ORIGINAL RESEARCH

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

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ABSTRACT

Background: Overall health and fitness contribute to surgical experience and recovery. The aim of this study was to describe an array of physiological characteristics in a presurgical patient cohort with obesity as a function of their sustained walking speed.

Methods: We performed a prospective single-center cohort study in Wollongong Hospital, Australia from 2016 to 2018. Patients (N = 293) with severe obesity completed a 6-min walk test and were classified as either slow or fast walkers according to the cut point of 0.9 $m \cdot s^{-1}$ (2 mph). These groups were compared for anthropometry, comorbidities, respiratory and cardiovascular physiology, blood biomarkers, patient-centered outcomes, and perception of effort.

Results: Slow walkers (n = 115; age 65 [63 to 67] years; mean [95% confidence interval]) and fast walkers (n = 178; age 54 [52 to 56]; $P < 0.05$) were not different in body weight but were different for body mass index (slow 43.2 [42.0 to 44.4] versus fast 41.1 [40.5 to 41.8]; $P < 0.05$). Cardiovascular disease and renal disease were more prevalent in slow walkers. Respiratory physiology reflective of restrictive lung disease (force vial capacity [L] slow 2.61 [2.45 to 2.77] versus fast 3.34 [3.19 to 3.47]; $P < 0.05$) was more common in slow walkers, who also reported higher dyspnea ratings. Resting cardiovascular characteristics were not different, although N-terminal pro-B-type natriuretic peptide levels were higher in the slow group ($P < 0.05$). Quality of recovery at postoperative day 30 was higher in the fast walking group.

Conclusion: In this Australian cohort, patients with obesity undergoing nonbariatric surgery differed in their physiological profiles according to walking speed. This study supports the need to appreciate the physical fitness of patients beyond simplified body weight and classification of obesity in the perioperative period.

Keywords: obesity, surgery, fitness, physiology, 6-min walk test, 6MWT

INTRODUCTION

Successful ambulation is critical for activities of daily living. Walking speed is correlated with a number of indices of long-term health and is a strong independent predictor of disability, healthcare utilization, nursing home admission, and mortality (1,2). The ability to maintain fast walking over moderate distances is a proxy measure of aerobic capacity. Fitness is a predictor of mortality in older adults and is independent of overall and abdominal adiposity (3–6). Notably, the influence of low cardiorespiratory fitness on mortality has been shown to be similar to that of coronary artery disease, smoking, and diabetes (all with hazard ratios of 1.3 to 1.4) (6).

Body composition may play an important role in the complex interaction between energetics, mobility, and aging (7,8). The amount of energy consumed per kilogram of body weight in basic activities such as walking is related to body composition, but the relationship may be complex and

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counter intuitive. For example, more muscle mass may facilitate activity and help stabilize gait but may also increase energy requirements and consumption. A higher fat-to-lean mass ratio is associated with a lower energy requirement for essential activities but is also associated with a lower reserve capacity and lower overall energy available for physical activity (2). Aging, obesity, and specific metabolic diseases affect the anatomical, metabolic, and functional characteristics of muscle in addition to changes in absolute muscle mass.

Severe obesity, defined as a body mass index (BMI) greater than or equal to 35 $kg \cdot m^{-2}$ with or without comorbidities, is becoming more common in western society (9,10). Twenty-eight percent of Australian adults are obese, with the rate of severe obesity nearly doubling (4.9% to 9.4%) over the past 2 decades (11). As a result, patients present for surgery are often obese. Local area health data from Illawarra (New South Wales), Australia, reported that 35% of the general surgical population was obese, which rose to up to 55% for certain operations such as laparoscopic cholecystectomy (12). Most patients with severe obesity will journey through a surgical episode with only minor problems, but some will experience serious events due to the severity of their obesity and underlying systemic diseases (13,14).

