Effect of Mobile Application-Based Interventions on Lifestyle and Outcomes of Patients after Obesity Surgery

Asmaa A. A. Saleh[1], Ahmed E. I. Mansour[2]

[1]Medical-Surgical Nursing Department, Faculty of Nursing, Ain Shams University. Egypt.
e-mail: dr.asmaa.saleh@nursing.asu.edu.eg ORCID: http://orcid.org/0000-0003-3725-949X
[2]Critical Care Nursing Department, Faculty of Nursing, Ain Shams University. Egypt.
e-mail: dr.ahmed.elsayed@nursing.asu.edu.eg

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ABSTRACT

Context: The use of the mobile application in the provision of health care services like patient education has the potential to change patients' behaviors and improve patients outcomes.

Aim: This study aimed to evaluate the effect of mobile application-based interventions on the lifestyle and outcomes of patients with obesity surgery.

Methods: A quasi-experimental (one group pretest-posttest) design was utilized to conduct this study. The study was conducted in the obesity surgery department and outpatient clinic at El-Demerdash Hospital, affiliated to Ain Shams University hospitals. A purposive sample of 104 patients with obesity surgery was included in the study. Data collection tools included patients' assessment records, lifestyle assessment questionnaires, medication adherence rating scale, perceived stress scale, and patients' outcome assessment questionnaires. WhatsApp mobile application was used as a mobile application to conduct the patient's education.

Results: The studied patients' mean age was 32.57±6.18; 75% were females, 92.3% had chronic diseases, and 53.8% of their body mass index (BMI) was between 40-<50 kg. A statistically significant difference was revealed in the lifestyle of patients with obesity surgery before and after mobile application interventions. In addition, there were statistically significant differences in the patients' quality of life after the intervention compared to before the intervention.

***Conclusion*:** Utilizing mobile applications to provide educational materials for patients with obesity surgery has a positive effect on improving lifestyle and outcomes of obesity surgery. The study recommended investing the mobile application based-interventions for all patients with obesity surgery. Regularly updating the content of educational materials help to improve lifestyle practices and clinical outcomes for those patients.

Keywords: Mobile application interventions, lifestyle, obesity surgery, patients' outcomes

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1. Introduction

Obesity is an alarmingly increasing universal public health problem, described as an epidemic by the World Health Organization (WHO). Several countries worldwide have witnessed a double or triple escalation in the prevalence of obesity in the last three decades. This escalation may be due to urbanization, adopting a Western lifestyle, increased consumption of unhealthy, high-calorie food, and inactivity *(Tiwari & Balasundaram, 2022)*.

It is a chronic, life-limiting disease that is associated with many serious health conditions such as type 2 diabetes mellitus, cardiovascular disease, high blood pressure, obstructive sleep apnea, asthma, osteoarthritis, and some types of cancer (such as prostate, breast, ovarian, colon and pancreatic) *(WHO, 2019)*. Obesity also impacts the mental well-being of the person. It may trigger psychological and social consequences such as depression, anxiety, poor self-esteem, distorted body image, feelings of shame, frustration, social stigmatization, and a higher chance of being bullied *(Fulton et al., 2022)*.

Obesity surgery, called bariatric surgery or weight loss surgery, is increasingly recognized as the most effective treatment for individuals who are severely obese. Obesity surgery not only helps in weight reduction but also improves obesity-related medical conditions that, in turn, improve the quality of life *(Parrott et al., 2020).* Weight loss after Obesity surgery is reported to cause long-term reduction of type-2 diabetes, decrease the person's risk for heart disease and stroke, relieve depression and shortness of breath, and improve fertility, mobility, self-esteem, social interaction, and patient satisfaction. In addition, it helps the patient stay consistent with physical activity and reduces joint pain and stress levels *(Coulman & Blazeby, 2020)*.

Worldwide, the total number of obesity surgery performed annually is 580,517 surgical. The International Federation for the Surgery of Obesity and Metabolic Disorders (IFSO) developed a Global Registry to create a global estimate of bariatric surgery practice. Data were submitted from over 550 hospitals in 51 countries spanning five continents, including data from 14 national registries. All data presented concern operative data from 2014 to 2018 and included 394,431 individual records, of which 190,177 were primary

[1]*Correspondance author: Asmaa Abdel Rahman Saleh*

operations performed since 2014. Data were submitted on 72,645 Roux en Y gastric bypass operations (38.2%), 87,467 sleeve gastrectomy operations (46.0%), 14,516 one anastomosis gastric bypass procedures (7.6%), and 9534 gastric banding operations (5.0%) as the primary operation since 2014. In Egypt, it was estimated by 454 bariatric surgery operations were done at that time *(Welbourn et al., 2019)*.

Lifestyle changes are behavior modifications or habit changes that encourage positive changes in a person's life. Long-term strategies are required to promote weight loss and prevent postoperative medical complications. People undergoing obesity surgery are required to adhere to healthy lifestyle practices after the operation that includes; following specific eating and drinking behaviors; exercising regularly; taking medication/supplements daily; stopping smoking, managing stress, and attending follow-up medical appointments for regular monitoring of the glycaemic control, blood lipid profile, obstructive sleep apnea, gastroesophageal reflux disease, body weight, quality of life, eating behavior and bone health *(Ariel-Donges et al., 2020)*.

Digital health technologies such as mobile phone apps, web platforms, and wearable activity trackers have been proven to be good opportunities for monitoring and providing continuous patient care. They provide counseling and information that is easily accessible and patient-friendly, encouraging patients to participate in their care *(Robinson et al., 2022)*. Mobile technology has advanced rapidly, and most people use smartphones. Mobile applications can help patients achieve the required lifestyle changes after obesity surgery through continuous educational intervention, support from healthcare providers, and timely feedback *(Cho et al., 2018)*. Researchers have used mobile phone applications to support behavioral change by providing more interactive and timely access to relevant information and providing knowledge-specific prompt assistance *(Ricci-Cabello et al., 2019)*.

