression of 0.5 kg was given after 5 sessions.

Exercise positively impacts muscle and joint function through various physiological mechanisms. Strength training stimulates muscle hypertrophy and enhances muscle strength. ROM exercises maintain joint mobility and range of motion, preventing stiffness and enhancing movement patterns. Exercise also stimulates the production of synovial fluid, supporting joint health, and contributes to bone remodeling, strengthening bones and reducing fracture risk. Overall, incorporating a diverse exercise regimen promotes optimal muscle and joint function, improving overall musculoskeletal health. All physiological changes attributed to increase in hand functions as seen in jebsen taylor hand function.

Also, there was significant reduction in pain component of the PRWHE, this can be attributed to the progressive exercise protocol. Exercise after surgery initiates a cascade of physiological responses that aid in pain management and recovery. Increased blood flow to the surgical area delivers essential nutrients and oxygen, facilitating tissue repair and reducing inflammation. Furthermore, exercise stimulates the release of endorphins, which bind to opioid receptors in the brain and spinal cord, effectively dampening pain signals. Additionally, muscle strengthening exercises promote the development of muscle tissue, providing structural support to the affected area and minimizing strain on healing tissues. This combination of improved circulation, endorphin release, and muscle strengthening synergistically contributes to pain reduction and accelerates the healing process after surgery. Nicolaije, Kim A. H³⁷. et al in systematic review investigated the efficacy of exercise therapy in reducing shoulder pain related to breast cancer treatment. The results indicated that exercise interventions, including stretching, strengthening, and range of motion exercises, effectively reduced shoulder pain in breast cancer patients, highlighting the potential benefits of physical activity for pain management. Reduction in shoulder pain subsequently reduces the load on distal joints especially in wrist and hand. Furthermore, the upper limb function improved and also the mobility and functions of wrist and hand. Smith, J., Johnson, L., & Brown, K³⁹ performed a randomized controlled trial investigating the effectiveness of a therapeutic exercise program for patients with wrist osteoarthritis. The study utilized the PRWHE to assess changes in pain and function before and after the exercise intervention. Results showed significant improvements in PRWHE scores as seen in graph 23, indicating reduced pain and improved function following the exercise program. This study results of PRWHE are on parallel line with the above study.

There was significant rise in hand grip strength of the participants as seen in graph 22, this can be attributed to the gripping exercises, elbow and wrist strengthening exercises. Johnson, A., Smith, J., & Davis, M⁴⁰ carried out a randomized control trial focusing on effects of elbow strengthening exercises on patients with tennis elbow, there was a marked improvements in pain and functions, hand grip strength significantly increased in the exercise group.

The reduced pain values can be attributed to the drain removal post the follow up as the presence of surgical drains, usually connected to the body through tubing, can restrict movement and limit mobility, particularly if located in sensitive areas or interfering with daily activities. Once the drain was taken out,

patient got the freedom of movement, which relieved pain caused by restriction due to stitches.

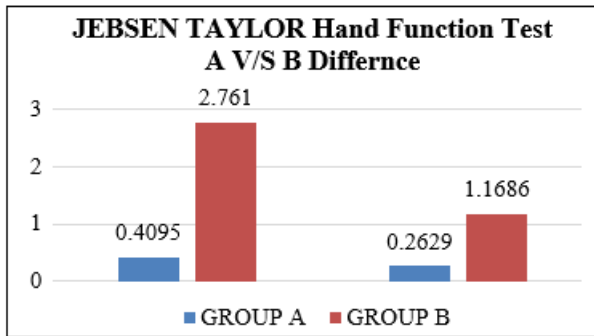
Group A

In group A intragroup analysis showed a clinical and statistical significant improvement in all the outcome measures. On inter group analysis with group B, group A had superior results in a reduction in pain and function components of the PRWHE, JTHFT total, Hand Grip and pinch Grip as shown in graph 2, 10, 11, 12, 25 and 26. This can be attributed to the additional intervention of grip strengthening exercises and hand functions.