Exercise tolerance is multifactorial and is determined by psychological, physiological, and physical limitations (15). During sustained walking, several factors are known to influence the ability of people with obesity to continue or stop. Psychological factors include perceptions related to encouragement, tolerance of discomfort, and achievement of goals. Central physiological limitations include mechanical restriction of the chest wall, small airway obstructive disease, and reduced left ventricular compliance and strain influencing cardiac output (16). Peripheral physiological effects of obesity include an altered uptake of oxygen and oxidative capacity in skeletal muscle, which contributes to reduced aerobic capacity (17). Physical factors include skin friction, urinary incontinence, varicose veins, lower body joint pain, and leg bulk (18). Increased body mass adds to the complex concept of mechanical efficiency (8). The overall impact of severe obesity is that cardiorespiratory fitness is often reduced, which is reflected in the ability of an individual to tolerate physiological stress. Our previous work demonstrated that people with a slow or incomplete 6-min walk test (6MWT) had worse postoperative patient-centered outcomes than those who walked faster (19,20). The most useful cutoff value appeared to be a 6-min walk distance of 308 m, equivalent to a sustained walking speed of 0.9 $m \cdot s^{-1}$ (2.0 mph), which is in agreement with the poor overall health and physical function of those unable to sustain a walking speed >1.0 $m \cdot s^{-1}$ (>2.2 mph) (21).

Surrogate assessments of exercise capacity, such as sustained walking speed, offer insight to the physiological strain associated with a raised metabolic rate. Individuals tend to walk at a speed that minimizes their gross energy cost even though this requires greater aerobic effort in people with obesity (22). The aim of this study was to explore several factors that may contribute to functional capacity, as measured by a 6MWT, in individuals with severe obesity who were scheduled for nonbariatric surgery.

METHODS

This study was a prospective single-center cohort study in Wollongong Hospital, New South Wales, Australia, that was conducted from 2016 to 2018 to investigate the ability of the 6MWT to predict postoperative disability in adult surgical patients with severe obesity. Ethical approval was granted by the local regulatory body (HE15/379), and the trial was registered with the Australian New Zealand Clinical Trial Registry (ACTRN 12615001264572). Wollongong Hospital is an outer metropolitan general tertiary hospital with 350 beds and 15 operating theaters and performs approximately 13,000 operations per year of all types, excluding cardiothoracic and complex pediatric procedures.

The study protocol has been published elsewhere (19, 20). In summary, preoperative measures were collected at the preoperative clinic and included height, body weight, waist and hip circumference, resting heart rate and blood pressure, spirometry, routine blood tests, N-terminal pro-B-type natriuretic peptide (NT pro-BNP) levels, World Health Organization Disability Assessment Schedule 2.0 (WHODAS) (23), surgical severity scoring using the Portsmouth Physiological and Operative Severity Score for the Enumeration of Morbidity and Mortality definitions (24), and a 6MWT (25). The 6MWT was performed according to the American Thoracic Society guidelines in the preoperative clinic along an out and back 30 m course with markers every meter for guidance (25). Patients were instructed to complete the 6 min of walking at the fastest pace they could sustain for that time. If required, they were permitted to momentarily rest. Within the first 3 min after ceasing to walk, the patient's heart rate, blood pressure, and ratings of perceived exertion (scale of 1 to 10) and dyspnea (scale of 1 to 5) were recorded. Intraoperative and anesthesia data were obtained from electronic records. Postoperative data included medical and surgical complications, a quality of recovery score (26) at days 3 and 30, and WHODAS scores at days 30 and 180.

The analysis in this current study focuses on the physiological characteristics of these patients as they relate to associations with the 6MWT outcome. Variables explored include patient demographic characteristics, comorbidities, the quality of recovery and WHODAS scores, cardiorespiratory parameters such as heart rate, blood pressure, and lung function, blood test results, and details of the 6MWT itself, including the recovery period. A walking speed cutoff of 0.9 $m \cdot s^{-1}$ was used to analyze and compare the physiology of patients performing the 6MWT, as this speed was previously identified in predicting recovery and disability after surgery in these patients. This walking speed was calculated as the mean sustained speed over the 6 min or, when a patient was unable to complete the assessment, the sustained speed according to the distance covered at the time point at which the patient stopped walking.

Statistical analyses were conducted using the software program Statistix, version 10 (www.statistix.com; Tallahassee, Florida, USA). Continuous data were analyzed using unpaired *t* tests. A Kruskal-Wallis 1-way analysis of variance was performed when data were not normally distributed. Categorical data (such as the existence of comorbidities in the groups) were analyzed using the χ^2 association test. The α level of significance was set at $P < 0.05$. Prism GraphPad (version 9) was used to log transform NT pro-BNP values due to non-normal distribution and then describe their relationships in terms of the relative frequency of BMI (<BMI 50 or not), reported cardiovascular disease (or not), and walking speed (<0.9 $m \cdot s^{-1}$ or not; GraphPad Software, Boston, Massachusetts, USA).

