

CASE REPORT

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Assessment of cardiovascular risk, heart rate variability, and functionality in the late postoperative period of bariatric surgery submitted to whole-body vibration exercise: A case report

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ABSTRACT

Currently, a high prevalence of risk factors for cardiovascular diseases, such as obesity, sedentary lifestyle, and poor diet, has been observed among young people. Obesity is a public health problem that directly impacts the economy. In this case study, the authors are using data from a survey of a late postoperative bariatric surgery patient. Male patient, 23 years old, obese since childhood, 186 kg [body mass index (BMI) 61], sedentary, without other comorbidities. He denies smoking. On 10/30/2019, he underwent Y gastropasty (Gastric Bypass) with a reduction of approximately 90% of the stomach. On 09/13/2021, he started an intervention protocol through whole-body vibration (WBV). Cardiovascular risk, heart rate variability, functionality,

and quality of life were evaluated in the acute phase and in the chronic phase. The training was conducted through 10 interventions with exercises on the vibrating platform. Functionality was assessed through the tests: "Timed up and Go," Sit/Stand, 6-minute Walk Test, and handgrip strength. A 7.1% gain in functional capacity was observed, with a 37.5% reduction in perceived exertion. In addition, there was a 39% gain in handgrip strength and a reduction in the execution time in the functional capacity tests. Heart rate variability after interventions showed that WBV can reduce cardiovascular risk. In conclusion, the exercise program allowed the reduction of body weight and body mass index and impacted the alteration of body composition and functionality, resulting in a reduction in cardiovascular risk.

Keywords: Cardiovascular risk, Glycemia, Heart rate variability, Obesity

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INTRODUCTION

Obesity is becoming a pandemic, with an estimated 2.8 million people dying annually as a result of being overweight or obese [1]. Driven primarily by changes in the global food system, processed food production is more accessible and effectively marketed more than ever before [2].

Obesity is a public health problem that directly impacts the economy, where the main consequences are lower wages, lower probability of employment, and higher costs of health care, such as spending on medicines and hospitalizations [3].

Currently, a high prevalence of risk factors for cardiovascular diseases, such as obesity, sedentary lifestyle, and poor diet, has been observed among young people (18–50 years), in contrast to the trend of lower incidence of cardiovascular diseases in adults over 50 years old, who live in developed countries [4].

Often, severe obesity is characterized by low physical fitness and high cardiovascular risk due to a sedentary lifestyle. In addition, long-term maintenance of elevated levels of high blood pressure, hypercholesterolemia, and excess weight is associated with cardiovascular diseases [5]. Morbid obesity (BMI >40 kg/m²) is associated with reduced functional capacity, multiple comorbidities, and higher overall mortality [6].

Increased adiposity and insufficient musculature in obese individuals may alter bipedal posture and gait, reduce the quality of musculoskeletal tissue, and impair neuromuscular feedback. These physiological changes have an impact on stability [7].

Bariatric surgery is a world-class treatment for individuals with severe obesity. Compared to other treatments, it has been shown to be more effective and sustainable for weight loss and the resolution of obesity-related comorbidities [8].

There is evidence that the regular practice of physical activity promotes improvement in physical fitness parameters and contributes directly to the functional capacity and quality of life of operated individuals [9].

Whole-body vibration (WBV) emerged in the late 1990s and, recently, full-body vibration exercises have become an increasingly popular alternative training modality [10, 11]. This exercise passively generates intense stimulation that produces dynamic changes in muscle fiber length through the tonic vibration reflex. The technique utilizes rapid and repeated oscillations transmitted from a vibrating device while the individual is standing or sitting on a ground platform [12]. Whole-body vibration may be an appropriate exercise approach for patients who have difficulty practicing general exercises due to its efficacy and convenience of use. This form of exercise causes strong stimulation of the muscles with brief exposure to vibration. Many previous studies have reported the efficacy of WBV in various fields of medical science and physiology [11].

Considering the increase in the obese population, this study may contribute to public health measures and the option of using the vibrating platform as an alternative to physical activity to help combat obesity. The aim of this study was to evaluate the cardiovascular risk, heart rate variability, capillary glycemia, functionality, and handgrip strength in the late postoperative period of bariatric surgery submitted to WBV.