Growing evidence supports the use of mobile applications to deliver patient education, share reliable health information, support patients to adopt a healthy lifestyle, enhance the quality of life, improve self-care and adherence to recommended dietary intake, physical activity, medication, sleeping, stress management, smoking cessation, and follow-up visits *(Yang et al., 2022)*. Interventions delivered by mobile phone applications have proven to prevent disease complications by supporting behavior change toward more healthy lifestyles and treatment adherence *(Ricci-Cabello et al., 2019)*.

Lifestyle behavior is the changes patients make in the postoperative period that can positively impact the operative outcomes and the success of the obesity surgery. Patient-reported outcomes (PROs) are data reported directly by a patient on his or her health condition without interpretation by a doctor or anyone else. They enable patients to report on improving the associated clinical conditions and quality of life represented by self-esteem, physical status, social status, work capacity, and sexual performance. In addition, patients can also report daily functioning, signs and symptoms, a change from a previous measure, and other aspects of their health and well-being. Patients need to understand that surgery does not provide a quick fix for their obesity problem and that long-term adherence to lifestyle recommendations is the key to success. Proper lifestyle changes and long-term follow-up by the healthcare team are very important *(Castanha et al., 2018)*.

2. Significance of the study

It was estimated that 5875 individuals underwent obesity surgery in Egypt *(Angrisani et al., 2015)*. According to the "100 million health" initiative, which was conducted in Egypt in 2019 and screened 49.7 million adult Egyptians (≥18 years old), 39.8% of adults suffer from obesity (BMI ≥ 30 kg/m^2). Obesity was more prevalent in adult females than adult males (49.5% of Egyptian adult females suffered from obesity compared to 29.5% of males) *(Aboulghate et al., 2021)*. Bariatric surgery is markedly proven to be an effective treatment for morbid obesity, resulting in sustained weight loss and alleviation of comorbidities caused by obesity. The popularity of mobile technology worldwide has provided a unique platform for delivering health information to patients via mobile applications, which have been shown to positively promote lifestyle changes after obesity surgery.

Patients need to receive the necessary knowledge, skills, and behaviors required to ensure successful outcomes of obesity surgery, to change their lifestyle, and avoid physical, social, and psychological problems after obesity surgery. To our best knowledge, this is the first research on the usability of mobile app-based interventions for patients after obesity surgery at El-Demerdash hospital.

3. Aim of the study

This study aimed to evaluate the effect of mobile application-based interventions on the lifestyle and outcomes of patients with obesity surgery through:

- Assessing patients' lifestyle before obesity surgery (pre-intervention).
- Developing and implementing lifestyle educational materials utilized through the mobile application.
- Evaluating the effect of mobile application-based interventions on lifestyle and outcomes for patients with obesity surgery.

3.1. Operational definition

Lifestyle changes after obesity surgery refer to behavior modifications or habits that encourage positive changes in the patient's life. It is any action or choice the patient makes to replace unhealthy habits with a healthy one. This study included making healthy diet choices, practicing physical activity, changing sleeping patterns, managing stress, medication adherence, and follow-up.

The outcomes of obesity surgery in this study refer to the information that comes directly from the patient about his/her health. It included reporting weight loss, co-morbid condition improvement, complications, quality of life (degree of self-esteem, physical activity, social life, work condition, sexual activity), and patient satisfaction with the interventions. It was used to measure the effectiveness of an intervention.

3.2. Research hypothesis

The current study hypothesized that mobile application-based interventions positively affect patients' lifestyles and outcomes after obesity surgery.

4. Subjects & Methods

4.1. Research Design

Quasi-experimental (one group pre-test/post-test) design was used to achieve the aim of this study. A quasi-experimental design was done to test whether mobile application-based interventions would improve the lifestyle and outcomes of patients after obesity surgery. A quasi-experimental design is a non-randomized study design used to evaluate the effect of an intervention. The intervention can be a training program, a policy change, or a medical treatment, and it aims to demonstrate causality between an intervention and an outcome. Quasi-experimental studies can use pre-intervention and post-intervention measurements and a non-random selection of participants *(Kumar, 2019)*.

4.2. Study setting

The study was conducted in the obesity surgery outpatient clinic and obesity surgery department at El-Demerdash Hospital, affiliated to Ain Shams University, Cairo, Egypt. The obesity surgery department is located on the third floor of El-Demerdash Hospital and consists of five rooms, two rooms for male patients and three for female patients. Each room contains three beds. The outpatient clinic is on the ground floor and contains one room with one bed.

4.3. Subjects

A purposive sample of 104 adult patients with obesity surgery was selected according to certain inclusion criteria: Patients who are not more than one month after obesity surgery, age over 18 years, willing to participate in the study, from both genders, and people with obesity-related comorbidity. The sample size selection was calculated based on power analysis according to the number of patients with obesity surgery who were admitted to the obesity surgery department at El-Demerdash Hospital during the year 2020/2021, which was 277 patients with Type I error alpha (α) = 5% with confidence level 95% and (α) significant level at 0.05. Type II error by power test 90% and β = 10%.

$$n = \frac{N \times p(1-p)}{\left[\left[N-1 \times \left(d^2 \div z^2\right)\right] + p(1-p)\right]}$$

4.4. Tools of data collection

Five tools for data collection were used as follows:

4.4.1. Patients Assessment Record

The researchers developed this tool in Arabic based on related literature *Cummings, (2014)*. It includes two parts. Part 1 includes demographic characteristics of patients under study, such as age, gender, residence, level of education, marital status, and occupation. Part 2 includes patients' clinical data, such as co-morbid disease, and the type of these comorbidities, such as hypertension, diabetes mellitus, and BMI.