RESULTS

The outcomes of predicting recovery and disability after surgery for these patients are published (19). Two hundred and ninety-three patients undertook the study. The median BMI was 41 $kg \cdot m^{-2}$, and the mean distance walked in the 6MWT was 322 m (standard deviation [SD] 137 m).

Participant characteristics are reported in Table 1. Overall, 58% of the patients were female, with similar proportions of females in both walking groups (slow walking, 62% females; fast walking, 57% female). The walking groups differed in several factors, including age and BMI, but not body mass. The slow group had a higher proportion of cases with a history of cardiovascular and renal disease. Several other variables, including the prevalence of heart failure, β-blocker use, stroke, and atrial fibrillation, were not different between groups, with very small numbers present in both. Obstructive sleep apnea, the use of continuous positive airway pressure, and cigarette smoking were also not different, with high numbers present in both groups.

Overall, numerous patients in this study cohort had a low 6MWT distance. Only 10% reached a distance that was within 10% of the distance predicted by their age, height, and weight (27). A 6MWD cutoff point of 308 m was the distance that best distinguished between groups regarding postoperative recovery and function, which is equivalent to a walking speed of approximately 0.9 $m \cdot s^{-1}$. As such, the primary focus of the current study was to present a comparison of the physiological characteristics of the patients when divided into these 2 walking groups, those who walked at <0.9 $m \cdot s^{-1}$ and those who walked at ≥0.9 $m \cdot s^{-1}$. One hundred and fifteen individuals walked at less than 0.9 $m \cdot s^{-1}$, and 178 walked at this speed or faster. Slower walkers reported a lower quality of recovery at postoperative day 30, with higher disability scores both preoperatively and postoperatively. The Portsmouth Physiological and Operative Severity Score for the Enumeration of Morbidity and Mortality scores were also significantly higher in the slower walkers (Table 2).

Patient lung function was reduced in the slower walking group. A restrictive pattern of lung disease, as demonstrated by reduced total lung volumes, forced vital capacity, and peak expiratory flow rate, were more common in the slower walking group. There was no clinically significant difference between groups in resting blood pressure and heart rate (Table 3).

Blood analysis confirmed some differences between the groups in measures of kidney function, hemoglobin, and NT pro-BNP levels (Table 4). Values of estimated glomerular filtration rate (eGFR) that were recorded as >90 $mL \cdot min^{-1} \cdot 1.73\ m^{-2}$ were assigned as 90 $mL \cdot min^{-1} \cdot 1.73\ m^{-2}$ for the purposes of analysis. Therefore, the means in both groups are approximate and likely to be slightly lower than the values in real life, particularly in the fast walking group, which

TABLE 1. Participant characteristics and comorbidities for those with a mean walking speed of <0.9 $m \cdot s^{-1}$ (n = 115) and ≥0.9 $m \cdot s^{-1}$ (n = 178).

Variable	Walking Speed of <0.9 $m \cdot s^{-1}$ (Males, 44; Females, 71)[a]	Walking Speed of ≥0.9 $m \cdot s^{-1}$ (Males, 79; Females, 99)[a]	*P* Value[a]
Age (y)	65 (63–67)	54 (52–56)	<0.01
Weight (kg)	115 (111–119)	116 (114–119)	0.21
Height (m)	1.63 (1.61–1.64)	1.68 (1.67–1.69)	<0.01
Waist (cm)	130 (128–132)	125 (123–126)	<0.01
Hip (cm)	138 (136–141)	133 (132–135)	<0.01
Waist:hip	0.94 (0.93–0.96)	0.94 (0.93–0.96)	0.04
BMI	43.2 (42.0–44.4)	41.1 (40.5–41.8)	0.01
Comorbidities (number of patients)[a]			
IHD	32	16	<0.01
AMI	18	4	<0.01
Normal ECG	86	151	0.01
COPD or asthma	33	40	0.23
Severe COPD	0	1	0.42
Known kidney disease	19	5	0.00
Known DM	45	44	<0.01
HT	81	76	<0.01

AMI = acute myocardial infarction; COPD = chronic obstructive pulmonary disease; DM = diabetes mellitus; ECG = electrocardiogram; HT = hypertension; IHD = ischemic heart disease

[a]Age and anthropometrics were analyzed using a Kruskal-Wallis 1-way analysis of variance. Values are shown as mean (95% confidence interval). Comorbidities are expressed as absolute number of patients and were analyzed by χ^2 analysis association test. Significance for both was set as $P < 0.05$.

