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Lower-limb amputation and body weight changes in men

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Abstract—Little is known about the relationship between lower-limb amputation (LLA) and subsequent changes in body weight. We conducted a retrospective cohort study using clinical and administrative databases to identify and follow weight changes in 759 males with amputation (partial foot amputation [PFA], *n* = 396; transtibial amputation [TTA], *n* = 267; and transfemoral amputation [TFA], *n* = 96) and 3,790 men without amputation frequency-matched (5:1) on age, body mass index, diabetes, and calendar year from eight Department of Veterans Affairs medical care facilities in the Pacific Northwest. We estimated and compared longitudinal percent weight change from baseline up to 39 mo of follow-up in men with and without amputation. Weight gain in the 2 yr after amputation was significantly more in men with an amputation than without, and in men with a TTA or TFA (8%–9% increase) than in men with a PFA (3%–6% increase). Generally, percent weight gain peaked at 2 yr and was followed by some weight loss in the third year. These findings indicate that LLA is often followed by clinically important weight gain. Future studies are needed to better understand the reasons for weight gain and to identify intervention strategies to prevent excess weight gain and the deleterious consequences that may ensue.

Key words: adult, lower-limb amputation, men, obesity, partial foot amputation, toe amputation, transfemoral amputation, transtibial amputation, Veterans, weight change.

INTRODUCTION

An estimated 185,000 amputations are performed each year in the United States [1–3]. Excess body weight is a major concern for people with a lower-limb amputation (LLA) because it can have numerous deleterious consequences, including an increased risk of musculoskeletal pain, osteoarthritis, cardiovascular disease, falls and other injuries, impaired functional capacity, reduced prosthesis fit and function, and a diminished quality of life [4–8]. These consequences can in turn result in reduced activity levels and a cascade of events such as increased wheelchair use, a more sedentary lifestyle, greater healthcare utilization and costs, reduced ability to

Abbreviations: BMI = body mass index, DCG = diagnostic cost group, ICD-9 = International Classification of Diseases–9th edition, LLA = lower-limb amputation, PFA = partial foot amputation, SCD = service-connected disability, TFA = transfemoral amputation, TTA = transtibial amputation, VA = Department of Veterans Affairs, VISN = Veterans Integrated Service Network.

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live independently, and increased burden on formal and informal caregivers [7–8].

A few older cross-sectional studies found that obesity was approximately two times more prevalent in persons with an LLA than in those without [9–10]. To our knowledge, only one longitudinal study has assessed weight change following LLA. This study included 87 individuals who underwent a dysvascular LLA [11]. Compared with 6 wk after amputation, body mass index (BMI) had increased by 1.4 kg/m^2 on average 12 mo postamputation, or about 4.5 kg (10 lb) for a person with a starting weight of 100 kg (220 lb) and height of 1.8 m (5 ft 10 in.), providing support for the hypothesis that amputation leads to excess weight gain. Nevertheless, this study was small, did not include a comparison group of persons without amputation, and examined outcomes only in the first year after an amputation.

To better understand how an incident LLA may affect weight, observational studies are needed to describe typical weight trajectories to better understand the scope of the problem and ultimately to develop interventions to prevent unhealthy weight gain and improve health outcomes in this population. To this end, we conducted a retrospective cohort study with two primary aims: (1) to evaluate the relationship between incident amputation and body weight change in the 3 yr after an LLA relative to a demographically similar population without an amputation and (2) to examine the extent to which weight change varied by level of amputation (i.e., no amputation vs partial foot amputation [PFA], transtibial amputation [TTA], and transfemoral amputation [TFA]) and BMI prior to surgery. We hypothesized that weight gain would be greater among those with amputation than without, and among those with an amputation, those whose mobility was more impaired, operationalized as those with a more proximal amputation. We were uncertain of how preamputation BMI might affect weight gain.

METHODS

Population

Data were obtained from the Department of Veterans Affairs (VA) Northwest Region database (Veterans Integrated Service Network [VISN] 20), which includes demographic characteristics and clinical and administrative medical record information on outpatient and inpatient encounter, vital sign, pharmacy, and laboratory data. VISN 20 is one of 21 VA networks and comprises eight medical centers (VA Puget Sound, Washington; Portland, Oregon; Spokane, Washington; Boise, Idaho; Walla Walla, Washington; Roseburg, Oregon; Anchorage, Alaska; and White Center, Oregon) and their community-based outpatient clinics.