4.4.2. Patients' Lifestyle Assessment Questionnaire

This tool assessed patients' lifestyles regarding diet, physical activity, sleeping and rest, smoking cessation, and follow-up after obesity surgery. The researchers developed it in an Arabic language using the following related literature *Still et al. (2018); American Society for Metabolic and Bariatric Surgery (2018); Kumar and Gomes (2017)*. It includes 54 statements that were grouped into five sections as follows: Diet (20 statements), physical activity (14 statements), sleeping and rest (7 statements), smoking cessation (8 statements), and follow-up post-obesity surgery (5 statements).

Scoring system

Regarding the scoring system of the patient's lifestyle assessment questionnaire, the response for each statement was either (yes or no). The (Yes) answer was given one grade. (No) answer was given zero. The total grade was 54 grades. The total score for every section was calculated by summing the patients' responses and converted into percent scores. Then, the total scores of the entire questionnaire for every patient were calculated and converted into percent scores. The score of the part and the total was categorized into:

- Good healthy lifestyle (≥75%= ≥40.5 degrees and more).
- Fair, healthy lifestyle (50%-75% = 27-<40.5 degrees).
- Poor lifestyle (<50%= less than 27 degrees).

4.4.3. Medication Adherence Rating Scale (MARS)

It was used to assess patients' adherence to medication after obesity surgery. It was adopted from *Thompson et al. (2000).* It includes ten statements that ask about medication adherence behaviors (e.g., if the patient forgets to take medicine, stop taking medication if they feel better, and if the medication makes them tired and sluggish).

Scoring system

Regarding the Medication Adherence Rating Scale scoring system, the response for each statement was either (yes or no). The (Yes) answer was given one grade. (No) answer was given zero.

A patient who responds by "NO" to questions from 1- 6 and questions from 9 -10 and by "YES" to questions 7 and 8 is considered adherent to medication. The total score for this part was calculated for every patient, then for all patients, and was categorized as follows:

- Non-adherent to medication (0-3).
- Partially adherent (4-6).
- Adherent (7-10).

4.4.4. Perceived Stress Scale (PSS)

It was used to assess patients' stress levels. It was adopted from *Cohen et al. (1983)*. Patients were asked about their feelings and thoughts during the past month and had to

indicate how often they felt or thought in a certain way. It includes ten statements, questions number 1, 2, 3, 6, 9, and 10 are negative statements, while question number 4, 5, 7, and 8 are positive statements.

Scoring system

Each negative statement had five responses (Never=zero, almost never=1, sometimes=2, fairly often=3, very often=4). The response to the positive statement is reversed, where (Never= 4, very often = 0). The total score for this part was calculated for every patient, then for all patients, and was categorized as follows:

- Perceived low stress (0-13 degrees).
- Moderate stress (14-26 degrees).
- High stress (27-40 degrees).

4.4.5. Patients' Outcomes Assessment Questionnaire

This tool was used to assess the outcomes of patients with obesity surgery. It includes two parts: The first is the Bariatric Analysis and Reporting Outcome System (BAROS) questionnaire, which was used to assess bariatric surgery outcomes, including weight loss and improvement in co-morbid conditions and complications and reoperation. In addition, the BAROS questionnaire combines the Moorehead-Ardelt quality of life (QoL) questionnaire, which evaluates a patient's self-perception of quality of life, and it includes questions about self-esteem, activity levels, social life, work conditions, and sexual activity as these items impacting QoL outcomes after obesity surgery. It was adopted from *Moorehead et al. (2003)*.

Scoring system

The BARO consists of a scoring table that includes three columns. The first column assesses weight loss (successful weight loss post-obesity surgery can be defined as the percentage of excess weight loss (%EWL), where:

- Excess weight = Total weight pre-bariatric surgery – Ideal weight.
- %EWL = Weight loss/Excess weight × 100.

The sum of the previous equation is calculated in points as follows; weight gain = (-1), 0-24= (0), 25-49= (1), 50-74= (2), 75-100= (3).

The second column evaluates changes in medical conditions. It includes five points as follows:

Aggravated= (-1), unchanged= (0), improved= (1), one major resolved, other improved= (2), all major resolved, other improved= (3).

The third column assesses changes in quality of life after the intervention. It includes five domains expressed by graphic symbols, each one of them had a scoring point as follows: Self-esteem (-1 to +1), physical activity (-0.5 to +0.5), social life (-0.5 to +0.5), work conditions (-0.5 to +0.5) and sexual activity (-0.5 to +0.5). Points are added or subtracted according to changes in these domains (as much less= -0.50, less= -0.25, the same= 0, more= +0.25, and much more= than +0.50).

Three points are given to each domain to evaluate changes after medical or surgical intervention. Points are deducted for complications as follows; minor complications (-0.2) and major complications (-1), and deduct (-1) for reoperations. The total number of points defines five categories of outcome groups from "failure" to "excellent" as follows: Failure (one point or less), fair (>1 to 3 points), good (>3 to 5 points), very good (>5 to 7 points), excellent (>7 to 9 points).

The second part is the patients' satisfaction questionnaire. This part assessed patients' satisfaction with using the mobile application in providing educational materials and follow-up after obesity surgery. It was developed by researchers in the Arabic language based on related literature by *Yang et al. (2022); Alshahrani et al. (2021); Morte et al. (2021)*. It included (20) items divided into three sections. The first section contained (10) statements that concerned patients' satisfaction with WhatsApp mobile application. The second section included (5) statements that assessed educational materials about lifestyle and the third section asked about the health care providers (researchers and general surgery surgeons) and included (5) statements.

Scoring system

The patient's response to the statements was on a 3-point Likert scale where 1=unsatisfied, 2=neutral, and 3=satisfied. The total score of the questionnaire was 60 grades. The total score for the questionnaire was calculated for every patient, then for all patients, and were categorized as satisfied (65%= 39-60 degrees), neutral (35%= 21-≤40), and unsatisfied (33%= 1-≤20 degrees).

