

Impact of Unilateral Mastectomy on Gait Parameters

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Abstract

Background: The prevalence of breast cancer has risen dramatically in recent years and became the second most common cause of cancer mortality in women, after lung cancer. Mastectomy is the most common surgery for treating breast cancer and have the highest survival rate.

Aim of Study: The study's goal is to demonstrate how alterations in gait characteristics are caused by mastectomy.

Subjects and Method: One hundred & forty females were divided into two groups. Seventy females post-mastectomy serves as a study group and another seventy healthy group.

The study group's age ranged from 30 to 67 years and subdivided into 2 other groups. (group A) young group from 30 to 44 years and (group B) old group from 45 to 67 years.

All candidates were required to move back and forth in the physical therapy room at their own pace while dressed comfortably and with passive markers on their feet.

Their walk was recorded by HD Nikon camera for one whole minute. Following that, the information was gathered and processed by HD-Cam Kinovea Software to derive gait parameters.

The parameters collected were Step Length, Stride Length, Step Time, Cadence, and Left-Right Asymmetry.

Results: The results of current study revealed significant differences in all parameters between Controlled and Study groups ($p < 0.01$), considering the age groups within the study group, there were differences between young and older group in all parameters, so the age is considered to be one of the reason of the deterioration of the gait parameters.

Conclusion: There are gait parameters changes as a result of mastectomy as a surgery.

Key Words: Mastectomy — Kinovea — Software — Gaitparameters.

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Introduction

AMONG female patients globally, breast cancer is the most prevalent malignant tumor. Over 2.3 million new cases and 685,000 deaths from breast cancer occurred [1].

Women over 40 tend to develop cancer more frequently, which alters the musculoskeletal system. [2].

1 in 9 women estimated to be discovered to have breast cancer diagnosis before turning 85. The current 5-year breast cancer survival rate is 93% [3].

In order to treat or prevent breast cancer, entire breast tissue is surgically removed from the chest this procedure called a mastectomy. With all these types, the most common and sophisticated surgeries are radical & modified radical [4].

Breast cancer survivors' physical function is negatively affected by diminished muscular strength and decreased postural stability, which raises their risk of falling. Additionally, they discovered that cancer patients who had not had any chemotherapy had less stable gait than cancer survivors who had [5]. When malignant and suspicious tissue is removed, the chest cavity is left with a gap, which frequently gives women the impression that their weight is distributed improperly whether she is wearing an external breast prosthesis or not.

This will alter the patient's spine curve, leading to an imbalance to fall on the lower body parts and distorting the patient's gait [5].

Overall body posture is significantly altered by mastectomy; these changes first became apparent six months after surgery and tended to worsen until 18 to 24 months later [6].

And with the altered muscle sensitivity, these changes cause a disturbance in body statics that alters how the center of gravity is projected and affects motor response [7].

Hence, Mastectomy may result in significant changes to a woman's trunk anatomy that may affect her spatiotemporal gait patterns. (Physical parameters of the gait cycle, such as the length of a step and velocity of walking) in various ways, with or without a prosthesis [8]. Not to mention, after a mastectomy, women are exposed to a variety of conditions that are known to significantly alter gait metrics [6].

Gait deviation was presented in a study as a postural instability adaptation, modifying the step during gait and providing compensatory mechanisms for efficient movement control to move during daily activities.

The study highly supported this type of deviation after evaluation gait of 60 females in two groups according to average of age ladies post mastectomy & Controlled group healthy females.

The results were finding significant difference in Step & Stride lengths, Step Time, Cadence, number of steps & velocity [6].

Limited studies were found regarding unilateral mastectomy effect on gait parameters post-surgery; therefore, this study is strived to assess how the walking pattern has changed following a mastectomy.

This research may advance our understanding of whether a vital examination of gait in breast cancer survivors undergoing physical therapy rehabilitation should be included & to build a new intervention to resume regular living activity with the best balance in gait pattern to minimize gait deviation as a post-mastectomy consequences.

Material and Methods

Subjects:

This trial was assented by the Ethical Committee of the Faculty of Physical Therapy, Cairo University. All aspects of the study were disclosed, and informed consent was obtained.

