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Original article

Changes in spatiotemporal gait patterns during flat ground walking and obstacle crossing 1 year after bariatric surgery

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Abstract

Background: Obesity has a negative impact on motor function, leading to an increase in fall risk. Massive weight loss improves some aspects of gait on flat ground. However, we have little information about whether gait changes during flat-ground walking and during more complex motor tasks beyond flat-ground walking.

Objectives: Our objectives were to examine how massive weight loss after Roux-en-Y bariatric surgery affects gait during flat-ground walking and obstacle crossing 1 year postsurgery.

Setting: United States.

Methods: Nineteen women walked under 5 conditions: initial baseline walking on flat ground, crossing 3 obstacle heights, and final baseline walking on flat ground, for a total of 25 trials. Spatiotemporal gait parameters were collected simultaneously using a gait carpet and body-worn sensors.

Results: Gait improved postsurgery, with the strongest effect observed for double-limb support time during flat-ground walking ($P < .001$) and obstacle crossing ($P < .001$). The reduction in body mass index was correlated with improved swing ($P < .01$) and double-limb support time ($P < .01$) during flat-ground walking and improved swing during obstacle crossing on low ($P < .01$), medium ($P < .01$), and high ($P < .01$) obstacles. Improved gait postsurgery was more pronounced on high obstacles for velocity ($P < .001$) and double-limb support time ($P < .001$).

Conclusions: Massive weight loss results in improved spatiotemporal gait patterns during flat-ground walking. Examining how massive weight loss affects spatiotemporal gait may help create ways to encourage a more active lifestyle for adults with obesity. (Surg Obes Relat Dis 2016;▮:00–00.)

Keywords: Obesity; Gait; Bariatric surgery; Walking; Obstacles

Obesity, defined as elevated body mass index (BMI), affects over 30% of U.S. adults [1] and is classified as a disease [2]. Obesity has a negative impact on motor function; adults with obese BMI (BMI ≥ 30 kg/m^2) walk with slower velocities, shorter step lengths, and more time in double-limb support compared with adults with normal BMI [3–5]. Presumably, they walk more slowly, take

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shorter steps, and have longer foot contact to increase stability. These modifications could affect recovery from loss of balance to prevent falls (e.g., impaired postural control during quiet stance) [6]; fall risks are 50% higher for adults with obesity over 65 years of age [7].

Bariatric surgery is a direct method for inducing massive weight loss. After Roux-en-Y bariatric surgery, adult body mass decreases by nearly 35%, with most weight loss occurring by 1 year postsurgery [8]. In studies showing improved gait during flat-ground walking at 3 months [9], 8.8 months [10], 12 months [11–13], and up to 5 years [14] after surgery, patients showed decreased step width (i.e., lateral distance between the feet) [9,10] as well as increased velocity, step length, and single-limb support time [9].

Despite the potential for massive weight loss to improve gait parameters related to fall risks, we know little about gait changes after bariatric surgery. Although valuable information exists about some changes in gait after bariatric surgery, gait has mainly been examined during flat-ground walking. Atypical gait linked with obesity is more pronounced when meeting an external constraint [15], such as obstacle crossing [16]. Thus, it is unknown if improvements on flat ground transfer to tasks beyond flat ground. Our aims were to determine spatiotemporal gait differences before and 1 year after bariatric surgery in 3 parameters: during flat-ground walking, during obstacle crossing, and between a reduction in BMI and gait postsurgery. We hypothesized that massive weight loss would lead to improved gait during flat-ground walking and obstacle crossing.

Materials and Methods

Participants

Nineteen women (mean age = 44.16, SD = 8.2) with obese BMI were recruited at XXXXX Medical Center from the Nutrition and Weight Management and Bariatric Surgery Clinics (demographic and anthropometric information shown in Table 1).

Patients between 30 and 60 years of age who were eligible to undergo Roux-en-Y bariatric surgery were included. All participants walked independently without assistive devices. Participants were excluded if they had or were scheduled to undergo knee surgery, were receiving dialysis, or being treated for cancer. The study was approved by the XXXXX institutional review board and conformed to the Declaration of Helsinki. Informed written and verbal consent were obtained before testing began.

Table 1
Demographic and anthropometric information for participants

	Presurgery	Postsurgery
Weight (kg)	114.5 (14.7)	81.3 (16.5)
Height (cm)	164.7 (6.8)	
BMI (kg/m^2)	42.3 (4.2)	29.96 (5.1)
% Excess BMI Lost		74.65 (25.1)

BMI = body mass index.
Means are provided with standard deviations in parentheses.

Gait measurements and obstacles

Data were collected simultaneously using a GAITRite Walkway system (CIR Systems Inc., Sparta, New Jersey) and LEGSys wearable sensor technology (Biosensics, Cambridge, Massachusetts) [17,18]. The GAITRite mat was a 4.88 × .61-m pressure-sensitive mat with a temporal resolution of 120 Hz and a spatial resolution of 1.27 cm. LEGSys includes 5 wearable sensors containing triaxial gyroscopes, accelerometers, and magnetometers [17,18]. Dependent variables selected included velocity (cm/s) and percent of gait cycle spent in swing and double-limb support.

For the obstacle task, participants stepped over obstacles of various heights. Obstacles were created using a wooden dowel (121 cm long) and 2 rectangular towers (9 cm × 10 cm × 22 cm) with holes drilled at 4, 8, and 16 cm (low, medium, and high). Towers were placed halfway down the walking path (8 m) on either side of the GAITRite with dowels fitted into corresponding holes in each tower (Fig. 1).

Procedure

After consenting, participants' height and weight were measured using a stadiometer and scale, respectively. They were then fitted with 5 LEGSys sensors attached with stretchable Velcro straps to anterior aspects of both thighs above the knees, anterior portions of both shins above the ankles, and posteriorly on the small of the back.

Participants walked at a self-selected pace for 25 trials down a 16-m walking path with the GAITRite in the center. The 25 trials included 5 conditions for 5 trials each: initial baseline, crossing obstacles of 3 heights, and final baseline. Initial and final baselines involved walking on flat ground without obstacles. For obstacle conditions, low, medium, and high obstacles were placed halfway down the path. Obstacle height order was randomized using a random number generator and counterbalanced between patients.

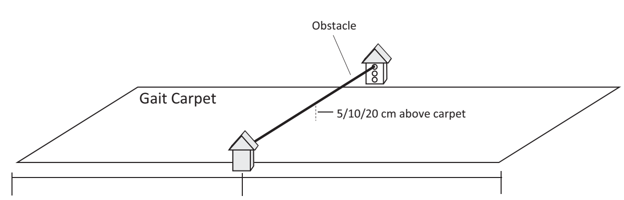

Fig. 1. Obstacle crossing experimental setup. Participants began obstacle trials at the far end of the carpet facing the wooden dowel. They crossed 3 obstacle heights created by fitting the dowel into corresponding holes in each tower.