4.5. Procedures

WhatsApp mobile application was launched in 2009 as a social media application that allows exchanging of messages, documents, and multimedia files through chat rooms *(Giansanti, 2020)*. It was used in this study to deliver educational materials for patients with obesity surgery. The researchers selected this application from different available mobile applications because it works on multiple platforms (Android, IOS), is free and interactive, has a simple interface, and allows sending real-time messages to multiple recipients, and the messages can be customized. Also, it is easy to use, allow video calls, add, and remove participants, connect users in one group, send and receive messages to share with others and is available on mobile phone and through a web page on a desktop computer or laptop. WhatsApp is available at the Google store and the search engine at http://web.whatsapp.com.

The patient assessment tool, patients' lifestyle assessment questionnaire, and the healthy lifestyle educational materials were reviewed by a panel of seven experts (2 surgeons from the faculty of medicine, two professors, and three assistant professors in the medical surgical nursing department, Ain Shams University) in order to evaluate its face and content validity. The experts reviewed the tools for their content, clarity, simplicity, relevance, comprehensiveness, appropriateness, and applicability. Minor modifications were done, and then the final forms of the tools were developed. Testing the reliability of the purposed data collecting tools was done by

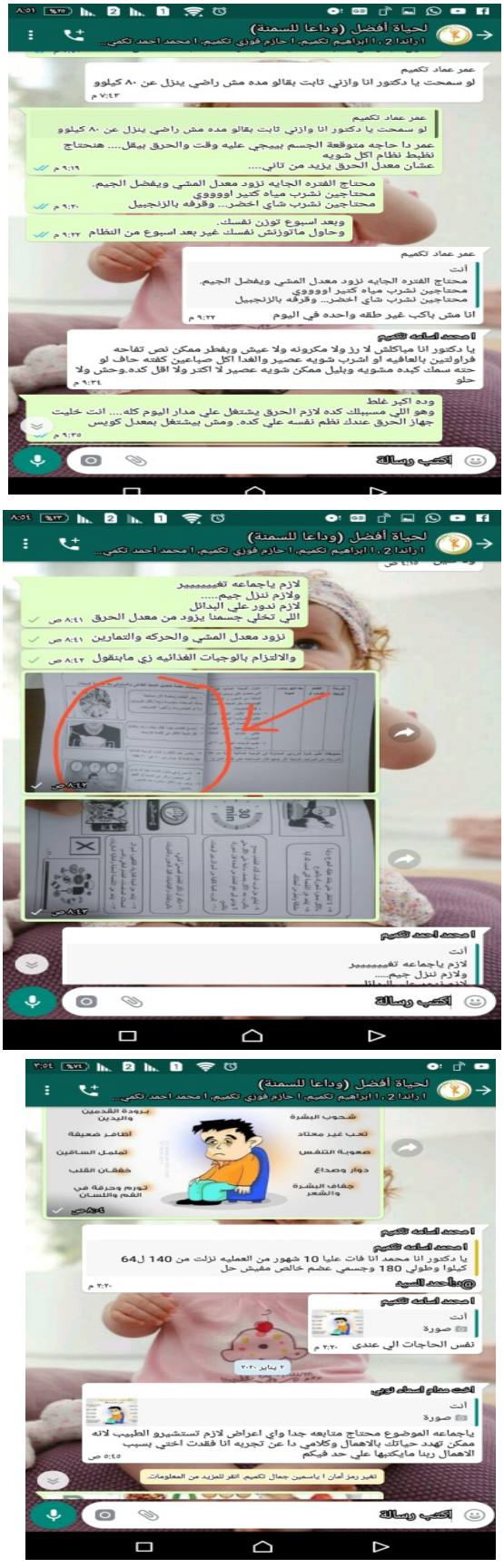

Figure (1): WhatsApp mobile application with text messages for patients with obesity surgery.

the alpha Cronbach test. It was 0.86 for the lifestyle assessment questionnaire, the medication adherence rating scale 0.75, 0.78 for the perceived stress scale, and 0.84 for the BAROS questionnaire.

Ethical Considerations: Ethical approval was obtained from the ethical research committee at the faculty of nursing of Ain Shams University before initiating the study. All participating patients were informed that they could withdraw from the study without giving any reasons or penalties. Patients were reassured that participation, or withdrawal, from the study, would not affect their care from the outpatient clinic and department from which they were recruited.

Prior to data collection, verbal informed consent was obtained from patients to ensure their willingness to engage in the study. The aim, procedures, benefits, anonymity, and confidentiality of subjects' data were clarified to patients. Written permission to collect data for the study was also obtained from the director of the hospital at which the study was conducted.

A pilot study was carried out on 10% (10) of patients to test the applicability of the study and to test the clarity of the designed tools, as well as to estimate the time needed for each tool to be filled in and the feasibility of the research process. No modifications were done to the tools used. Patients of the pilot study were included in the study's subjects.

The procedure included three phases: Preparation, implementation, and evaluation phase.

Preparatory phase: This phase involves extensive reviewing of the recent related literature to develop tools for data collection. Then, researchers developed healthy lifestyle educational materials in Arabic to be utilized by the patients through WhatsApp mobile application. The materials consisted of three modules.

The first module includes the anatomical function of the gastrointestinal tract, obesity and its causes, diagnostic procedures, and complications related to obesity. The second module includes obesity surgery, benefits, indications, contraindications, types of obesity surgery, and complications of each type. The third module includes lifestyle change instructions regarding diet, physical exercise, sleep and rest, stress management, medication, and follow-up. Diet instructions include instructions to patients that help them improve skills in preparing foods in healthy ways, selecting healthy types, eliminating prohibited diets, and adhering to the daily allowed amounts based on instructions offered through the mobile application.

Implementation phase: This phase started by selecting patients post-bariatric surgery (pre-intervention) who met the inclusion criteria. The aim and nature of the study were explained to patients, and their approval to participate in the study was obtained prior to data collection.

The patients' telephone numbers were obtained at the first interview to facilitate contact with them and to determine other appointments to complete the data collection process. The patients' assessment tool, the patients' lifestyle assessment questionnaire, the stress scale, and the medication adherence scale were used to assess patients

before implementing the mobile application interventions. These tools were filled in by the researchers or by the patients according to patients' educational level; it took about 30-45 minutes to be filled in according to the health condition of every patient.