Patients were interviewed for inclusion criteria. One hundred & forty females were divided into two groups. Seventy females post-mastectomy by 4 to 6 months after surgery served as a study group and another seventy healthy group served as controlled group. Study group was divided by age into (group A) young group from 30 to 44 years (group B) old group from 45 to 66.

All participants in study & controlled were selected from bahya's institute for early detection of

breast cancer. The group's age ranged from 30 to 67 years. Patients within the study group were enrolled in the trial if they met the following criteria:

(1) Age between 22 to 70 years, (2) Patients with unilateral mastectomy surgery with a duration of 4-6 months post-surgery without implants, and excluded in case of: (1) The participant with musculoskeletal or neurological deficits prior to mastectomy surgery. (2) Patients with recurrent malignancy. (3) Uncooperative patients (4) Patients with lymphedema, while seventy healthy females were included with age between 22 to 70 years, and if the participant has good health & body posture, while excluded in case of musculoskeletal or neurological deficit that positively affects her gait, a history of cancer illness and has been treated before or recently and uncooperative patients.

Assessment tools:

- 1- Digital camera Nikon a digital camera Nikon D3200 Full HD resolution 1280 x 720 pixels at 50 frames per second (fps).
- 2- 1 Meter tripod.
- 3- Phosphoric markers or steaky phosphoric dots.
- 4- Kinovea software:

Kinovea@ is a free 2D motion analysis software for computers that can be used to measure kinematic parameters without electronic markers attached to the patient.

Kinovea is a valid and reliable tool in assessing gait kinematics parameters [8] and the main parameters we are going to measure are Step length, Step time, Stride Length, Stride Time, Left Right time asymmetry, & cadence.

Assessment procedure:

All cases were invited to the Bahia Institute Physical Therapy Clinics to evaluate their Gait in a room with a temperature of 25-26 Celsius to be as normal as possible.

The patient's profile was assessed when her illness worsens and more therapies like chemotherapy and radiation are administered. Also, recognizing and accounting for any drug-induced impairments that are directly causing gait deviation in the patient.

The top candidates were selected for the test after carefully screening the patient's medical history.

Participants in the study should be comfortable and dressed casually for data collection. To avoid any potential biomechanical alterations brought on by various footwear, no shoes were worn.

The passive markers were placed on back of the heel at first, 2nd and fifth base of tarsal phalanges.

Participants in this study walked continuously back and forth down the hallway for one full minute

at their own preferred walking tempo. The patient stucked to the floor, which was marked and measured by a measurement tap as a caliber reference of distance for the camera's shooting zone, whereas the camera was left stationary.

The walk was caught on camera video using the smallest zoom possible. It was located perpendicular to the participant at 2.5m distance and 1m above the floor on a tripod. A stopwatch was used to calculate the time for the walk.

After filtering the videos to choose the good records, data were collected from the camera and analyzed via Kinovea software by marking the passive markers in the software. The Kinovea version analyzed was 0.9.24. The procedure included seven steps:

- 1- Using a feature line to determine the distance.
- 2- Using the stopwatch feature to determine the time of steps.
- 3- Kinovea frame calibration to match the frames of the camera therefore the time was real.
- 4- Data extraction and transformation for statistics.

Parameters that were collected from Kinovea are: (Step length, Step time, Stride Length, Stride Time, Left Right time asymmetry, & cadence).

- The participant was only aware of being video graphing their walk without explaining the idea behind it until the end of the test. It took 1min for each case for the test.
- and 1 other min to explain procedure and sign consent form. Adding 2 minutes for recapture in case of misunderstanding the test. The video was collected and analyzed by kinovea software to collect row of data to analyze it.

Sample size: Sample size calculations of G* power revealed that sample size for this study results is 140 patients divided into 70 patients in each group using power=90% and effect size=0.5.

Statistical analysis: An unpaired t-test was conducted for comparison of subject characteristics between groups. Normal distribution of data was checked using the Shapiro-Wilk test.

Levene's test for homogeneity of variances was conducted to ensure the homogeneity between groups. Unpaired t-test was conducted for comparison of gait parameters between study and control groups and between young and older females of the study group.

The level of significance for all statistical tests was set at $p < 0.05$. All statistical measures were performed through the statistical package for social sciences (SPSS) version 25 for windows.

Results

Subject characteristics:

Subjects' characteristics were demonstrated in Table (1). There was no significant difference between study and control groups in age, weight, height and BMI ($p > 0.05$).