Cohort of Individuals with Incident Amputation

We considered for inclusion male VISN 20 patients who had an incident toe, foot, or leg amputation (International Classification of Diseases–9th edition [ICD-9] surgical codes: 84.10–84.17) between January 1, 1997, and December 31, 2008, and a plausible baseline weight (“baseline” and “plausible” defined subsequently) and one or more follow-up weight(s) occurring between 2 wk and 39 mo (3.25 yr) after their baseline weight. We selected approximately 3 yr of follow-up to balance the desire for longer-term follow-up with the reality that for a relatively large fraction of patients, weights were not available 3 or more years after their amputation (e.g., due to death or lack of weight measures in the electronic medical record). **Figure 1** presents exclusion criteria and numbers excluded for each reason. Briefly, we excluded women because they represented so few of all persons with an amputation. In order to limit our sample to a healthier population for whom a weight management intervention might be indicated, we excluded men who died or had a subsequent amputation within 18 mo of their index amputation. However, we included individuals who had two or more amputations within the initial 45 d postsurgical period who otherwise met the eligibility criteria noted previously. Their index amputation date was the date of their last amputation. Persons with amputation who had a subsequent major amputation 18 to 39 mo after their index amputation were censored at that time and no subsequent weights were included. Amputation etiology was inferred via diagnoses present at the time of the amputation. We created three mutually exclusive amputation groups based on the most proximal level of amputation: (1) PFA (ICD-9 84.11–84.12), (2) TTA (ICD-9 84.13–84.16), and (3) TFA (ICD-9 84.17).

Cohort of Individuals Without Amputation

To determine what the typical weight trajectory might have been in the absence of an amputation, we constructed a comparison group of men without lower-limb loss (either prior to baseline or during follow-up)

