

Obesity Impairs Physical Function with Minimal Impact on Ankle Mechanics in End-Stage Arthritis

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INTRODUCTION: More than 50,000 people are diagnosed with ankle arthritis (AA) annually.¹ Patients with AA typically experience increased pain, decreased mobility, and a lower quality of life.² Total ankle arthroplasty (TAA) and ankle arthrodesis are the surgical options to treat painful end-stage AA. Historically, obesity (body mass index > 30 kg/m²) has been considered a contraindication for TAA, with obesity being associated with increased complication rates.⁴ With advancements in implant design and considering comorbidities, surgeons are performing TAA in obese patients.⁵ As obesity is predicted to rise, with over 48.9% of adults expected to be classified as obese by 2030, it is important to understand the impact of obesity on gait in patients with AA. No prior studies have examined differences in physical function and lower limb mechanics between obese, overweight, and normal weight patients with AA. We hypothesize that there would be a significant difference between the obesity groups (normal, overweight, and obese) with obese patients demonstrating worse physical function, decreased gait speed, and decreased kinematics and kinetics when compared to normal weight patients.

METHODS: This is a secondary analysis of prospectively collected data. A prospective database was developed in the initial Institutionally Review Board approved study. Patients planning to undergo a TAA for the treatment of end-stage AA were enrolled within two weeks of the TAA procedure. Enrollment criteria for the current study included all patients with unilateral AA, no prior joint replacement in any lower extremity joint, and were able to walk unassisted at the initial visit from the database. A total of 425 (213 Female, 212 Male) patients with end-stage AA were identified with an average age of 61.95±9.85 years, height of 1.71±0.10 m, weight of 85.79±17.71 kg, walking speed of 0.892±0.269 m/s and BMI of 29.17±5.39. The World Health Organization (WHO) categorizes adults into BMI groups: normal (<25 kg/m²), overweight (25-30 kg/m²), obese (>30 kg/m²).⁶ These thresholds were used to define the three groups for this study (Table 1). Each participant completed at least two trials of a 30 second sit-to-stand (STS), and the Timed Up and Go (TUG). Then participants completed up to seven walking trials across a 10-meter walkway at a self-selected comfortable speed. Lower extremity kinematics and kinetics were collected using marker-based motion capture techniques (60Hz) (Motion Analysis Corporation, Santa Rosa, CA, USA) and embedded force plates (1200 Hz) (AMTI, Watertown, MA, USA). Data was processed in Visual 3D (HAS Motion, Kingston, Ontario, CA) and variables of interest were obtained using custom MATLAB codes (MathWorks, Natick, MA, USA). Outcome measures included the weight acceptance and push-off peak vertical ground reaction force (vGRF), sagittal plane ankle range of motion (A-ROM), peak ankle dorsiflexion (A-DF), peak ankle plantarflexion (A-PF) and peak A-PF moment. The vGRF data was normalized to body mass, while the A-PF moment was normalized to body mass and standing height. Group demographics, TUG and STS were compared using a 1x3 ANOVA and other variables were compared using a linear mixed effects model with participant as the random effect and gait speed and group (normal weight, overweight, obese) as the fixed effects ($p<0.05$) using JMP Pro 15 (SAS Institute, Inc, Cary, NC, USA). Post-hoc pairwise comparisons were conducted using Tukey's Honestly Significant Difference (HSD).

RESULTS SECTION: Height ($p=0.010$), BMI ($p<0.001$), average walking speed ($p=0.002$), TUG ($p=0.006$), and STS ($p=0.003$) were different between groups ($p=0.010$). From post-hoc comparisons, the obese group was shorter than the overweight group ($p=0.013$) and BMI was different between all pairwise comparisons ($p<0.001$). Average walking speed was lower in the obese group compared to the normal-weight group ($p=0.002$). Additionally, the normal-weight group had faster TUG times compared to the overweight ($p=0.049$) and obese ($p=0.005$) groups, as well as faster STS times compared to the overweight ($p=0.037$) and obese ($p=0.002$) groups. Gait speed was a significant factor for all gait outcome measures ($p<0.028$) except peak push-off vGRF ($p=0.060$) and ankle dorsiflexion ($p=0.383$) (Table 2). Group differences were not found for any gait outcome measure ($p>0.123$), except for peak A-PF moment ($p=0.042$) with the obese group having lower peak A-PF moment compared to the overweight group ($p=0.044$).