CASE REPORT

The present study is characterized as a case study. The protocol followed the guidelines of the Declaration of Helsinki and Resolution No. 466/12, approved by the Ethics Committee of Universidade Iguazu – CAAE: 40309720.1.0000.8044. Data collection took place at Clínica Escola de Fisioterapia da Universidade Iguazu – Campus Nova Iguazu – Rio de Janeiro.

We report the case of a 23-year-old male patient, obese since childhood, 186 kg (BMI 61), sedentary, without other comorbidities. He denied smoking. On 10/30/2019, he underwent Y gastropasty (Gastric Bypass) with a reduction of approximately 90% of the stomach. On 09/13/2021, he started an intervention protocol through WBV. The anthropometric measurements on admission were 142.8 kg (BMI 48.3), height: 172 cm, abdominal circumference of 122 cm, conicity index: 1.1; waist/height ratio: 0.7, blood pressure: 120 × 80 mmHg, heart rate (HR): 87 bpm; maximum heart rate: 197 by the Karvonen Formula.

Prior to the exams, the volunteer was informed about the need to stop smoking at least 2 hours before the tests, not consuming coffee and/or alcohol in a period of less than 6 hours and abstaining from vigorous exercises for at least 24 hours before arriving at the school clinic.

On the day of the evaluation, he was duly informed about the content of the tests and signed an informed consent form. Then, an identification and anamnesis form were filled out.

Body mass and height were measured to the nearest 0.1 kg and 0.01 m, respectively, with the subject wearing light clothes and without shoes. Height was measured with a stadiometer (Welmy/Brazil) and body mass and bioimpedance were measured using the balance Itecnik (Model: IK-PCA00/China). Body mass index (BMI) was calculated as weight (kg)/height² (m²).

The anthropometric method proposed to analyze the distribution of body fat was waist circumference (WC). It was determined by the average of 2 measurements taken with flexible tape at the waist (at the midpoint between the last rib and the iliac crest) [13]. Afterward, we calculated the conicity index and the waist-height ratio, calculated by WC (cm) divided by height (cm) [14, 15].

Cardiovascular risk was measured using the Framingham risk scale. The score was calculated based on the version of the Framingham Risk Score published

in 2002 [16]. The maximum heart rate was obtained through the Karvonen formula ($220 - \text{age}$) [17].

Heart rate recording was performed using a frequency meter (Polar—model S—810/Finland—2001) for a period of 15 minutes. To perform the HRV (variation of heart rate) spectral analysis, the time series of the R-R intervals were submitted to the Fast Fourier Transform using the Kubios HRV 2.0 software (Kubios—Savonia do Norte—Finland).

The isometric handgrip strength was determined using a WTC Fitness dynamometer (China). The elbow was flexed to a 90° angle in the sitting position. The peak torque consisting of three maximal efforts was determined as the maximum force. Each isometric contraction was maintained for 6 seconds. The results were normalized to body weight (kg).

The 6-minute walk test (6MWT) was performed on the day of evaluation and on the last day of intervention. The tests were carried out on a 30-meter course by a single examiner. The patient was instructed to walk according to his/her exercise tolerance for a period of 6 minutes. Phrases of encouragement were said during the walk. Before the start of each test, the respiratory rate, heart rate, and pulse oximetry were measured by a G-TECH/China oximeter, and the blood pressure was measured using a Premium/China sphygmomanometer and a Littmann stethoscope, as well as the perception of effort using the Borg Scale. At the end of each test, the same parameters were recorded again. The final result of the 6MWT was the measurement of the total distance walked in meters during 6 minutes [18].

The Timed Up and Go (TUG) was performed on the day of evaluation and on the last day of intervention. The test consists of getting up from a chair with a backrest, walking a distance of 3 meters, turning around, and returning. At the beginning of the test, the individual had the back resting on the back of the chair, and, at the end, he/she returned to the initial position. The individual received the instruction “GO” to perform the test and the time was timed in seconds from the command voice

until the moment he/she touched their back on the back of the chair again. The test was performed once for familiarization and a second time for measuring the time. The time spent to perform the test generated a risk rating, being low risk (<10 seconds) and high risk (>20 seconds) [19, 20].