TABLE 2. Patient-centered measures for those with a mean walking speed of <0.9 m·s^{-1} (n = 109 to 115) and ≥0.9 m·s^{-1} (n = 170 to 178).

Variable	Walking Speed < 0.9 m·s^{-1a}	Walking Speed ≥ 0.9 m·s^{-1a}	P Value[a]
QOR_3	123 (119–128)	126 (123–129)	0.42
QOR_30	132 (129–136)	139 (137–141)	<0.01
WHODAS pre	29 (29–32)	13 (11–15)	<0.01
WHODAS 30d	19 (16–22)	8 (6–9)	<0.01
WHODAS 6m	13 (10–16)	4 (3–5)	<0.01
PPOSS morb	24.7 (21.3–28.1)	14.5 (13.1–15.8)	<0.01
PPOSS mort	1.8 (1.2–2.3)	0.7 (0.6–0.8)	<0.01

QOR = quality of recovery score at postoperative days 3 and 30; POSS morb = Portsmouth Physiological and Operative Severity Score for the Enumeration of Morbidity and Mortality morbidity score; POSS mort = Portsmouth Physiological and Operative Severity Score for the Enumeration of Morbidity and Mortality mortality score; WHODAS = World Health Organization Disability Assessment Schedule scores preoperatively (pre) and at 30 days (30d) and 6 months (6m) postoperatively
[a] Data were analyzed by Kruskal-Wallis 1-way analysis of variance and are shown as mean values (95% confidence interval). Significance was set at a *P* value of <0.05.

TABLE 3. Seated resting blood pressure, heart rate, and arterial saturation (n = 137 to 156) and standing spirometry characteristics for those with a mean walking speed of <0.9 m·s^{-1} (n = 108 to 115) and ≥0.9 m·s^{-1} (n = 166 to 178).

Variable	Walking Speed < 0.9 m·s^{-1a}	Walking Speed ≥ 0.9 m·s^{-1a}	P Value[a]
Heart rate (b·min^{-1})	81 (78–83)	80 (78–82)	0.81
Systolic BP (mmHg)	143 (140–146)	140 (137–143)	0.19
Diastolic BP (mmHg)	81 (78–83)	83 (82–84)	0.11
Arterial O_2 saturation (%)	96.4 (96.0–96.7)	96.8 (96.6–97.0)	0.02
FVC (L)	2.61 (2.45–2.77)	3.34 (3.19–3.47)	<0.01
FEV_1 (L)	2.05 (1.91–2.18)	2.65 (2.53–2.76)	<0.01
FEV_1/FVC (%)	79 (77–81)	80 (78–81)	0.49
PEFR (L·s^{-1})	267 (247–288)	343 (324–361)	<0.01

BP = blood pressure; FEV_1 = forced expiratory volume in 1 s; FVC = forced vital capacity; PEFR = peak expiratory flow rate
[a] Data were analyzed by Kruskal-Wallis 1-way analysis of variance and are shown as mean values (95% confidence interval). Significance was set at a *P* value of <0.05.

contained more patients with eGFR values in the normal range of >90 mL·min^{-1}·1.73 m^{-2}. The difference between groups was still highly significant, with no overlap in the 95% confidence intervals.

NT pro-BNP was investigated in more depth. As the data were non-normally distributed, with a skew toward lower numbers plus high value outliers, the data were transformed logarithmically to allow further analysis. Figure 1 shows the relative frequency of log NT pro-BNP concentrations for the categories of BMI greater than or less than 50 kg·m^{-2}, cardiovascular disease present or absent, and walking speed greater than or less than 0.9 m·s^{-1}. Nonlinear analysis was applied with the null hypothesis being that one curve would fit all of the data. For all 3 analyses, the *P* value was <0.05, meaning that the null hypothesis could be rejected, and therefore two different curves best fit the data for each binary response. The slope for those with a lower BMI, no cardiovascular disease, and faster walking speed was steeper, meaning that the log NT pro-BNP concentration for those groups was lower overall.