Table (1): Basic characteristics of participants.

	Study group (N=70)	Control group (N=70)	P value
	Mean \pm SD	Mean \pm SD	
Age (years)	45.77 \pm 9.35	43.43 \pm 10.02	0.15
Weight (kg)	76.85 \pm 12.61	74.64 \pm 11.71	0.28
Height (cm)	161.87 \pm 5.29	162.17 \pm 4.74	0.71
BMI (kg/m ²)	29.24 \pm 3.95	28.34 \pm 4.02	0.18
<i>Side of mastectomy:</i>			
Right side	36 (51.4%)		
Left side	34 (48.6%)		

SD: Standard deviation. p-value: Level of significance.

I- Comparison of step and stride length and Asymmetry index between study and control groups:

There was a significant decrease in right and left step and stride length and cadence and a significant increase in right and left step time of study group compared with that of control group ($p < 0.001$).

There was no significant difference in Asymmetry index between study and control groups ($p > 0.05$). (Table 2).

II- Comparison of step time and cadence between study and control groups:

There was a significant increase in right and left step time of study group compared with that of control group ($p < 0.001$). (Table 2).

There was a significant decrease in cadence of study group compared with that of control group ($p < 0.001$). (Table 2).

Comparison of step and stride length between group A and B & Step Length & Cadence between group A & B:

There was a significant decrease in right and left step and stride length of group B compared with that of group A ($p < 0.01$). (Table 3).

There was no significant difference in Asymmetry index between group A and B ($p > 0.05$). (Table 3).

There was a significant decrease in right and left step and stride length and cadence of group B compared with that of group A ($p < 0.01$). (Table 3).

There was a significant increase in right and left step time of group B compared with that of group A ($p < 0.01$). There was no significant difference in Asymmetry index between group A and B ($p > 0.05$). (Table 3).

Table (2): Comparison of gait parameters between study and control groups.

	Study group	Control group	MD	t-value	P-value	Sig.
	X ± SD	X ± SD				
Right step length (cm)	43.25±6.84	53.15±5.21	-9.9	-9.62	0.001	S
Left step length (cm)	42.35±6.82	51.88±6.379	-9.53	-8.53	0.001	S
Right stride length (cm)	86.16±12.21	105.91±10.30	-19.75	-10.34	0.001	S
Left stride length (cm)	86.08±13.01	105.46±10.96	-19.38	-9.53	0.001	S
Asymmetry index	6.57±5.87	5.83±4.99	0.74	0.81	0.42	NS
Right step time (sec)	0.55±0.05	0.49±0.03	0.06	7.98	0.001	S
Left step time (sec)	0.56±0.06	0.50±0.03	0.06	7.65	0.001	S
Cadence (steps/min)	69.22±8.98	81.53±8.10	-12.31	-8.51	0.001	S

X : Mean. t-value: Unpaired t-value. MD: Mean difference.
SD: Standard deviation. p-value: Probability value. S : Significant.

Table (3): Comparison of step and stride length and Asymmetry index & Step time and Cadence between group A and B.

	Group A	Group B	MD	t-value	P-value	Sig.
	X ± SD	X ± SD				
Right step length (cm)	45.45±6.84	40.47±5.85	4.98	3.22	0.002	S
Left step length (cm)	45.37±6.47	38.55±5.23	6.82	4.75	0.001	S
Right stride length (cm)	90.68±12.48	80.46±9.24	10.22	3.80	0.001	S
Left stride length (cm)	91.05±12.98	79.83±10.15	11.22	3.94	0.001	S
Asymmetry index	5.63±4.15	7.76±7.40	-2.13	-1.52	0.13	NS
Right step time (sec)	0.54±0.05	0.57±0.04	-0.03	-2.59	0.01	S
left step time (sec)	0.55±0.06	0.58±0.05	-0.03	-2.56	0.01	S
Cadence (steps/min)	71.33±8.03	66.58±9.52	4.75	-8.51	0.02	S

X : Mean. t-value: Unpaired t-value. MD: Mean difference. NS : Non Significant.
SD: Standard deviation. p-value: Probability value. S : Significant.

Discussion

Total mastectomy is still a common option found of treatment according to aggressiveness of cancer and how many lymph nodes affected [9].