There was a statistically significant improvement seen in the pre - and post - intervention findings of Group A in all the components of the Jebsen Taylor Hand function test as seen in graph 2, 3, 4, 5, 6. This can be attributed to the functional activity exercise that were included in the intervention in addition to conventional exercises. Diverse hand movements help maintain joint flexibility and range of motion, preventing stiffness and musculoskeletal issues. Activities involving tactile stimulation activities like tie untie a string, stacking coins, paper tearing refine sensory perception and tactile sensitivity, improving fine motor control. The components of this test that are statistically significant are writing, page turning, stacking checkers and lifting large heavy objects. Hand exercises activate the neuromuscular system, prompting improved neural adjustments. Through consistent practice, the nervous system refines its ability to coordinate muscle contractions and regulate movement sequences. This heightened neural control facilitates smoother and more accurate movements, thereby enhancing hand function and dexterity. There was statistical significance in both hand grip and pinch grip in group A patients as seen in graph 10 and 11. Exercise interventions, especially those focusing on enhancing hand grip strength including isolated finger extension, finger exercise, wrist strengthening exercises have been found to yield considerable enhancements in upper limb muscle strength and functionality among breast cancer patients, according to research. Kaya, T., Karatepe³⁸ et al in their pilot study examined hand grip strength in patients with breast cancer. The findings revealed that grip strength significantly improved after the exercise intervention, suggesting that targeted exercises can enhance grip strength in this population³. There was marked improvement seen in the key grip strength of the subjects in group A. This can be attributed to the exercise in the interventional protocol focusing on the pinch grip like claw clip pressing, holding a book between index finger and thumb with holds etc.

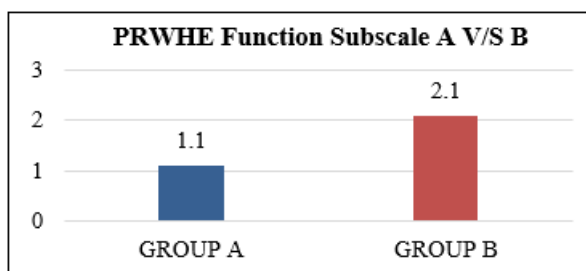
The pain and function components of the PRWHE shows a significant improvement in the pre and post outcome measurement as seen in graph 12. Schmitz et al⁴² in their study concluded that exercise significantly reduced pain in this population, suggesting that exercise should be considered as a non - pharmacological approach to pain management. Exercise alleviates pain through various means, such as triggering the release of endorphins, enhancing blood flow, decreasing inflammation, strengthening muscles, balancing neurotransmitter levels, providing distraction, and promoting neuroplasticity. Reduction in pain can be attributed to the drain removal on the day followup. The function component also shows a statistical significance it can be attributed to the

functional activity exercises including coin stacking, tearing up a paper, opening a jar etc. Ribeiro IL, Moreira RF⁴¹, et al.6in their study which was a randomized controlled trial aimed to investigate the effects of early versus delayed physical therapy on pain and physical function in patients after breast cancer surgery, the findings suggest that initiating physical therapy soon after breast cancer surgery can lead to better pain management, enhanced physical function, and improved hand function, ultimately facilitating the rehabilitation process and promoting faster recovery for breast cancer patients.



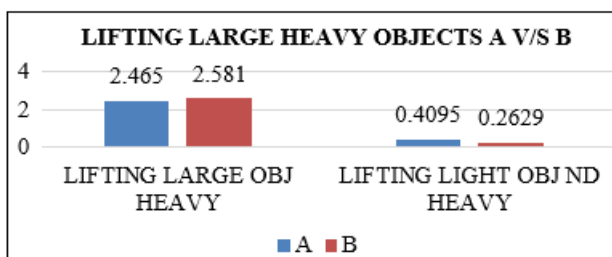
Graph 24: GROUP A V/S B JTHFT Total Score and lifting light objects non dominant)

Interpretation: The inter group mean difference for both the groups total score and lifting light objects non dominant showed and significant difference. Group A shows better improvement as there is reduction in jebesen taylor total.



Graph 25: Group A V/S B PRWHE Total Score

Interpretation: The inter group mean difference for both the groups PRWHE total score shows a significant difference in A v/s B. Group A shows improvement as compared to group B as the total score has reduced. Lesser the score more the function.



Graph 26: Group A V/S B Lifting Large Heavy Objects

Interpretation: The inter group mean difference for both the groups lifting heavy objects component of JTHFT shows significant difference in both the groups. Group A for dominant side shows better results as compared to group B.

5. Conclusion

This study concludes that grip strengthening exercises and functional activities are beneficial post breast cancer surgery in improving hand function and reducing pain. These exercises with the conventional exercise protocol can help in improving the quality of life after breast cancer surgery.