The slow walking group covered significantly less distance in the allocated time (Table 5). Despite walking a shorter distance at a slower speed, objective measurements of cardiovascular function (recovery heart rate and blood pressure) were not clinically different in slower walkers, despite small changes in blood pressure that were statistically significant (Table 5). However, and most relevant to the primary interest of the study, slower walkers perceived their effort and degree of dyspnea to be significantly higher than faster walkers.

DISCUSSION

In surgical patients with severe obesity, those with a 6MWD of <308 m, equivalent to a walking speed of less than 0.9 m·s^{-1}, displayed several differences compared with patients who walked faster over the duration of 6 min. The slower walkers were older, with a larger waist circumference and a statistically higher mean BMI. There was no difference between groups in absolute body weight. They were more comorbid, with higher rates of cardiovascular disease, kidney disease, diabetes, and restrictive spirometry. They had more severe disability both preoperatively and postoperatively and higher estimated rates of postoperative morbidity and mortality. After walking at a slower speed and therefore less distance on a 6MWT, they noted more fatigue and dyspnea than patients who walked farther and more quickly and demonstrated similar changes in cardiorespiratory parameters.

The 229 patients who were able to complete the full 6MWT did so at a mean walking speed of 1.1 m·s^{-1}. The predicted walking speed for this group was 1.5 m·s^{-1}. The mean walking speed for those under 70 years of age was 1.0 m·s^{-1}, and the mean walking speed was 0.63 m·s^{-1} for those 70 years and older. One previous study found a

TABLE 4. Blood electrolyte, hemoglobin, white cell count, glucose, and N-terminal pro-B-type natriuretic peptide levels (n = 115 to 139) for those with a mean walking speed of <0.9 m·s⁻¹ (n = 91 to 111) and ≥0.9 m·s⁻¹ (n = 156 to 176).

Variable	Walking Speed < 0.9 m·s⁻¹ᵃ	Walking Speed ≥ 0.9 m·s⁻¹ᵃ	P Valueᵃ
Sodium (mmol·L⁻¹)	141 (141–142)	141 (141–141)	0.87
Potassium (mmol·L⁻¹)	4.6 (4.5–4.7)	4.6 (4.5–4.6)	0.33
Urea (mmol·L⁻¹)	7.2 (6.4–8.1)	5.6 (5.3–6.0)	<0.01
Creatinine (mmol·L⁻¹)	96.0 (78.6–113.4)	77.4 (73.1–81.7)	0.44
GFR (mL·min⁻¹·1.73 m⁻²)	72.9 (68.8–77.1)	82.0 (80.0–84.2)	<0.001
Bicarbonate (mmol·L⁻¹)	25.2 (24.7–25.8)	24.7 (24.3–25.0)	0.05
Hemoglobin (g·L⁻¹)	135 (132–138)	140 (138–142)	<0.01
White cell count (×10⁹/L)	8.3 (7.8–8.8)	8.1 (7.8–8.4)	0.47
Glucose (mmol·L⁻¹)	8.0 (6.0–9.9)	6.4 (6.0–6.7)	0.03
NT pro-BNP (pmol·L⁻¹)	50.3 (24.0–76.7)	13.4 (10.3–16.6)	<0.01

GFR = estimated glomerular filtration rate; NT pro-BNP = N-terminal pro B-type natriuretic peptide
[a] Data were analyzed by Kruskal-Wallis 1-way analysis of variance and are shown as mean values (95% confidence interval). Significance was set at a *P* value of <0.05.

TABLE 5. Physiological and perceptual responses collected at the point of recovery to the 6-min walk test for those with a mean walking speed of <0.9 m·s⁻¹ (n = 106 to 115) and ≥0.9 m·s⁻¹ (n = 165 to 178).