As the best treatment provided is according to tumor's size and how many lymph nodes are affected and the type of cancer cell aggressiveness, the most effective technique was simple mastectomy with the lowest risk of cancer regression and higher survival rates [in

As Mastectomy is still the effective treatment for breast cancer in conjunction with adjacent therapy like hormonal, chemotherapy & radiation, the metastasis stops for good, and the patients gets a chance to live again. Mastectomy has been developed to many types of techniques & developed to lymph node dissection, selected tissue removal and partial mastectomy all known as breast conserving surgeries. Although breast conserving surgery such as partial or also called lumpectomy has better survival rate than mastectomy.

The aim of the work:

To identify if there are any differences in gait parameters after mastectomy following the surgery by 4 to 6 months average of acceptable candidates

to make sure that mainly lymphedema as a common complication would not kick in and caused the actual deviation. Kinovea is the easiest inexpensive HD VideoCam-Kinovea software to analyze gait parameters and measure angles & distance anywhere at any time.

The latest version is used to track speed of jumping and sport activities to detect the weakest muscle to focus on training. It is common to use it with high resolution camera.

Our study showed that there was a difference seen in all gait parameters between both groups, moreover, taking into consideration that age factor within the postmastectomy patients' group also demonstrated changes in step and stride length and time and hence decrease in cadence within the older group than younger patients.

In this study, we manage to choose the best timing before developing lymphedema, as it's a possible complication with all mastectomies, and making sure to be excluded as not to let its weight to be the reason for gait deviation.

The measurements were recorded post-surgery from 4 to 6 months. All patients were finished from chemotherapy before surgery and had their last To-

diation shoot before the test by 1 month to exclude any fatigue element that could affect the data.

However, the results were nearly the beginning of a change in gait parameters that could be permanent change after completing one full year post mastectomy, it is in agreement with Serel et al., study which supports that pelvic inclination starts after 1 year of unilateral mastectomy [11], and in balance with another study which reported significant variations in the pelvic inclination angle in mastectomy patients [12].

The center of gravity (COG) of the body begins to change when breast weight is removed therefore, it disturbs muscle tension between the right and the left sides of the body. So, it is suggested and confirmed in study by Montezuma, that unilateral mastectomy affects postural control, as it was showed an increase in displacement and velocity of the center of pressure on the force platform when compared to the healthier group [13].

And so the body works to adapt beginning from the spine. Confirming this change, Genthon and Rougier tracked pressure center in the body weight distribution with different loads and noted that the mechanism of control decreases with increasing postural asymmetry, affecting a change in pressure center displacement toward medial-lateral side, with the change of COG in postmastectomy patients [14].

Another study showed that increased weight distribution causes a unilateral postural asymmetry and displacement of the mass center, directly affecting the larger unilateral weight, and providing poorer postural stability and augmentation of the displacement velocity of the pressure center. Experimental studies have confirmed that when one side of the body is overloaded, the COG will be shifting to where the load is greater [15].

Not to mention that it also will lead to greater rate of medial-lateral displacement, increasing the risk of falls. Since mastectomy surgery causes a larger number of postural asymmetries and mass center displacements, it could be deduced that more significant contralateral breast surgery would lead to worse postural control [16]. It was confirmed that the feeling of unevenness in our study that the patient has felt following the surgery along with other complications were commonly appears post mastectomy as mentioned before and It's likely to link it with the uneven disruption of the spine.

Gait deviation was presented in a study whereas a form of postural instability adaptation, the modify step during gait and provide compensatory mechanisms for efficient movement control to move during daily activities.

The study by Hojan highly supported this type of deviation after gait evaluation of 60 patients in two

groups according to average of age in ladies post mastectomy and found deviations in Step & Stride lengths, Step Time, Cadence, number of steps & velocity [6], however, despite the attempt to counteract the loss of breast tissue on the severed side with an externally attached weight, an external breast prosthesis did not address the alignment issues with the body [6,17].

The reason for gait deviation, if it was not from the spinal changes, it would be supported by sideeffect of chemotherapy. As recovery from vinca alkaloidneurotoxicity can take up to 2 years, and persistent symptoms have been reported in one third of patients [18].