The tools were filled in either the obesity surgery department or the waiting area of the obesity surgery outpatient clinic. Patients who filled out the questionnaire were within one month after surgery "pre-intervention." The collection of these data continued for two months, from September 2021 to October 2021. The researchers created a group called "Goodbye Obesity" on the WhatsApp mobile application to provide patients with educational materials bout healthy lifestyles after obesity surgery.

The WhatsApp mobile social application was used as the intervention tool. The researchers asked the patients to download the WhatsApp application on their phones if it was not present. Patients were added to the group by the researchers. Each module was uploaded first as a PDF file to allow participants to read the educational materials. Then, the researchers started to post daily simple, short information as a text message combined with illustrative pictures or videos to remind patients of the instructions that should be followed after obesity surgery and the benefits of keeping healthy life patterns (Figure 1).

Providing information through the WhatsApp application took two months, from November to December 2021. Each module continues over 20 days. The researchers posted the information of each module on the WhatsApp application in the form of text messages, audio messages, or video and illustrative pictures; it also included motivational images and text. In addition, frequent reminder messages were sent on the WhatsApp application to remind patients to take their medicine on time.

Patients were allowed to ask questions by typing or recording their messages on WhatsApp in case they misunderstood any information or had any individual health issues. Patients were encouraged to review the educational materials' text messages and PDF files to help them adhere to the required healthy lifestyle instructions after obesity surgery.

The researchers emphasized the importance of follow-up visits. They informed patients that they would be followed and evaluated by the researchers at the obesity outpatients' clinics after six months of obesity surgery.

Evaluation phase: After six months of obesity surgery, all tools except the patient's assessment tool were refilled in again to evaluate the effect of mobile application intervention on patients' lifestyle, outcomes, and satisfaction after obesity surgery. This phase started from February 2022 to the end of March 2022. The evaluation was done by comparing the results pre-and post-implementation of the mobile application interventions. The data collection process continues for seven months, starting in September 2021 and ending in March 2022. Data collection was conducted in the morning and afternoon shifts on Sunday and Tuesday of each week because these days are determined for obesity surgery patients in the outpatient clinic.

4.6. Data analysis

The data were collected, coded, and entered into a suitable excel sheet. Data were transferred into SPSS. The collected data were analyzed using the Statistical Package for Social Science (SPSS) for Windows, version 20.0 Armonk, NY: IBM Crop. Quantitative data were presented as mean and standard deviation (SD) to present normally distributed continuous variables. A chi-square test x^2 was used to compare categorical data to determine the differences before and after implementing educational material through the mobile application. Categorical variables were presented using numbers and percentages (%). The significance of the observed difference was obtained at a P value ≤ 0.05.

5. Results

Table 1 shows the frequency and percentage distribution of demographic characteristics of the studied patients. The table clarifies that approximately two-thirds of the studied patients (61.5%) fall into the age group between 30-<40 years old, and the mean age of all patients was 32.57±6.18 years. Regarding patients' gender, three-quarters of them (75%) were females, and 72.1% lived in urban areas. Regarding the studied participants' educational level, approximately half (49%) of patients had secondary school diplomas. Also, 64.4% were married, and 77.9% of the studied patients were not working.

Table 2 demonstrates the frequency and percentage distribution of studied patients' clinical data. The table illustrates that 92.3% of the studied patients suffered from the co-morbid disease. Regarding body mass index, 53.8% of the studied patients were between 40 kg^2-<50 kg^2, and 32.7% were ≥50 kg^2 according to the BMI.

Table 3 shows a comparison of patients' lifestyle changes pre and post-intervention, there is (55.8%) of patients got a good level of following a healthy diet after the implementation of mobile application-based interventions compared with (10.6%) pre-intervention. The table also shows that (58.7%) of patients perform fairly regular physical exercise after the mobile intervention compared with (6.7%). In addition, after the mobile intervention, most patients (81.7% and 80.8%) achieved good levels of following sleep instructions and commitment to follow-up, and more than half (57.7%) achieved a fair level of lifestyle changes with a highly statistically significant difference between the two study phases regarding all lifestyle dimensions.

Table 4 illustrates that 58.7% of patients adhered to medication after the mobile application-based intervention compared with 19.3% pre-intervention, with a statistically significant difference as p-value <0.001. While 2.9% only did not adhere to medication post-mobile intervention. Regarding perceived stress, the table shows a statistically significant difference between the numbers of patients who got different stress levels before and after mobile application-based intervention where *p*-value <0.001.

Table 5 reveals the comparison of studied patients' outcomes after obesity surgery. The table shows statistically significant differences in patients' outcomes pre-and post-

implementation of mobile application-based interventions among the studied patients concerning weight loss, co-morbid condition, complications, and reoperation. In contrast, more improvement was indicated post-mobile interventions than pre (p<0.05).

Table 6 reveals the comparison of quality-of-life outcomes after obesity surgery. There were statistically significant differences in patients' outcomes pre-and post-implementation of mobile application-based interventions among the studied patients concerning self-esteem, physical activities, social life, work conditions, and sexual activity, where p<0.05.

Table 7 compares the total quality of life of the studied patients pre and post-intervention. Table 7 represents statistically significant differences in total patients' outcomes levels pre and post-implementation of mobile application-based interventions among the studied patients at p<0.05, which supports the research hypothesis.

Table 8 represents satisfaction with using the mobile application to change patients' lifestyles. The results show that 96.2% of patients under study were satisfied with using mobile applications in providing educational materials about lifestyle and follow-up care after obesity surgery, and most (98.1%) of patients reported that educational materials were satisfactory. In addition, (97.1%) of them were satisfied with the care provided by the healthcare providers.