Variable	Walking Speed < 0.9 m·s⁻¹ᵃ	Walking Speed ≥ 0.9 m·s⁻¹ᵃ	P Valueᵃ
Distance (m)	181 (162–200)	413 (405–421)	<0.01
Heart rate (b·min⁻¹)	86 (84–89)	87 (84–89)	0.85
Systolic BP (mmHg)	146 (143–150)	141 (138–144)	0.02
Diastolic BP (mmHg)	81 (78–83)	84 (82–85)	0.01
Arterial O_2 saturation (%)	96.4 (95.9–96.9)	96.7 (96.3–97.1)	0.36
RPE	1.6 (1.2–2.0)	1.1 (0.9–1.3)	0.02
Dyspnea	1.9 (1.6–2.3)	1.4 (1.2–1.6)	0.01

BP = blood pressure; RPE = rating of perceived exertion
[a] Data were analyzed by Kruskal-Wallis 1-way analysis of variance and are shown as mean values (95% confidence interval). Significance was set at a *P* value of <0.05.

preferred walking speed of around 1.4 m·s⁻¹ in individuals both with and without obesity (7). Almost all patients in this study cohort therefore had a relatively slow walking speed, even those in the younger and the "faster" groups. They also displayed multiple markers of low fitness, including a low 6MWT distance, low walking speed, high resting heart rate (28,29), high waist circumference (30), and low lung volumes. Dividing the patients into slower or faster walkers appeared to differentiate between those with better or worse outcomes. This was independent of absolute weight, which was equivalent between the groups.

Very few individuals reach their cardiovascular limit when walking at usual speed for 6 min. They are more likely to do so if they have poor respiratory function or a degree of heart failure, as demonstrated by the slow walkers in this study who reached the same cardiorespiratory parameters as faster walkers despite less distance and with more fatigue and dyspnea. Both obesity and sex have been shown to affect the net metabolic rate of walking (7). Metabolic rates of subjects with obesity were 10% greater per kilogram than for normal-weight subjects, and metabolic rates for women were 10% greater than for men. Preferred walking speed was not different across groups (1.4 m·s⁻¹) and was close to the speed that minimized gross energy cost per distance. Sex-based differences were not explored in the current study.

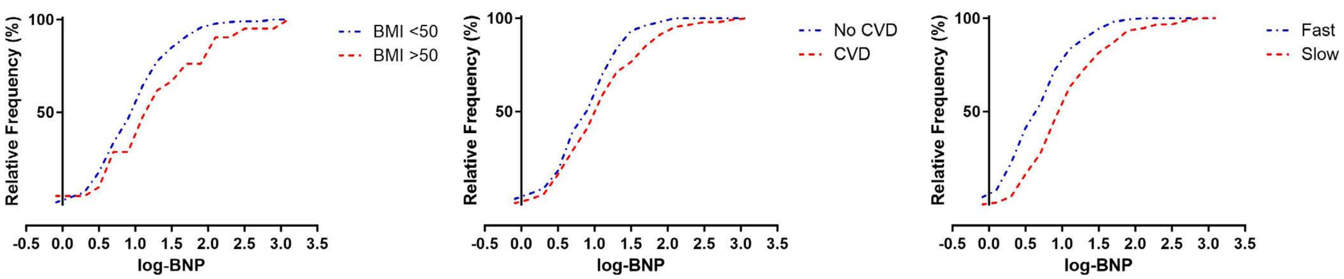

FIGURE 1. Relative frequency of the log N-terminal pro-B-type natriuretic peptide (BNP) concentration for body mass index (BMI), cardiovascular disease (CVD), and walking speed (m·s⁻¹).

Slower walkers demonstrated a higher prevalence of comorbidities. They had a higher recorded incidence of known cardiorespiratory, kidney, endocrine, and restrictive lung disease, which was confirmed by investigations such as spirometry, NT pro-BNP levels, random blood glucose levels, and eGFR. This may be partially explained by their older age and its relationship with function, fitness, disease states, and obesity.

Obesity is known to affect respiratory function, including higher respiratory rates, lower tidal volumes, reduced compliance, and the possibility of microatelectasis, leading to ventilation-perfusion mismatching (16). Distribution of fat mass, for example upper compared with lower body, may have a more important impact on these factors than BMI alone. Restrictive lung disease is noted to be a feature of obesity (16,31) and may be most relevant due to the increased inertial mass on the chest wall. Slower walkers had significantly higher NT pro-BNP and lower hemoglobin concentrations. Associations between cardiovascular disease and anemia and walking speed occur in other populations (32–34). Both physiological and physical factors may influence the development and impact of comorbidities and exercise limitation.