On the day of the first and last training day, the individual was monitored and submitted to blood glucose measurements before training, 5, 10, 15 minutes of training, and 30 minutes after training. In the other sessions, blood glucose was measured only immediately before and immediately after training. Prior to blood sample collection, asepsis was performed with 70% ethyl solution in the distal portion of the middle fingertip of the right hand. The puncture was performed with lancets of disposable material. One drop of blood was applied to one area of the test strip and was analyzed by Accutrend Plus.

The intervention on the vibrating platform (Kikos 204—São Paulo) was performed according to protocol: Varied frequency and varied peak-to-peak displacement (distance from the feet)—WBV exercise once a week, with a progressive frequency every 2 sessions, as follows: 2 sessions—5 Hz; 2 sessions—10 Hz; 2 sessions—15 Hz; 2 sessions—20 Hz; and 2 sessions—25 Hz. Being 3 repetitions (“bouts”), each bout is composed of 1 minute of platform, 1 minute of rest, 1 minute of platform, 1 minute of rest, and 1 minute of platform (Figure 1).

During the training on the platform, the individual held his hands in the platform maneuver and remained with his knees bent at 130° and bare feet.

For data analysis, these were organized in Excel spreadsheets. Statistical analyses were performed using the OriginLab Origin 8.0 (USA) program. Descriptive statistics were performed with means/standard deviation and percentage, plotted in graphs and tables.

The 10-year cardiovascular risk found was 2% (low) according to the Framingham scale. The measured waist circumference was 122 cm, with a conicity index of 1.23 and a waist-to-height ratio of 0.7 (Table 1).

Table 1: Anthropometric data

Anthropometric measurements	Acute phase 09/13/2021	Chronic phase 11/29/2021	%
Body mass (kg)	142.8	142	0.6
BMI (kg/m ²)	48.3	48.1	0.5
Abdominal circumference (cm)	122	122	0
Body fat (%)	53	52.7	0.6
Visceral fat	29	29	0
Skeletal muscle (%)	30.4	30.6	0.6
Muscle mass (kg)	63.8	63.9	0.1
Body liquid (%)	34	34.2	0.5
Bone mass (kg)	3.3	3.3	0
Metabolic age (years)	30	30	0

Functional capacity was assessed by the 6-minute walk test. A 7.1% gain in functional capacity was observed, with a 37.5% reduction in perceived exertion. A 39% gain in handgrip strength was observed, as well as a reduction in the execution time in the following functional capacity tests: “Time Up and Go” and sit/stand, according to Table 2.

Capillary glycemia was evaluated in two moments. First, a glycemic curve was drawn during the first and last intervention (acute and chronic phase), as shown in Table 3. In addition, during the 10 interventions, glycemia before intervention and immediately at the end of the intervention was evaluated (Figure 2).

Heart rate variability was captured at rest and immediately at the end of the first and tenth intervention (Table 4).

SD1 represents the dispersion of points perpendicular to the identity line and appears to be an index of instantaneous recording of beat-to-beat variability; SD2 represents the dispersion of points along the identity line and represents the HRV in long-term records; the ratio of both (SD1/SD2) shows the ratio between the short and long variations of the RR intervals. We observed a slight increase (1.3%) in post-WBV HR (high frequency) in the acute phase and a reduction in post-WBV HR of 7.4% in the chronic phase, where the vibrating platform protocol was performed with an intensity of 25 Hz. There was a reduction in the “Stress Index” and SD2 (%) predominated over SD1 (%) in both phases. The sympathovagal balance represented by the LF/HF (low frequency/high frequency) ratio was <1.5 in the acute and chronic phases.

Table 2: Assessment of functional capacity

Functional assessment	Acute phase 09/13/2021	Chronic phase 11/29/2021	%
HGS (kg)	21	29.2	39
TUG (sec)	7"79	6"53	16.1
Sit/stand (sec)	13"05	11"60	11.1
Distance (m)	420	450	7.1
BORG	8	5	37.5

Table 3: Glycemic curve during first and last intervention

Glycemia	Acute phase 09/13/2021	Chronic phase 11/29/2021	Delta	%
Pre	110	96	-14	12.7
05 min	86	85	-1	1.1
10 min	89	88	-1	1.1
15 min	91	89	-2	2.1
30 min post (after)	86	99	+13	15.1