Table (1): Frequency and percentage distribution of studied patients' demographic characteristics (n=104)

Participants characteristics	N	%
Age		
18-<30	17	16.3
30-<40	64	61.5
40 <50	17	16.3
≥50	6	5.9
Mean ±SD	32.57±6.18	
Gender		
Male	26	25.0
Female	78	75
Residence		
Rural	29	27.9
Urban	75	72.1
Educational level		
Cannot read and write	22	21.2
Diploma education	51	49.0
Higher education	31	29.8
Marital status		
Single	27	26.0
Married	67	64.4
Widow/ Divorced	10	9.6
Occupational state		
Free work	7	6.7
Governmental work	14	13.5
Not working	81	77.9
Others	2	1.9

Table (2): Frequency and percentage distribution of studied patients' clinical data (n=104).

Present history	N	%
Suffers from co-morbid diseases		
Yes	96	92.3
No	8	7.7
Co-morbid diseases*		
Hypertension	27	26.0
Diabetes Mellitus	34	32.7
Others (ex., thyroid problems)	14	13.5
Body Mass Index (BMI)		
30 kg^2 -<35 kg^2	0	0
35 kg^2 -<40 kg^2	14	13.5
40 kg^2 -<50 kg^2	56	53.8
≥50 kg^2	34	32.7

**Patients may have more than one disease.*

Table (3): Comparison of the lifestyle levels of studied patients per and post mobile application-based interventions (n=104).

Lifestyle dimensions	Good		Fair		Poor		X^2	P-value	95% CI
	N	%	N	%	N	%			
Follow a healthy diet after obesity surgery									
Pre	11	10.6	28	26.9	65	62.5	69.07	0.001	1.409-1.944
Post	58	55.8	34	32.7	12	11.5			
Perform physical exercise regularly									
Pre	0	0.0	7	6.7	97	93.3	80.00	0.001	2.383-2.735
Post	8	7.7	61	58.7	35	33.7			
Follow sleep and rest instructions									
Pre	40	38.5	30	28.8	34	32.7	40.73	0.001	1.195-1.687
Post	85	81.7	10	9.6	9	8.7			
Follow smoking cessation									
Pre	0	0.0	4	23.5	13	76.5	0.151	0.697	2.579-2.892
Post	0	0.0	5	29.4	12	70.6			
Committed to follow-up visits									
Pre	51	49.0	34	32.7	19	18.3	26.75	0.001	1.075-1.514
Post	84	80.8	18	17.3	2	1.9			
Total changes in lifestyle									
Pre	1	1.0	19	18.3	84	80.8	62.51	0.001	1.614-2.151
Post	16	15.4	60	57.7	28	26.9			

Table (4): Comparison of studied patients' medication adherence and perceived stress level pre and post-mobile application-based interventions (n=104).

Variables	Pre (1 month)		Post (6 months)		X^2	P-value
	N	%	N	%		
Total Medication Adherence						
Adherent	20	19.3	61	58.7		
Partially adherent	41	39.4	40	38.5	55.548	<0.001
Non-adherent	43	41.3	3	2.9		
Total perceived stress Scale						
High stress	34	32.7	4	3.8		
Moderate stress	59	56.7	72	69.3	32.385	<0.001
Low stress	11	10.6	28	26.9		

Table (5): Comparison of studied patients' obesity surgery outcomes pre and post-mobile application-based interventions (n=104).

Variables	Pre		Post		X^2	P-value
	N	%	N	%		
Weight loss						
Weight gain (-1)	0	0	0	0		
0-24 (0)	46	44.2	0	0.0		
25-49 (l)	58	55.8	23	22.1	142.12	<0.001
50-74 (2)	0	0.0	81	77.9		
75 -100 (3)	0	0	0	0		
Medical condition						
Aggravated (-1)	0	0	0	0		
Unchanged (0)	18	17.3	0	0.0		
Improved (1)	80	76.9	41	39.4	78.14	<0.001
One major resolved; others improved (2)	6	5.8	50	48.1		
All major resolved; others improved (3)	0	0.0	13	12.5		
Complications						
Major	21	20.2	1	1.0		
Minor	4	3.8	1	1.0	22.90	<0.001
No complications	79	76.0	102	98		
Reoperation						
Non	104	100.0	104	100.0		

Table (6): Comparison of patients' quality of life outcomes pre-and post-implementation of mobile application-based interventions (n=104).

QoL Dimensions		Much less		Less		The same		More		Much more		X^2	P-value
		N	%	N	%	N	%	N	%	N	%		
Self-esteem	Pre	0	0.0	37	35.6	56	53.8	10	9.6	1	1.0	87.05	<0.001
	Post	0	0.0	5	4.8	23	22.1	61	58.7	15	14.4		
Physical activities	Pre	29	27.9	23	22.1	32	30.8	15	14.4	5	4.8	52.36	<0.001
	Post	6	5.8	10	9.6	18	17.3	58	55.8	12	11.5		
Social life	Pre	22	21.2	25	24.0	34	32.7	13	12.5	10	9.6	23.30	<0.001
	Post	13	12.5	14	13.5	21	20.2	39	37.5	17	16.3		
Work condition	Pre	12	11.5	67	64.4	25	24.0	0	0.0	0	0.0	90.84	<0.001
	Post	40	38.5	16	15.4	10	9.6	23	22.1	15	14.4		
Sexual activity	Pre	0	0.0	5	4.8	47	45.2	52	50.0	0	0.0	37.45	<0.001
	Post	0	0.0	0	0.0	23	22.1	57	54.8	24	23.1		

Table (7): Comparison of the studied patients' obesity surgery outcomes and quality of life pre and post-mobile-based application interventions (n=104).

Total	Pre (1 month)		Post (6 months)		X^2	P-value
	N	%	N	%		
Excellent	3	2.88	16	15.4	41.56	<0.001
Very good	18	17.3	48	46.2		
Good	39	37.5	19	18.3		
Fair	31	29.8	9	8.65		
Failure	13	12.5	12	11.5		

Table (8): Patients' satisfaction with using the mobile application in changing lifestyle after obesity surgery (n=104).

