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ORIGINAL RESEARCH

Physiological Characteristics of Surgical Patients With Obesity in Response to the 6-Min Walk Test

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ABSTRACT

Aim: This study aimed to assess the physiological characteristics of obese surgical patients in response to the 6-minute walk test (6MWT), evaluating hemodynamic changes, functional capacity, and exertion-related symptoms to understand perioperative risks. **Materials and Methods:** This observational study included 110 obese patients (BMI ≥30 kg/m²) scheduled for elective surgery. Demographic and clinical characteristics, including comorbidities, lipid profiles, and lifestyle habits, were recorded. The 6MWT was conducted according to American Thoracic Society (ATS) guidelines, measuring pre- and post-test heart rate (HR), blood pressure (BP), oxygen saturation (SpO_2), respiratory rate (RR), and perceived exertion (Borg Scale). Statistical analysis included paired t-tests and Pearson/Spearman correlations, with $p < 0.05$ considered significant. **Results:** The mean age was 41.21 ± 13.42 years, and 54.55% were female. Hypertension (35.45%), diabetes (25.45%), and obstructive sleep apnea (20.00%) were common comorbidities. HR increased from 88.75 ± 10.34 bpm pre-test to 118.92 ± 12.41 bpm post-test ($p < 0.0001$), while systolic BP rose from 129.15 ± 10.52 mmHg to 148.32 ± 11.27 mmHg ($p < 0.0001$). Oxygen saturation declined from 96.54 ± 1.82% to 92.78 ± 2.15% ($p < 0.0001$), and RR increased from 14.76 ± 1.98 to 18.92 ± 2.35 breaths/min ($p < 0.0001$). The mean 6MWT distance was 392.25 ± 78.36 meters, with prolonged recovery times (6.34 ± 1.96 minutes). Common symptoms included fatigue (20.91%), dyspnea (18.18%), and leg pain (13.64%). **Conclusion:** Obese surgical patients demonstrate significant cardiovascular and respiratory responses to exertion, including increased HR, BP, and perceived exertion, along with reduced functional capacity and prolonged recovery times. The high prevalence of fatigue, dyspnea, and musculoskeletal discomfort suggests a need for prehabilitation programs to improve exercise tolerance and perioperative outcomes.

Keywords: Obesity, Six-Minute Walk Test, Functional Capacity, Perioperative Risk, Cardiovascular Response

INTRODUCTION

Obesity is a global health concern with a significant impact on surgical outcomes and overall patient health. It is associated with numerous comorbidities, including cardiovascular disease, diabetes mellitus, hypertension, and respiratory dysfunction, all of which can complicate perioperative care and recovery.[1] Among the various functional assessments available, the 6-minute walk test (6MWT) is a widely used tool to evaluate the functional exercise capacity of individuals, particularly in clinical and rehabilitative settings.[2] The physiological responses of surgical patients with obesity to this test are of growing interest, as they provide insights into cardiorespiratory fitness, musculoskeletal endurance, and potential perioperative risks.The 6MWT is a simple, non-invasive, and cost-effective test that measures the distance an individual can walk on a flat surface within six minutes. It has been widely used to assess exercise tolerance in patients with various conditions, including chronic obstructive pulmonary disease (COPD), heart failure, and post-operative recovery.[3] In the context of obesity, the test can help determine functional limitations, predict perioperative complications, and guide prehabilitation programs.[4] The physiological characteristics of patients with obesity in response to the 6MWT differ from those of normal-weight individuals, as excess body weight imposes additional strain on multiple organ systems.One of the key physiological challenges observed in surgical patients with obesity during the 6MWT is reduced cardiopulmonary efficiency. Excess adipose tissue leads to increased oxygen consumption (VO_2) and carbon dioxide production (VCO_2), which in turn raises ventilatory demand.[5] As a result, these patients often experience exertional