Table 4: Assessment of heart rate variability in the acute phase (5 Hz frequency) and the chronic phase (25 Hz frequency)

		09/13/2021 (Pre)	09/13/2021 (Post)	%	11/29/2021 (Pre)	11/29/2021 (Post)	%
Parasympathetic nervous system	Mean RR (ms)	770	764	0.8	902	973	7.8
	RMSSD (ms)	24.4	35.1	44	64.1	72	12.3
	SD1 (%)	43.4	45.9	5.8	48.2	57.5	9.2
	Mean HR (bpm)	78	79	1.3	67	62	7.4
Sympathetic nervous system	Stress index	19	16.2	14.7	9.4	8.2	12.7
	SD2 (%)	56.6	54.1	4.3	51.8	42.5	18
	LF/HF	1.377	1.455	5.6	0.873	0.492	43.6

Abbreviations: BMI: body mass index, bpm: beats per minute, Cm: centimeter, HF: High-frequency, HR: heart rate, HRV: heart rate variability, Hz: Hertz, kg: kilogram, LF: low-frequency, m: meter, mmHg: millimeters of mercury, RMSSD: Root-mean square successive difference, SD1: dispersion of points perpendicular to the identity line, SD2: dispersion of points along the identity line, TUG: Timed Up and Go, WBV: whole-body vibration, WC: waist circumference

The recordings of HRV uptake pre- and post-WBV in the acute phase are shown in Figure 3. The records of HRV uptake pre- and post-WBV in the chronic phase are shown in Figure 4.



Figure 1: Vibrating platform (Kikos 204—São Paulo).

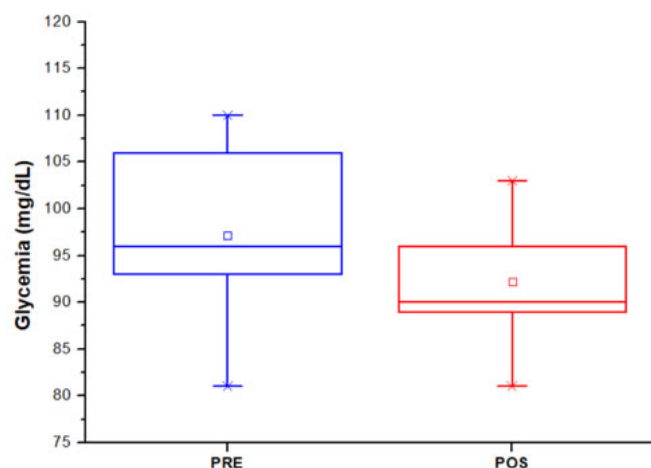


Figure 2: Pre- and post-intervention glycemia.



Figure 3: Pre- and post-WBV heart rate variability in the acute phase.



Figure 4: Pre- and post-WBV heart rate variability in the chronic phase.

DISCUSSION

The studied individual has risk factors for cardiovascular diseases, obesity, and a sedentary lifestyle. Physical inactivity increases the relative risk of developing type 2 diabetes mellitus by up to 112% [21].

The clinical guidelines recommend the use of cardiovascular risk assessment tools (risk scores) to predict the risk of events such as cardiovascular death, since these scores can assist in clinical decision-making and thus reduce the social and economic costs of cardiovascular disease [22].

The 10-year cardiovascular risk found was low (2%) according to the Framingham scale. However, the anthropometric measurements are above the cutoff value indicating cardiovascular risk. The measured waist circumference was 122 cm (cutoff value ≥ 94 cm) [23], with a conicity index of 1.23 (cutoff value ≤ 1.25) [23, 24] and waist/height ratio of 0.7 (cutoff value 0.50) [23]. According to Rosa et al. [25], the measurement of the distribution of fat deposits in the visceral region is made with greater precision by means of imaging exams; however, in population studies and in clinical practice, anthropometric measurements such as waist circumference, conicity index, and waist-to-height ratio are considered appropriate.

Although elevated body mass index (BMI) is used to define obesity, recent data indicate a superior role for waist circumference (WC) over BMI in assessing cardiometabolic risk [26]. Waist circumference is one of the most widely used methods in literature to assess abdominal adiposity, with suggestions for cutoff points associated with increased cardiovascular risk [27].