Satisfaction elements	Satisfied		Neutral		Unsatisfied	
	No.	%	No.	%	No.	%
Usability of mobile application	100	96.2	4	3.8	0	0
Educational materials	102	98.1	2	1.9	0	0
Healthcare providers (researchers)	101	97.1	3	2.9	0	0

6. Discussion

Weight gain, physical inactivity, smoking, unhealthy diet intake, and lack of sleep and rest are major preventable public health problems linked to increased risks of obesity surgery failure and subsequent inappropriate outcomes. Therefore, an intervention that helps motivate patients to change their lifestyle set a goal, and offer feedback on their activity can help maintain weight loss, improve physical activity, adhere to medication, and follow up *(Islam et al., 2020)*. This study aimed to evaluate the effect of mobile application-based interventions on lifestyle changes and patients' outcomes after obesity surgery. It found that it significantly improved patients' lifestyles and obesity surgery outcomes. The hypothesis of the current study demonstrated that mobile application is an effective tool to help this group of obesity surgery patients to modify their lifestyle.

The findings of the present study show that nearly two-thirds of the studied patients fall into the age group between 30-<40 years old, and the mean age of all patients was 32.57±6.18 years, three-quarters of them were females, most of them suffering from comorbidities such as diabetes and hypertension and more than half of them were obese. These findings indicate the common age group who seek weight loss surgeries as they are young, seek better work and marriage chances, and seek long-term weight loss. Female patients also seek a better body image through these surgeries. This results in the same line with *Jassil* et al. (2022), who reported that two-thirds of participants were females with bariatric surgery, two-fifths of them in the age group from 30-40 years old. In addition, *Gullaam Rasul et al. (2022)* stated that the mean pre-operation BMI was 51.4 kg/m^2.

The study findings illustrate that more than half of patients follow instructions on choosing and eating a healthy diet after six months of obesity surgery and conducting interventions through mobile. They adhered to the recommended diet after obesity surgery. This result may be due to the motivational text messages, illustrative pictures, and support provided by researchers through the WhatsApp application and the desire of patients to achieve good outcomes after obesity surgery and to achieve the appropriate weight loss. In addition, it improved patients' skills in preparing foods in healthy ways, selecting healthy types, eliminating prohibited diets, and adhering to the daily allowed amounts based on instructions offered through the mobile application. This result is supported by *Lim (2021)*, who mentioned that at six months, the app intervention led to reductions in total energy, carbohydrate, sugar, total fat, and saturated fat intake with statistically significant differences between the control and intervention groups in a study that evaluate the effect of Smartphone-based intervention on weight and metabolic outcomes.

Regarding the dimension of physical exercises, the study revealed a statistically significant difference in practicing physical exercises by patients before and after implementing

healthy lifestyle educational materials through mobile applications. This finding is because the researchers emphasized to the patients that the successful outcomes of bariatric surgeries depend not only on adherence to a healthy diet and medication but also on adherence to regular physical exercise that helps to achieve a sustainable desirable weight loss. So that, patients complied with the instructions to do physical exercises because they feared operation failure and weight regain.

This finding agrees with *Jassil et al. (2022)*, who reported that participants described how tele-exercise classes through the zoom mobile application helped them cope with the changes to their lives and helped them adhere to the lifestyle changes required after obesity surgery. Participants found the tele-exercise schedule, content, and intensity acceptable and were satisfied with the technology and classes' privacy, security, and safety. Professional supervision and guidance from the exercise therapist were central to the tele-exercise provision. Participation in the tele-exercise provided physical, emotional, and social benefits.

Most studied patients adhered well to sleep and rest instructions after obesity surgery. It might be referred that the recommended instructions about sleep and rest after obesity surgery were easy and simple to apply and followed by most of the patients. The mobile instruction enhances sleep quality and duration and improves obesity-related comorbidities such as obstructive sleep apnea and body posture. This result is consistent with *Chan et al. (2022),* who stated that setting up mobile health education in various formats, including diagrams and videos about sleep hygiene for women with obesity, helps guide ways to facilitate good sleeping hours and healthy lifestyles on physical activity and mental health. At the same time, it was contradicted by *Cho et al. (2018),* who stated that there was no improvement in obstructive sleep apnea after implementing short-term lifestyle modification intervention based on a mobile application (App) linked to a hospital electronic with no statistical significance between control and mobile application intervention group.

Regarding follow-up, the present study shows that most of the studied patients have a good level of attendance to follow-up visits over six months after obesity surgery. This finding might be due to the researchers emphasizing the importance of following up through motivational text messages on a mobile application to achieve good surgical outcomes and identify early complications or any other problems that may occur in the postoperative period. Patients might find that follow-up promoted their health, reduced the risk of weight regain, and allowed for early recognition of complications. This finding makes people more motivated and committed to attending follow-ups at the scheduled time regularly.

This result agrees with *Yang et al. (2022)*, who stated that participants with obesity surgery who used the Smartphone app were satisfied with the flexibility of the home-based follow-up since they do not have to take a leave from work or spend time to visit the outpatient clinic or wait in the waiting room.

Regarding total changes in the lifestyle of patients with obesity surgery, the result demonstrates a statistically significant improvement after implementing mobile application where more than half of the studied patients had achieved a fair level of changes that might be referred to the effect of the recommendations and continuous instructions related to lifestyle during the first six months following obesity surgery. This finding reflected the positive effect of mobile applications in promoting patients' lifestyles after obesity surgery and supported the study's hypothesis.

This finding was similar to *Gullaam Rasul et al. (2022)*, who utilized the WhatsApp mobile application to study patients' experiences after obesity surgery. They found that patients gained significant advantages in various scopes of life, including physical health, sleep, and rest. Patients reported that support offered through WhatsApp after surgery gave them the confidence to venture into new hobbies and activities.