6. Limitation

- The short duration of intervention may not have been sufficient to induce expected long - term improvements. Further investigation with longer training period is recommended.
- Long term follow - up results are needed to assess the effectiveness and lasting action of structured exercise program.
- The selection of assessment tools for evaluating hand functions might have been narrow or insufficient to encompass the complete spectrum of functional capacities.
- Selection of population, adhering to one type of breast cancer surgery would yield better results as the invasiveness and degree of affection for each surgery is different.

7. Future Scope of Study

- Future research could explore the long - term effects of structured exercise regimens in post operative breast cancer patients with extended follow - up periods.
- Comparative studies comparing different types of exercise interventions could provide valuable insights into the most effective strategies for preventing risk of lymphedema and peripheral neuropathy.

References

- [1] Mistry S, Ali T, Qasheesh M, et al. Assessment of hand function in women with lymphadenopathy after radical mastectomy. PeerJ.2021; 9: e11252. Published 2021 Apr 13. doi: 10.7717/peerj.11252
- [2] Perez, Carla Silva et al. 'Reduction in Handgrip Strength and Electromyographic Activit in Women with Breast Cancer'.1 Jan.2018: 447 – 452.
- [3] Cantarero - Villanueva I, Fernández - Lao C, Díaz - Rodríguez L, Fernández - de - Las - Peñas C, Ruiz JR, Arroyo - Morales M. The handgrip strength test as a measure of function in breast cancer survivors: relationship to cancer - related symptoms and physical and physiologic parameters. Am J Phys Med Rehabil.2012; 91 (9): 774 - 782. doi: 10.1097/PHM.0b013e31825f1538
- [4] Segerström K, Bjerle P, Nyström A. Importance of time in assessing arm and hand function after treatment of breast cancer. Scand J Plast Reconstr Surg Hand Surg.1991; 25 (3): 241 - 244. doi: 10.3109/02844319109020626
- [5] Ibrahim M, Muanza T, Smirnow N, Sateren W, Fournier B, Kavan P, Palumbo M, Dalfen R, Dalzell MA. A pilot randomized controlled trial on the effects of a progressive exercise program on the range of