More than half of the study patients had NT pro-BNP levels that were above the normal limit. Patients with cardiovascular disease had higher mean levels than those without cardiovascular disease, confirming the validity of the measure in this population. Higher NT pro-BNP levels were also found in patients with very high BMIs and in slower walkers. NT pro-BNP concentrations are affected by several variables, including kidney function and weight, which may be relevant in this study cohort (35, 36). The literature contains conflicting reports of the usefulness of NT pro-BNP in perioperative risk prediction, and there is no report of its use in the perioperative population with severe obesity. The current findings support other literature suggesting that NT pro-BNP may represent a different underlying construct than that measured by other tools and that its addition may add value to combined risk models (37).

Perception of effort is known to be a factor that both contributes to and limits aerobic performance (38). One study in athletes demonstrated that perception of effort, rather than muscle fatigue or muscle pain, was the main underlying reason for exercise limitation during high-intensity aerobic exercise (39). This may be relevant to the study patients, as walking for 6 min may be perceived as intense sustained exercise for some. The relationship between assessment of functional capacity and perception of effort has not been previously explored in perioperative contexts. Using perceived effort as a measure of cardiorespiratory fitness may be of value.

Numerous large and well-designed longitudinal studies show that gait speed tends to decline with age and as a consequence of chronic disease. Slow walking speed is a strong independent predictor of incident disability, healthcare utilization, nursing home admission, and mortality. In a study in older community-dwelling males, a walking speed of 0.82 $m \cdot s^{-1}$ was found to be the most predictive of mortality (1). The figure of 0.9 $m \cdot s^{-1}$ from this body of work is very close to this figure despite differences in the study populations. It appears to be a relevant cut point for surgical patients with obesity. Stanaway et al. found no mortality within the 5-year study period for those who walked faster than 1.36 $m \cdot s^{-1}$, which was attained by only 11 participants (4%) in the current study (1).

Most walking tests reported in the literature are performed at usual walking speed over 6 meters. A more prolonged test, such as a 6MWT, is arguably better for assessing a sustained physiological response to exercise. It is also potentially more relevant to assessing or predicting the demands of the surgical stress response, which is a sustained level of physiological sympathetic nervous system activation that can last up to 72 h depending on the intensity of surgery (40). It is considered to represent moderate- to high-intensity exercise and to correlate well with cardiorespiratory fitness as measured with cardiopulmonary exercise testing (41, 42).

A range of usual walking speeds has been published, albeit under a wide range of walking conditions. One treadmill study with increasing predetermined speeds found a preferred walking speed of roughly 1.4 $m \cdot s^{-1}$ in both normal weight and overweight men and women (7). An investigation of the 6MWT in patients with different body morphology reported walking speeds of 2 $m \cdot s^{-1}$ in lean individuals, 1.6 $m \cdot s^{-1}$ in obese individuals, and 1.5 $m \cdot s^{-1}$ in women with severe obesity (18).

Bohannon and Andrews published a meta-analysis of 41 studies with a total of 23,111 apparently healthy adults walking at a normal pace over distances of 3 to 30 m on flat surfaces (43). In our study, patients had slower walking speeds than the reference data in all of these studies. For example, the average walking speed of our study patients aged 20 to 29 years was closest to that in the 60- to 79-year-old reference groups for both men and women. The study sample, with an average age of 58 years, had an average walking speed of 0.9 $m \cdot s^{-1}$, which was slightly slower than the average walking speed in the reference healthy individuals who were aged over 80 years. It is possible that the much slower walking speeds in the study participants were due to the more sustained effort required to walk for a longer distance and duration. A longer walk test has different requirements regarding stamina, physiological mechanisms, physical discomfort, and pacing and perceptual factors. The instructions for the 2 types of walking tests are also different. In the 6MWT, participants are instructed to walk as quickly as possible for them, whereas participants in shorter walking tests are usually asked to walk at their usual pace. It is difficult to assess any potential impact of different instructions, different test conditions, different study designs, and short compared with longer distances. This would form a good question for future investigations in this field.

CONCLUSION

In conclusion, this cohort of surgical patients with severe obesity demonstrated walking speeds slower than those previously reported by others. Several factors were found to be associated with a slow walking speed on a 6MWT. These included age, waist circumference, comorbidities, and disability. Absolute body mass was not significantly associated with walking speed. Walking speed is a potentially useful tool to study preoperative fitness and postoperative outcomes in surgical patients with severe obesity.

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