Finally this study confirmed the changes of gait parameters following mastectomy and presented the preliminary evidences for early introducing postural correction exercises for postmastectomy patients, however, some limitations must be considered when explaining these results; the most significant drawback of this experiment was absence of comparing the age as a factor in the healthy group to illustrate the difference between healthy and mastectomy patients, so future trials for gait assessment following mastectomy should evaluate the impact of age, weight and height on gait parameters, also to minimize human suffering and financial expenses, it is vital to raise awareness regarding the protection, early diagnosis, and timely therapy of gait deviations in post-mastectomy sufferers, moreover, trials should be conducted to evaluate early physical therapy intervention in prevention gait deviations and postural malalignment following mastectomy.

Acknowledgment:

Before and after all thanks to the Almighty Allah. It's a must to Thank my family for all of the Support I could get to finish what I had started until the end of the thesis. It is a great honor to express my most sincere and heartfelt appreciation to Assoc. Prof. Dr. Nancy Hassan, Associate Professor of Physical Therapy for Surgery Faculty of Physical Therapy, Cairo University. For all the time and effort she had put to come up with this amazing Thesis results and I may not have done it so well nor learnt it professionally without her help. Assoc. Prof. Dr. Maher Hassan, Associate Professor of Surgical Oncology National Cancer Institute, for his kind supervision throughout this work.

My gratitude and special thanks also go to Dr. Mahmoud Hamada, Associate Professor of Physical Therapy for Surgery, Head of Surgery Department in Ahran Canadian University, for his inspiration for this thesis and helpful guidance & my sincere gratitude to Dr. Nada Mohamed, Lecturer in Department of Physical Therapy, For Surgery Faculty of Physical Therapy, Cairo University, for her very sincere guidance, continuous effort, and inspired encouragement during this work. Last but not least

I would like to thank all the participants who participated in this study as well as the entire staff of Bahya institute for early detection of breast cancer for their valuable help and everyone who assist in this work.

Disclosure statement:

No author has any financial interest or received any financial benefit from this research.

Conflict of interest:

The authors state no conflict of interest.

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تأثير الاستئصال أحادى الجانب للثدى على تحليل أبعاد المشى

الهدف من البحث: دراسة ما إذا كان لعمليه استئصال الثدي أحادى الجانب تأثير على المشى بعد العملية.

مواد وأساليب البحث: مائه وأربعون سيده ٧٠ بعد عمليه استئصال الثدي و٧٠ سيده بدون أى اضطراب للهيكل العظمى أو العصبى تتراوح أعمارهم من ٣٠ إلى ٦٧ عاماً تم اختيارهم من مستشفى بهيه للاكتشاف المبكر لسرطان الثدي وتم تقسيمهم إلى مجموعتين حسب السن) ٣٩ سيده من سن ٣٠ إلى ٤٤ عاماً، ٣١ سيده من سن ٤٥ إلى ٦٧ عاماً. وتم عمل مقارنة لنتائج تحليل المشى كالتالى.

مقارنه أولى: ضمت هذه المجموعة ٣٩ مشاركة من العمر الأصغر من سن ٣٠ إلى ٤٤ عاماً بين السيدات من من تم استئصال الثدي لديهم وبين من لم يستأصلوا الثدي وطبيعيين.

مقارنه ثانيه: ضمت هذه المجموعة ٣١ مشاركة من العمر الأكبر من سن ٤٥ إلى ٦٧ عاماً بين السيدات من من تم استئصال الثدي لديهم وبين من لم يستأصلوا الثدي وطبيعيين.

مقارنه ثالثه: مقارنه للسيدات اللاتى استأصلوا الثدي بين مجموعه الاعمار ٣٠ إلى ٤٤ عاماً ومجموعه أخرى من عمر ٤٥ إلى ٦٧ عاماً.

النتائج: لقد أظهرت النتائج وجود اختلاف بين مجموعه من استئصال الثدي ومن لم تستأصل الثدي فى المسافة بين الخطوات للقدم الأيمن والقدم الأيسر وتوقيت كل خطوه للقدم الأيمن والقدم الأيسر، وكذلك فى عدد الخطوات، مع عدم تأثر معدل اختلاف المسافة للقدم الأيمن عن القدم الأيسر للحالة الواحدة تم اثباته إحصائياً. وتم اثبات أيضاً وجود اختلاف بين مجموعتى العمر الأصغر والعمر الأكبر اللاتى تم استئصال الثدي أحادى الجانب لديهم.