In only 10 WBV interventions we observed a slight improvement in body composition, as reported in previous studies [28, 29]. However, body weight and BMI hardly changed (reduction of 0.6% and 0.5%, respectively), as observed by Deng [30] in a study conducted in China with 39 obese university students. However, Zago et al. [28] state that even a modest weight loss (5–10% of body weight) helps reduce cardiovascular risk.

A study conducted by Roelants et al. [31] with 89 women demonstrated a gain in knee extension muscle strength. However, in a study conducted with eight obese male adolescents, no increase in handgrip power was observed [32]. In our case study, we observed a 39% increase in handgrip strength. Exposure to vibration directed to the body through the feet showed positive effects on muscle training and rehabilitation, probably due to the increases associated with muscle activity induced by vibration, blood flow, and muscle temperature [12].

The 6-minute walk test (6MWT) is a safe test that was originally developed to assess functional capacity, monitor the effectiveness of various treatments, and establish the prognosis of patients with cardiorespiratory diseases. However, more recently, the test has been validated in several populations [33, 34]. A study by de Souza et al. [35] evaluated the functional capacity of 51 obese patients after bariatric surgery and found the mean distance in the 6MWT of 381.9 ± 49.3 m before surgery and 467.8 ± 40.3 m after surgery.

The reference equation for the distance covered for this study was based on the research by Capodaglio et al. [36], where the proposed reference equation is: $6MWT = 894.2177 - (2.0700 \times \text{age}_{\text{years}}) - (51.4489 \times \text{male} = 0; \text{female} = 1) - 5.1663 \times \text{BMI}_{\text{kg/m}^2}$ m. Based on this equation the distance that should have been covered is 546.6 m. However, the distance traveled before intervention was 420 m and after intervention 450 m, remaining below the predicted. However, there is a slight gain of 7.1% in functional capacity with a significant reduction (37.5%) in the perception of effort by the BORG scale. There was no drop in saturation during the test. Studies consider oxygen desaturation during exercise to be significant when there is a $\geq 4\%$ decrease in basal saturation [37].

Postural instability explains the relationship between obesity [38] and the risk of falling due to the deleterious effects of increased plantar surface pressure on sensorimotor integrative processes and on the sensitivity of mechanoreceptors [39]. The TUG test has been widely used in clinical practice as an outcome measure to assess functional mobility, risk of falls, or dynamic balance in adults, and its normative values have already been established in this population [19, 40]. Whole-

body vibration has been proven effective in improving functional performance by reducing execution time in the “Timed Up and Go” and sit/stand tests.

According to Sanni et al. [21], WBV provides beneficial changes in glucose metabolism. Regarding the effect on capillary glycemia, we evaluated pre-WBV, at the 5th and 10th minutes, immediately after the intervention (15th minute) and 30 minutes after WBV. From these, there was a 17.3% decrease in capillary blood glucose in the individuals in the first intervention (acute phase) with a 5 Hz frequency, and 7.3% in the tenth intervention (chronic phase) with a 25 Hz frequency. It was also found that after 30 minutes of rest after WBV, there was a reduction of 21.8% in the acute phase and we noticed an increase in glycemia of 3.1% in the chronic phase. This result was similar to that found by Sanni et al. [21], as the low-amplitude EWBV contributed to a more favorable improvement in glucose metabolism when compared to high-amplitude WBV.

Comparatively analyzing glycemia before and immediately at the end of the intervention during the 10 interventions, we noticed a reduction of 4.9%. In a study conducted by Di Loreto et al. [41], with 10 healthy men, in which volunteers were studied on two occasions before and after remaining for 25 minutes in a soil plate in the absence (control) or in the presence (vibration) of 30 Hz WBV, vibration slightly reduced plasma glucose.

The data obtained through HRV show a sympathetic predominance over the parasympathetic, which might be related to autonomic imbalance and stress. There was an improvement of 8.4% in SD2(%) and 50.5% in the “Stress Index” obtained in the 10th intervention. The LF/HF ratio remained <1.5 in both measurements but decreased to <0.9 in the chronic phase. According to Yilmaz et al. [42], the normality value of the LF/HF ratio is 1.5–2.0 ms^2 . The increased sympathovagal balance, indicated by a higher LF/HF, reflects the sympathetic predominance and is associated with an increased risk of hypertension [43]. These data show that WBV improves cardiovascular function.