DISCUSSION: The results of this study demonstrate that physical function in patients with AA was different based on the obesity group as shown in Table 1. Contrary to our hypothesis there were limited differences (Table 2) in gait kinematics and kinetics across the obesity groups when accounting for the difference in gait speed. The difference in the A-PF moment that was reported could impact walking efficiency and energetics and should be explored in future studies. Exploring differences in functional and locomotor outcomes following TAA could provide additional insights on recovery in these subgroups.

SIGNIFICANCE/CLINICAL RELEVANCE: Physical proportions must be considered when determining surgical eligibility given their association with surgical complications.⁵ The results of this study demonstrate that physical function is impacted by body size with limited impact on gait mechanics. Future work exploring post-TAA changes could explore the impact of pre-operative physical proportion on post-operative recovery of gait and physical function.

REFERENCES: 1) Brown TD, et al. J Ortho Trauma. 20(10):739-44, 2006; 2) Saltzman, et al. JBJS. 88, 2366-2372, 2006; 3) Zamora-Kapoor et al. Public Health. 174:85-96, 2019.; 4) Werner BC, et al. Foot Ankle Int. 36, 863-70, 2015; 5) van der Plaats and Haverkamp. Ortho Res Rev; 9:63-73, 2017.; 6) WHO website, Viewed 8/8/2025.

IMAGES AND TABLES:

Table 1. Demographics and Clinical Measures (mean ± standard deviation)

	Age (yrs)	BMI (kg/m ²)	Height (m)	Walking Speed (m/s)	TUG (s)	STS (s)
Normal-Weight	62.48 ± 12.23	22.84 ± 1.80 ^{#%}	1.703 ± 0.092	0.965 ± 0.296 [%]	8.54 ± 2.84 ^{#%}	14.31 ± 4.96 ^{#%}
Overweight	62.40 ± 9.47	27.46 ± 1.47 ^{**}	1.733 ± 0.105 [%]	0.895 ± 0.268	9.56 ± 3.65 [*]	16.83 ± 6.42 [*]
Obese	61.19 ± 8.63	34.54 ± 4.01 ^{**#}	1.701 ± 0.107 [#]	0.846 ± 0.245 [*]	9.92 ± 3.28 [*]	16.16 ± 5.62 [*]

* Significantly different from Normal-Weight ($p<0.05$), # Significantly different from Overweight ($p<0.05$), % Significantly different from Obese ($p<0.05$)

Table 2. Gait Outcome Measures (LS mean ± standard error)

	Weight Acceptance vGRF (N/BW)	Push-Off vGRF (N/BW)	A-ROM (deg)	A-DF (deg)	A-PF (deg)	A-PF Moment (Nm/(BW*Height))
Normal-Weight	1.017 ± 0.008	0.989 ± 0.008	10.90 ± 0.56	7.09 ± 0.51	3.85 ± 0.47	1.105 ± 0.029
Overweight	1.013 ± 0.006	0.983 ± 0.006	10.87 ± 0.42	6.89 ± 0.38	3.98 ± 0.35	1.116 ± 0.022 [%]
Obese	1.005 ± 0.006	0.970 ± 0.006	11.05 ± 0.43	7.43 ± 0.39	3.59 ± 0.36	1.041 ± 0.022 [#]

* Significantly different from Normal-Weight ($p<0.05$), # Significantly different from Overweight ($p<0.05$), % Significantly different from Obese ($p<0.05$)