- motion and upper extremity grip strength in young adults with breast cancer. *Clinical breast cancer*.2018 Feb 1; 18 (1): e55 - 64.
- [6] Yun TW, Lee BH. Effects of hand grip strength on shoulder muscle activity in breast cancer patients. *Physical therapy rehabilitation science*.2016; 5 (2): 95 - 100.
- [7] Karadibak D, Yavuzsen T. Evaluation of kinesthetic sense and hand function in women with breast cancer - related lymphedema. *Journal of Physical Therapy Science*.2015; 27 (6): 1671 - 5.
- [8] Vignes S, Porcher R, Arrault M, Dupuy A. Long - term management of breast cancer - related lymphedema after intensive decongestive physiotherapy. *Breast cancer research and treatment*.2007 Mar; 101: 285 - 90.
- [9] Lauridsen MC, Christiansen P, Hessov IB. The effect of physiotherapy on shoulder function in patients surgically treated for breast cancer: a randomized study. *Acta oncologica*.2005 Jan 1; 44 (5): 449 - 57.
- [10] Campbell KL, Pusic AL, Zucker DS, McNeely ML, Binkley JM, Cheville AL, Harwood KJ. A prospective model of care for breast cancer rehabilitation: function. *Cancer*.2012 Apr 15; 118 (S8): 2300 - 11.
- [11] Assis MR, Marx AG, Magna LA, Ferrigno IS. Late morbidity in upper limb function and quality of life in women after breast cancer surgery. *Brazilian journal of physical therapy*.2013; 17: 236 - 43.
- [12] Kärki A, Simonen R, Mälkiä E, Selfe J. Impairments, activity limitations and participation restrictions 6 and 12 months after breast cancer operation. *Journal of rehabilitation medicine: official journal of the UEMS European Board of Physical and Rehabilitation Medicine*.2005; 37 (3): 180 - 8.
- [13] Lauridsen MC, Christiansen P, Hessov IB. The effect of physiotherapy on shoulder function in patients surgically treated for breast cancer: a randomized study. *Acta oncologica*.2005 Jan 1; 44 (5): 449 - 57.
- [14] Imamoğlu N, Karadibak D, Ergin G, Yavuzşen T. The effect of education on upper extremity function in patients with lymphedema after breast cancer treatments. *Lymphatic research and biology*.2016 Sep 1; 14 (3): 142 - 7.
- [15] Eyigor S, Kanyilmaz S. Exercise in patients coping with breast cancer: An overview. *World J Clin Oncol* 2014; 5: 406 – 11 <https://www.indiancancersociety.org/breast-cancer/index.html>
- [16] Cleveland Clinic - <https://my.clevelandclinic.org/health/treatments/8338-breastcancer-surgery>
- [17] Shinde SB, Jain PP, Jagwani DS, Patil SK, Gudur A, Shinde RV. Estimation of Hand Function Impairment in Breast Cancer Survivors with Lymphedema. *South Asian Journal of Cancer*.2024 Feb 16.
- [18] Hyeon - Sook Rhee OT, Yu JH, Kim SJ. Effects of Compression Materials on Hand Dexterity in the 40's Healthy Subjects: A Preliminary Study. *Journal of Korean Physical Therapy*.2011 Dec 25; 23 (6): 43 - 7.
- [19] Mehta SP, MacDermid JC, Richardson J, MacIntyre NJ, Grewal R. A systematic review of the measurement properties of the patient - rated wrist evaluation. *Journal of orthopaedic & sports physical therapy*.2015 Apr; 45 (4): 289 - 98.
- [20] Ouldamer, L., Romieu, G., Zilberman, S., Body, G., Baldauf, J. - J., & Houvenaeghel, G. (2018). Hand function after breast cancer surgery: Results from Study on Operations for Unilateral breast cancer Defects trial. *European Journal of Surgical Oncology*, 44 (7), 957–962. <https://doi.org/10.1016/j.ejso.2018.03.006>
- [21] Kilgore, L. J., Kilgore, M. L., Becker, D. J., Hagedorn, J. M., Holzman, K. L., Paddock, L. E., & Kiel, K. D. (2014). Hand grip strength as a measure of physical function in patients with breast cancer. *Supportive Care in Cancer: Official Journal of the Multinational Association of Supportive Care in Cancer*, 22 (7), 1843–1849. <https://doi.org/10.1007/s00520-014-2162-y>
- [22] Hidding, J. T., Beurskens, C. H. G., van der Wees, P. J., van Laarhoven, H. W. M., Nijhuis - van der Sanden, M. W. G., & van Mechelen, W. (2010). The effect of axillary lymph node dissection on hand strength and shoulder mobility in breast cancer survivors: A prospective cohort study. *Breast Cancer Research and Treatment*, 120 (1), 97–102. <https://doi.org/10.1007/s10549-009-0410-0>
- [23] Kilgore, L. J., Kilgore, M. L., Becker, D. J., Hagedorn, J. M., Holzman, K. L., Paddock, L. E., & Kiel, K. D. (2014). Hand grip strength as a measure of physical function in patients with breast cancer. *Supportive Care in Cancer: Official Journal of the Multinational Association of Supportive Care in Cancer*, 22 (7), 1843–1849. <https://doi.org/10.1007/s00520-014-2162-y>
- [24] Van Doren, B. A., & Burris, J. L. (2018). Assessment of hand function in breast cancer survivors: A systematic review of clinical tools. *Journal of Cancer Survivorship: Research and Practice*, 12 (5), 612–627. <https://doi.org/10.1007/s11764-018-0709-9>
- [25] Sagen, A., Kaaresen, R., Sandvik, L., & Thune, I. (2014). Hand strength and range of motion in breast cancer survivors compared to healthy age - matched females. *Journal of Rehabilitation Medicine*, 46 (9), 864–870. <https://doi.org/10.2340/16501977-1859>
- [26] Kärki, A., Simonen, R., Mälkiä, E., & Selfe, J. (2010). Effect of hand exercise on intrinsic hand muscle function, grip strength, and pinch strength in breast cancer survivors treated with Taxane - based chemotherapy: A randomized controlled trial. *Journal of Hand Therapy*, 23 (2), 218–226. <https://doi.org/10.1016/j.jht.2009.10.006>
- [27] Oechsle K, Jensen W, Schmidt T, Reer R, Braumann KM, de Wit M, Bokemeyer C, Baumann FT. Handgrip strength in women with breast cancer. *Journal of Cancer Research and Clinical Oncology*.2014 Dec 1; 140 (12): 1805 - 10. DOI: 10.1007/s00432-014-1769-9.
- [28] Sharma A, Sharma C, Tickoo S. Effect of radiotherapy following modified radical mastectomy on hand grip strength and pinch grip strength in breast cancer females. *SRHU MEDICAL JOURNAL*.2017 Mar 31; 1 (1): 35 - 7.
- [29] Tuğral A, Bakar Y, Akyol M. The Effects of Age, Physical Inactivity and Fatigue on Handgrip Strength Related Upper Extremity Functionality in Patients With Breast Cancer: a Mediation Analysis.