It is recognized as an effective alternative exercise modality compared to resistance exercise for its ability to increase strength and power, generate capacity in skeletal muscle, increase bone mass, and improve cardiovascular function [44].

CONCLUSION

Whole-body vibration exercise was able to transiently reduce capillary blood glucose, increase handgrip strength, and heart rate variability, as demonstrated by the increase in parasympathetic response. The exercise program allowed the reduction of body weight and BMI and impacted body composition change and functionality, resulting in a reduced cardiovascular risk. Although the results were positive, this work is a case study and further testing in populations is needed.

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Conflict of Interest

Authors declare no conflict of interest.

Data Availability

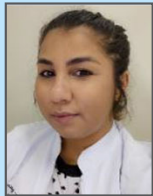
All relevant data are within the paper and its Supporting Information files.

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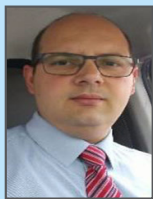
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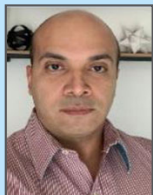
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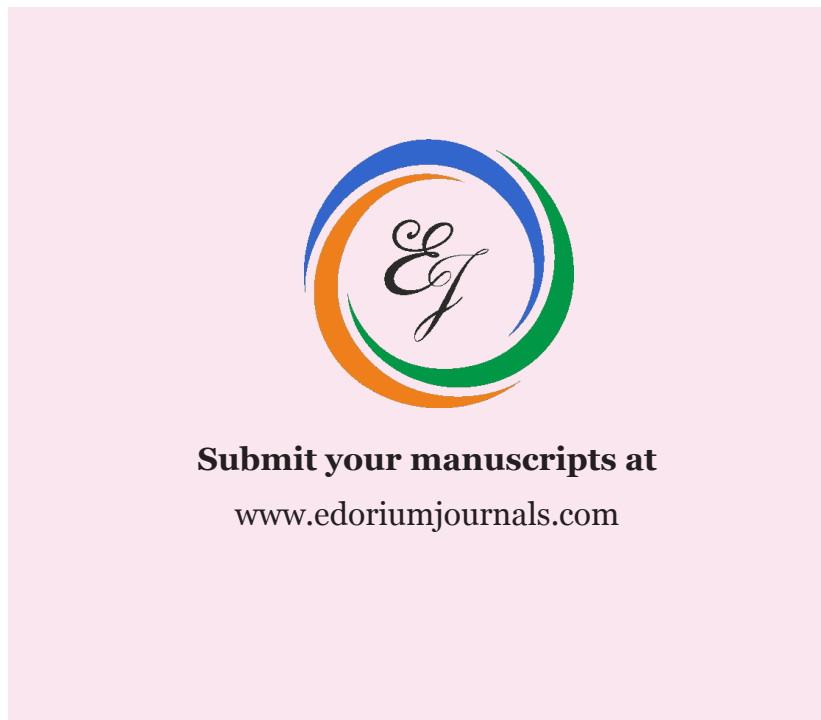
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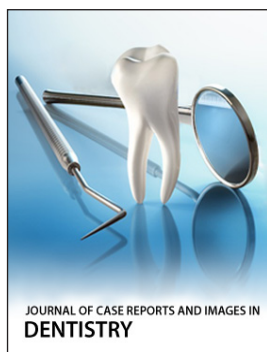
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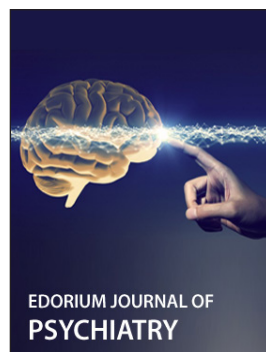
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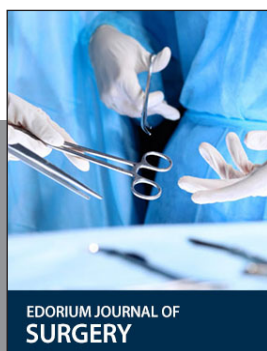
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