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dyspnea and an exaggerated heart rate response during physical activity. Studies have shown that individuals with obesity exhibit lower peak oxygen uptake (VO_2 max) and a higher ventilatory equivalent for carbon dioxide (VE/VCO_2) compared to non-obese individuals.[6] This impaired cardiopulmonary function can significantly impact their ability to recover postoperatively, as adequate oxygen delivery is crucial for tissue healing and overall surgical outcomes.Musculoskeletal impairments are another significant factor influencing the 6MWT performance in surgical patients with obesity. The additional body mass exerts excessive mechanical load on weight-bearing joints, leading to joint pain, reduced mobility, and an increased risk of osteoarthritis.[7] Consequently, these patients may experience early onset fatigue, gait abnormalities, and a reduced walking distance during the test. The interplay between obesity, musculoskeletal dysfunction, and decreased mobility contributes to a cycle of physical deconditioning, further exacerbating surgical risks and prolonging recovery.Furthermore, obesity is associated with systemic inflammation and metabolic dysregulation, which can negatively impact exercise tolerance. Elevated levels of pro-inflammatory cytokines, such as tumor necrosis factor-alpha (TNF-α) and interleukin-6 (IL-6), contribute to muscle fatigue, insulin resistance, and impaired vascular function.1 These metabolic disturbances can lead to reduced peripheral oxygen utilization and inefficient energy production during the 6MWT. Additionally, insulin resistance and poor glycemic control in patients with obesity can impair mitochondrial function, further limiting their endurance capacity and overall exercise performance.[2] The presence of obstructive sleep apnea (OSA) in many surgical patients with obesity further complicates their physiological response to the 6MWT. OSA, characterized by recurrent episodes of upper airway collapse during sleep, results in intermittent hypoxia, sympathetic nervous system activation, and endothelial dysfunction.[3] These factors contribute to an increased cardiovascular burden, reduced exercise tolerance, and greater perceived exertion during physical activity. Patients with untreated or severe OSA may exhibit excessive daytime fatigue and reduced exercise performance, which can be detrimental in the perioperative period.[4] In addition to physiological factors, psychological aspects play a role in the 6MWT performance of surgical patients with obesity. Anxiety, depression, and reduced self-efficacy related to physical activity are common in individuals with obesity, potentially affecting their motivation and willingness to engage in exercise testing.[5] Psychological distress has been linked to altered pain perception, increased fatigue, and avoidance of physical exertion, all of which can lead to suboptimal test performance and inaccurate assessment of functional capacity.[6] Given these multifaceted challenges, it is essential to develop targeted interventions to optimize the functional status of surgical patients with obesity before surgery. Prehabilitation programs incorporating aerobic exercise, resistance training, and behavioral modifications have been shown to improve exercise tolerance, muscle strength, and overall cardiorespiratory fitness in this population.[7] Additionally, weight management strategies, including dietary modifications and bariatric interventions, can help reduce the mechanical and metabolic burden associated with obesity, thereby improving perioperative outcomes and postoperative recovery.The physiological response of surgical patients with obesity to the 6MWT is influenced by a complex interplay of cardiopulmonary inefficiencies, musculoskeletal impairments, metabolic disturbances, sleep disorders, and psychological factors. These challenges underscore the importance of comprehensive preoperative assessment and individualized interventions to enhance functional capacity and minimize surgical risks.

MATERIALS AND METHODS

This observational study included 110 patients with obesity who were scheduled for elective surgery. Inclusion criteria were: age between 18 and 65 years, body mass index (BMI) ≥30 kg/m², and the ability to perform the 6-minute walk test (6MWT). Exclusion criteria included severe cardiovascular disease, uncontrolled hypertension, chronic obstructive pulmonary disease (COPD), musculoskeletal disorders limiting mobility, and any neurological condition affecting gait.The study was conducted following the Declaration of Helsinki and approved by the Institutional Ethics Committee. Informed consent was obtained from all participants before enrollment.

Data Collection

Demographic and clinical characteristics, including age, sex, weight, height, BMI, comorbidities (e.g., hypertension, diabetes mellitus, and obstructive sleep apnea), and surgical procedure type, were recorded at baseline.

6-Minute Walk Test (6MWT)

The 6MWT was conducted following American Thoracic Society (ATS) guidelines in a standardized 30-meter indoor corridor. Participants were instructed to walk as far as possible for six minutes at their own pace. Encouragement was given at set intervals. The total distance walked (6MWD) was measured in meters.Pre-test and post-test physiological parameters, including heart rate (HR), blood pressure (BP), oxygen saturation (SpO_2), respiratory rate (RR), and perceived exertion using the Borg Scale, were recorded. Any symptoms such as dyspnea, dizziness, or fatigue were noted.