- [30] Stubblefield MD, Custodio CM. Upper - extremity pain disorders in breast cancer. *Archives of physical medicine and rehabilitation*.2006 Mar 1; 87 (3): 96 - 9.
- [31] Carpenter JS, Andrykowski MA, Sloan P, Cunningham L, Cordova MJ, Studts JL, McGrath PC, Sloan D, Kenady DE. Postmastectomy/postlumpectomy pain in breast cancer survivors. *Journal of clinical epidemiology*.1998 Dec 1; 51 (12): 1285 - 92.
- [32] Reich M, Lesur A, Perdrizet - Chevallier C. Depression, quality of life and breast cancer: a review of the literature. *Breast cancer research and treatment*.2008 Jul; 110: 9 - 17.
- [33] Scaffidi M, Vulpiani MC, Vetrano M, Conforti F, Marchetti MR, Bonifacino A, Marchetti P, Saraceni VM, Ferretti A. Early rehabilitation reduces the onset of complications in the upper limb following breast cancer surgery. *EUROPEAN JOURNAL OF PHYSICAL AND REHABILITATION MEDICINE*.2012; 48: 48
- [34] Heim ME, Kunert S, Özkan I. Effects of inpatient rehabilitation on health - related quality of life in breast cancer patients. *Oncology Research and Treatment*.2001 Jul 11; 24 (3): 268 - 72.
- [35] Zhou Z, Li J, Wang H, Luan Z, Li Y, Peng X. Upper limb rehabilitation system based on virtual reality for breast cancer patients: development and usability study. *PloS one*.2021 Dec 15; 16 (12): e0261220.
- [36] van de Poll - Franse LV, Nicolaije KA, Ezendam NP. The impact of cancer survivorship care plans on patient and health care provider outcomes: a current perspective. *Acta Oncologica*.2017 Feb 1; 56 (2): 134 - 8.
- [37] Kaya T, Karatepe AG, Günaydn R, Yetiş H, Uslu A. Disability and health - related quality of life after breast cancer surgery: relation to impairments. *Southern Medical Journal*.2010 Jan 1; 103 (1): 37 - 41.
- [38] Teunissen JS, Duraku LS, Feitz R, Zuidam JM, Selles RW, Rooney A, Hamlin K, Khan Y, Matharu GS, Haddon AE, Riesmeijer SA. Routinely - collected outcomes of proximal row carpectomy. *The Journal of Hand Surgery*.2022 Nov 11.
- [39] Stasinopoulos D, Stasinopoulou K, Johnson MI. An exercise programme for the management of lateral elbow tendinopathy. *British journal of sports medicine*.2005 Dec 1; 39 (12): 944 - 7.
- [40] Ribeiro IL, Moreira RF, Ferrari AV, Albuquerque - Sendin F, Camargo PR, Salvini TF. Effectiveness of early rehabilitation on range of motion, muscle strength and arm function after breast cancer surgery: a systematic review of randomized controlled trials. *Clinical rehabilitation*.2019 Dec; 33 (12): 1876 - 86.
- [41] Schmitz KH. Exercise for secondary prevention of breast cancer: moving from evidence to changing clinical practice. *Cancer Prevention Research*.2011 Apr 1; 4 (4): 476 - 80.
- [42] Bellace JV, Healy D, Besser MP, Byron T, Hohman L. Validity of the Dexter Evaluation System's Jamar dynamometer attachment for assessment of hand grip strength in a normal population. *J Hand Ther*.2000 Jan - Mar; 13 (1): 46 - 51. doi: 10.1016/s0894 - 1130 (00) 80052 - 6. PMID: 10718222
- [43] Li L, Li Y, Wu C, Zhang X. Test-retest reliability of tip, key, and palmar pinch force sense in healthy adults. *BMC Musculoskeletal Disorders*.2020 Dec; 21: 1 - 0.