The study findings show a statistically significant improvement in patients' adherence to medication after implementing the mobile application. This finding could be attributed to the frequent reminder messages sent to patients through WhatsApp many times/per day to remind them to take their medicine at any time. In addition to the information provided via WhatsApp about the importance of prescribed medications, their action, benefits, schedules, and precautions of use, so the patients became more aware of the benefits of vitamins and minerals supplements for long life after surgery as a means to compensate for the essential elements that have been lost due to small dietary meals intake as a result of surgery mechanism. This study was contradicted by *Spetz et al. (2022)*, who found that the use of the Smartphone application did not obtain a lasting improvement in adherence to vitamin and mineral supplementation one-year post-obesity surgery with no statistically significant difference in change in adherence from before the intervention to post-intervention.

The perceiving of stress was statistically significantly improved among patients with obesity surgery post-intervention compared to pre-intervention because they were convinced about the bad effect of stress on health and surgery outcomes, so they practiced and adhered to the stress relieving measures that are posted by the researchers on WhatsApp and also included in the PDF file of educational materials about healthy lifestyle. Patients reported they could control irritable situations and practice relaxing exercises to relieve anxiety. This result goes in the same line with *Boniecka et al. (2017)*, who studied stress as a factor contributing to obesity in patients subjected to bariatric surgery and reported that nearly half of the studied individuals had a moderate stress level after psychological support interventions that helped them cope with stress compared to a high level of stress before intervention.

This result is contradicted by *Altazan et al. (2019),* who found in the group of pregnant women an association between higher weight gain and worse mood and an increment of depressive symptoms over time; yet, regarding the SmartMoms intervention, no significant effects were found on mood and quality of life.

In the present study, after six months of obesity surgery, it was illustrated that there was an improvement in patients' outcomes related to weight loss with statistically significant differences in the number of patients before and after mobile application interventions where p-value <0.05. This finding supported the research hypothesis and confirmed that using mobile application interventions has the potential to be effective in promoting weight loss and obesity surgery outcomes.

This result goes in the same line with *Alnasser (2019)*, who reported that after four months of engaging users with the Twazon mobile app, they experienced more successful outcomes. Their body weight was lowered on average by 1.3±0.6 kg (p=0.183), waist circumference was reduced by 4.9±1.1 cm (p<0.001), and daily energy consumption decreased by >600 calories (p=0.002). At the same time, unengaged users experienced minor changes in body weight, waist circumference, and reduced energy intake. This finding indicated that Twazon mobile app renders positive changes in body weight and potentiates outcomes and lifestyle changes for patients with obesity surgery.

Most current study patients suffer from other chronic diseases due to obesity, such as diabetes mellitus, hypertension, and thyroid disorders. One of the noticeable findings of this study was that there was a statistically significant improvement in the outcomes of other co-morbid conditions of those patients. These results may be the improvement in blood glucose test results and blood pressure readings, decreased dyspnea resulting from obesity, and improved thyroid function tests and physical activity.

These findings agree with *Gullaam Rasul et al. (2022)*, who stated in their qualitative study that one patient experienced great improvement and recovery from the diseases she suffered for years following the obesity surgery and after following a healthy lifestyle. Another patient expressed that she was glad she had the surgery, which brought tremendous health benefits. She felt that diabetes, high blood pressure, and high cholesterol are all gone. Moreover, one patient stated that adopting a healthy lifestyle after obesity surgery helped to reduce obstructive sleep apnea with no more snoring habits.

Regarding the outcomes of the quality of life of patients undergoing obesity surgery, it was illustrated that a statistically significant improvement in self-esteem, physical activity, social life, work condition, and sexual activity after implementing a mobile application with a p-value <0.05. The improvement in quality of life may be due to the success of patients in losing weight over time and the improvement of medical conditions, which improves the body image, subsequently enhances patients' self-esteem, and encourages them to engage in social activities.

This finding is supported by *Alkassis et al. (2019),* who found a statistically significant improvement in people's quality of life domains after obesity surgery, and no one had a very poor or poor quality of life score, where (pre mean= 0.33±0.93 and post mean=1.68±0.62). Also, *Gullaam Rasul et al. (2022)* demonstrated that excessive weight, joint pain, and poor physical fitness made patients' lives more difficult and led many to restrain from social life and sexual activities.

Patient experience is an important outcome of health care and is regarded as one of the central pillars of health care quality. One of the noticeable findings of this study was that most of the patients who participated in it were satisfied with using the mobile application service to provide information and support to patients after they were discharged from the hospital post-obesity surgery. They stated that they felt more secure because they were in the same mobile group with the healthcare providers who supported them, answered their questions, and offered counseling and education in the postoperative period, which helped them achieve successful operation outcomes. They also reported that the mobile application was simple and easy to use and did not require the support of a technical person to help them. Moreover, they recommend using this application with other groups of patients with different conditions, and they would like this service to be generalized to all people suffering from diseases.

This result goes in the same line with *Yang et al. (2022)*, who confirmed that the mobile app has excellent usability for patients and that individual aspect such as satisfaction, efficiency, ease of use, and learning ability scored well by patients undergoing bariatric surgery. Patients stated that they preferred if the service could be continuously implemented to improve the health support and follow-up care for patients after obesity surgery. However, it also reported some technical problems and difficulties that patients faced. They found that mobile application was useful for monitoring nutrition, surgical complications, weight loss, tracking pain, managing medication, and education after obesity surgery.

With rapidly increasing mobile device usage, mobile applications (Apps) offer an opportunity to help patients improve their access to health services, treatment adherence, behavioral changes, and ease of communication with healthcare providers.

7. Conclusion

This study concluded that using mobile applications for patients with obesity surgery positively improves their lifestyle, surgery outcomes, and patient satisfaction.

8. Recommendations

Based on the findings of the present study, it is recommended to integrate mobile application-based lifestyle interventions in the future pathway of care for obesity surgery to optimize patients' outcomes. Further research is needed to study the effect of mobile applications on the outcomes and lifestyle of patients with obesity surgery with a large sample size.

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