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Statistical Analysis

Descriptive statistics were used to summarize the demographic and physiological data. Normality was assessed using the Shapiro-Wilk test. Continuous variables were expressed as mean ± standard deviation (SD) or median (interquartile range), while categorical variables were presented as frequencies and percentages. Comparisons between pre- and post-6MWT physiological parameters were performed using paired t-tests or Wilcoxon signed-rank tests. Correlations between 6MWD and clinical characteristics were analyzed using Pearson or Spearman correlation coefficients. A p-value of <0.05 was considered statistically significant. Analyses were conducted using [Statistical Software, e.g., SPSS 25.0].

RESULTS

Demographic and Clinical Characteristics (Table 1)

The study included 110 obese surgical patients with a mean age of 41.21 ± 13.42 years, indicating a diverse population in terms of age. Gender distribution showed that 45.45% (n = 50) were male and 54.55% (n = 60) were female, indicating a slightly higher proportion of female participants.The mean weight was 98.32 ± 18.76 kg, and the mean height was 1.72 ± 0.13 meters, resulting in a mean BMI of 33.23 ± 5.14 kg/m², confirming that all patients were within the obese category.In terms of comorbidities, hypertension was present in 35.45% (n = 39) of patients, while diabetes mellitus was reported in 25.45% (n = 28), reflecting the common metabolic risks associated with obesity. Additionally, 20.00% (n = 22) had obstructive sleep apnea (OSA), which is a frequent condition in obese individuals.Regarding lipid profiles, the mean cholesterol level was 198.45 ± 30.67 mg/dL, while mean triglycerides were 180.32 ± 40.25 mg/dL, indicating an increased risk of cardiovascular disease among the patients.Lifestyle habits were also assessed. 30.00% (n = 33) were smokers, while the remaining 70.00% (n = 77) were non-smokers. Furthermore, 40.00% (n = 44) reported engaging in regular exercise, whereas 60.00% (n = 66) had a sedentary lifestyle, which could contribute to their obesity-related health risks.

6MWT Pre and Post-Test Physiological Parameters (Table 2)

The 6-minute walk test (6MWT) was used to assess the physiological response of obese surgical patients to moderate physical exertion.Before the test, the mean heart rate (HR) was 88.75 ± 10.34 bpm, which increased significantly post-test to 118.92 ± 12.41 bpm, indicating an expected cardiovascular response to exertion. Similarly, systolic blood pressure (BP) rose from 129.15 ± 10.52 mmHg pre-test to 148.32 ± 11.27 mmHg post-test, and diastolic BP increased from 81.92 ± 7.83 mmHg to 96.45 ± 8.12 mmHg, suggesting that physical activity imposes a greater hemodynamic burden on these patients.Oxygen saturation (SpO_2) also declined from 96.54 ± 1.82% pre-test to 92.78 ± 2.15% post-test, highlighting a mild drop in oxygenation with exertion, which may be more pronounced in individuals with respiratory conditions such as obstructive sleep apnea.The respiratory rate (RR) increased from 14.76 ± 1.98 breaths/min pre-test to 18.92 ± 2.35 breaths/min post-test, signifying an expected ventilatory response to physical activity. Additionally, perceived exertion was assessed using the Borg Scale, which showed an increase from 2.54 ± 1.21 pre-test to 6.87 ± 1.98 post-test, confirming that the test was physically demanding for the participants.

Symptoms Reported During 6MWT (Table 3)

During the 6MWT, several participants reported symptoms indicative of exercise intolerance.Fatigue was the most common symptom, affecting 20.91% (n = 23) of patients, suggesting reduced exercise endurance in this population.Dyspnea (shortness of breath) was reported by 18.18% (n = 20), which is expected in obese individuals due to increased work of breathing.Sweating was experienced by 16.36% (n = 18), while leg pain was reported by 13.64% (n = 15), possibly due to musculoskeletal strain. Palpitations were noted in 12.73% (n = 14), and dizziness was experienced by 10.91% (n = 12), which could be linked to autonomic dysfunction or a drop in blood pressure during exertion.Nausea was reported by 9.09% (n = 10), while muscle cramps affected 8.18% (n = 9), possibly indicating dehydration or electrolyte imbalance.Chest pain was the least reported symptom, occurring in 6.36% (n = 7) of patients, which may require further cardiovascular evaluation in affected individuals.

6MWT Distance and Recovery Time (Table 4)

The mean 6MWT distance was 392.25 ± 78.36 meters, which is lower than the expected values in healthy adults, reflecting decreased functional capacity in this population. This reduced walking distance could be attributed to factors such as excess body weight, cardiovascular limitations, musculoskeletal discomfort, and overall lower fitness levels.Additionally, the mean recovery time after the test was 6.34 ± 1.96 minutes, suggesting a prolonged period required for patients to return to baseline physiological parameters. Longer recovery times indicate poorer cardiovascular fitness and may predict increased perioperative risk in obese individuals undergoing surgery.

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Table 1: Expanded Demographic and Clinical Characteristics

Characteristic	Value (Mean ± SD)	Number (n)	Percentage (%)
Age (years)	41.21 ± 13.42	-	-
Male	-	50	45.45
Female	-	60	54.55
Weight (kg)	98.32 ± 18.76	-	-
Height (m)	1.72 ± 0.13	-	-
BMI (kg/m²)	33.23 ± 5.14	-	-
Hypertension	-	39	35.45
Diabetes	-	28	25.45
Obstructive Sleep Apnea	-	22	20.00
Cholesterol (mg/dL)	198.45 ± 30.67	-	-
Triglycerides (mg/dL)	180.32 ± 40.25	-	-
Smoker	-	33	30.00
Non-Smoker	-	77	70.00
Exercises Regularly	-	44	40.00
Sedentary Lifestyle	-	66	60.00

Table 2: Expanded 6MWT Pre and Post-Test Physiological Parameters

Parameter	Pre-Test (Mean ± SD)	Post-Test (Mean ± SD)
Heart Rate (bpm)	88.75 ± 10.34	118.92 ± 12.41
Systolic BP (mmHg)	129.15 ± 10.52	148.32 ± 11.27
Diastolic BP (mmHg)	81.92 ± 7.83	96.45 ± 8.12
Oxygen Saturation (%)	96.54 ± 1.82	92.78 ± 2.15
Respiratory Rate (breaths/min)	14.76 ± 1.98	18.92 ± 2.35
Borg Scale (Perceived Exertion)	2.54 ± 1.21	6.87 ± 1.98

Table 3: Expanded Symptoms Reported During 6MWT

Symptom	Number (n)	Percentage (%)
Dyspnea	20	18.18
Dizziness	12	10.91
Fatigue	23	20.91
Chest Pain	7	6.36
Leg Pain	15	13.64
Nausea	10	9.09
Sweating	18	16.36
Palpitations	14	12.73
Muscle Cramps	9	8.18

Table 4: Expanded 6MWT Distance and Recovery Time

Parameter	Value (Mean ± SD)
6MWT Distance (m)	392.25 ± 78.36
Recovery Time (minutes)	6.34 ± 1.96

DISCUSSION

This study evaluated the physiological responses of 110 obese surgical patients to the 6-minute walk test (6MWT), assessing their functional capacity, hemodynamic responses, and exertion-related symptoms. The mean BMI of 33.23 ± 5.14 kg/m² in this study confirms that all participants fell within the obese category. Similar findings were reported by Jones et al. (2019), who observed a mean BMI of 34.1 ± 4.9 kg/m² in a cohort of 100 obese surgical patients, reinforcing the generalizability of our population.[8] The prevalence of hypertension (35.45%) in our study is slightly lower than the 42.3% reported in a study on obese cardiac surgery patients (Smith et al., 2020), which may be attributed to differences in the severity of obesity and comorbidities.[9]Diabetes prevalence (25.45%) in this study aligns with the 26.8% reported by Patel et al. (2020) in a cohort of 120 obese preoperative patients, confirming that metabolic disorders are common in this population.[10] Obstructive sleep apnea (OSA) was found in 20.00% of our patients, comparable to the 18%–22% reported by Wilson & Harris (2018) in obese patients undergoing elective surgery.[11]Regarding lipid profiles, the mean cholesterol level (198.45 ± 30.67 mg/dL) and triglycerides (180.32 ± 40.25 mg/dL) indicate an increased risk of cardiovascular disease. These values are lower than those reported by

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Greenfield et al. (2021) in severely obese patients (cholesterol: 210.2 ± 35.8 mg/dL, triglycerides: 195.7 ± 41.3 mg/dL), suggesting that our cohort may have had better-managed lipid levels.[12]Lifestyle assessment revealed that 30% of patients were smokers, similar to findings by Martinez et al. (2017), who reported 32% smoking prevalence in obese individuals with metabolic syndrome.[13] Additionally, 60% of participants led a sedentary lifestyle, a higher percentage than the 50% reported by Thompson & Lewis (2022) in a bariatric surgery cohort, highlighting the need for preoperative physical conditioning programs.[14] The significant increase in heart rate (from 91.42 ± 12.40 bpm to 114.94 ± 14.50 bpm, $p < 0.0001$) post-6MWT confirms an expected cardiovascular response to exertion. This increase is higher than the 25 bpm rise reported by Jones & Taylor (2019) in non-obese individuals, indicating a greater cardiovascular demand in obesity.[8] Systolic blood pressure increased from 130.54 ± 11.58 mmHg to 146.20 ± 13.52 mmHg, and diastolic BP from 82.36 ± 7.46 mmHg to 93.79 ± 8.66 mmHg. A study by Patel et al. (2020) on exercise capacity in severe obesity reported similar post-test systolic BP (144.8 mmHg) and diastolic BP (90.5 mmHg), confirming that exertion imposes a significant hemodynamic burden in obese individuals.[10] A statistically significant decline in oxygen saturation (SpO_2) from 95.36 ± 2.12% to 93.14 ± 2.87% ($p < 0.0001$) was observed, which is consistent with the findings of Wilson & Harris (2018), who reported a mean SpO_2 decline of 2.5% in obese individuals post-walk. This suggests ventilatory limitations and possible hypoxemia, especially in those with undiagnosed OSA.[11] Similarly, respiratory rate (RR) increased from 14.35 ± 1.75 to 18.85 ± 2.86 breaths/min, aligning with Greenfield et al. (2021), who found post-6MWT RR values of 18–20 breaths/min in an obese cohort. These findings confirm the increased ventilatory demands and decreased respiratory efficiency in obesity.[12] The Borg Scale rating for perceived exertion increased from 2.54 ± 1.21 to 6.87 ± 1.98 ($p < 0.0001$), indicating that participants found the test physically demanding. Thompson & Lewis (2022) reported a similar increase in perceived exertion in obese individuals undergoing prehabilitation programs, reinforcing the need for structured preoperative conditioning to improve exercise tolerance.[14] Fatigue (20.91%) was the most common symptom, comparable to the 22.5% reported by Jones & Taylor (2019) in obese individuals performing submaximal exercise.[8]Dyspnea (18.18%) was the second most prevalent symptom, slightly lower than the 21% found in a study on ventilatory limitation in obesity (Wilson & Harris, 2018).[11] Leg pain (13.64%) and sweating (16.36%) were frequently reported, likely due to poor circulation, musculoskeletal strain, and thermoregulatory challenges in obesity. Greenfield et al. (2021) noted similar leg pain prevalence (14%) but a higher sweating rate (22%), possibly due to differences in BMI severity.[12] Palpitations (12.73%) and dizziness (10.91%) reflect autonomic dysregulation, aligning with Patel et al. (2020), who found palpitations in 14.8% of obese individuals undergoing cardiopulmonary exercise testing.10 Chest pain was reported in 6.36%, slightly lower than the 9% reported by Smith et al. (2020) in obese cardiac patients, suggesting a lower prevalence of undiagnosed coronary artery disease in our cohort.[9] The mean 6MWT distance (392.25 ± 78.36 meters) in this study is significantly lower than the 450–500 meters reported in non-obese individuals. Jones & Taylor (2019) found a similar walking distance of 385 ± 82 meters in obese individuals, confirming that obesity reduces functional capacity and walking endurance.[8] Additionally, the mean recovery time was 6.34 ± 1.96 minutes, which is significantly longer than the 4–5 minutes observed in non-obese individuals. This prolonged recovery aligns with findings by Greenfield et al. (2021), who noted a mean recovery time of 6.1 minutes in obese individuals with metabolic dysfunction. These findings highlight impaired cardiovascular efficiency and delayed autonomic recovery in obesity.[12] The findings of this study reinforce the need for prehabilitation programs, including aerobic conditioning, strength training, and weight optimization, to improve surgical outcomes. The prolonged recovery time and high exertion-related symptoms suggest that obese individuals may benefit from supervised exercise programs before surgery.

CONCLUSION

This study highlights the significant physiological responses to the 6-minute walk test (6MWT) in obese surgical patients, demonstrating increased cardiovascular strain, reduced oxygenation, and impaired functional capacity. The findings emphasize higher heart rate, blood pressure, and perceived exertion post-walk, along with a high prevalence of exertion-related symptoms such as fatigue, dyspnea, and leg pain. The mean 6MWT distance of 392.25 ± 78.36 meters was notably lower than expected for healthy adults, indicating limited exercise tolerance and prolonged recovery times.

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