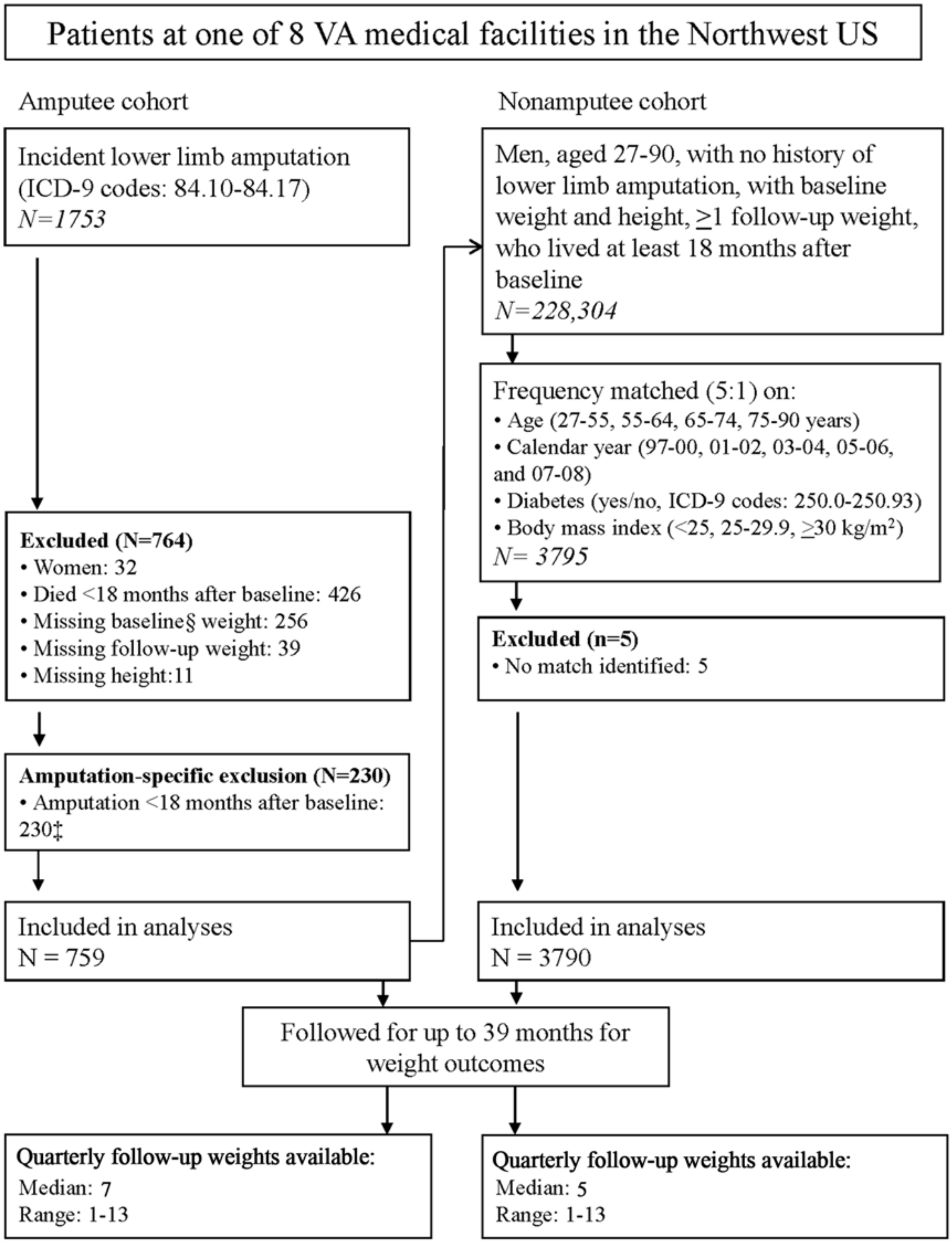

Figure 1.
Flow diagram of exclusions and study design of persons with amputation and frequency-matched nondisabled cohort. [§]For persons with amputation, baseline defined as median of weights measured 2–8 wk after index amputation, or if not available, median of weights measured in 8 wk prior to amputation after subtracting predicted/estimated weight of limb loss (see **Appendix**, available online only). [‡]Disqualifying amputations were those that occurred at level higher than toe <18 mo after baseline (n = 53). ICD-9 = International Classification of Diseases–9th edition, VA = Department of Veterans Affairs.

who were frequency matched (5:1) to persons with amputation based on (1) diabetes, (2) BMI (further explained subsequently), (3) age (in categories reflecting the age range of the persons with amputation), and (4) calendar year (see **Figure 1** for more details). For matching purposes, BMI in persons with limb loss was based on their preamputation weight (**Appendix**, available online only). The reference date for persons without amputation was the first date that they had the matching factors and a weight record available. Persons without amputation who died <18 mo after their reference date or who did not have any weight measures 2 wk to 39 mo after baseline were not eligible for inclusion.

Weight, Height, and Body Mass Index

We used weights and heights obtained during inpatient and outpatient clinical encounters.

Since we were not interested in assessing weight changes because of limb loss, in persons with an amputation baseline weight was the median of weights obtained 2 to 8 wk after their index amputation. We selected this time period because weights often fluctuate in the first 2 wk after an amputation due to changes in fluid balance. We divided follow-up time into 3 mo intervals and calculated the median recorded weight for each individual during each time interval for a maximum of 13 possible weight measurements per person during 39 mo of follow-up, or until the last day when data were available at the time this study was conducted (August 31, 2010), whichever was later, permitting a minimum of 20 mo of follow-up for all study participants.

To address the potential problem of measurement and/or data entry errors, we used a multistep process to clean and select apparently valid weights and heights (**Appendix**). Among individuals with multiple height measures over time, the modal height was used to calculate BMI.

Percent weight change, calculated as the difference between weight at time *x* and weight at baseline, divided by baseline weight × 100, was the primary outcome of interest.

Other Covariates

Demographic information (e.g., age, marital status, and race) was obtained from the VISN 20 Data Warehouse. We recorded the service-connected disability (SCD) percentage as a measure of functional impairment as it relates to an individual's military service. SCD percentage is associated with physical and mental health status and has been used as a proxy for socioeconomic status and disease severity [12]. Veterans with an SCD of 50 percent or higher qualify for healthcare and prescriptions without copayment. Comorbidity was assessed via diagnostic cost group (DCG) score. DCG is computed as a ratio of the person's cost to the average cost in the entire Medicare population [13–14]. The DCG of the Medicare population average is calibrated to be 1; a DCG > 1 indicates greater costs than the average Medicare patient. The VA national average DCG is 0.7 based on fiscal year 2006 claims.*

Statistical Methods

Descriptive analyses include the presentation, by level of amputation, of percentages (for categorical variables) and medians and interquartile ranges (for continuous variables) for demographic, amputation-related and health-related characteristics. The distributions of 1, 2, and 3 yr percent weight changes (relative to baseline) were summarized using the following categories: >5 percent weight loss, 5 percent weight loss to < 5 percent weight gain ("stable weight"), 5 to <10 percent weight gain, and ≥10 percent weight gain. To explore the shape of trajectories of percent weight change over time, we used nonparametric smoothing plots, overall and for different covariate subgroups. The "lowess" smoother uses locally weighted regression to fit a smooth curve representing average percent weight change as a function of time [15]. In parametric linear regression modeling of (continuous) percent weight change from baseline, we included time in months after the index amputation and time squared (to allow for nonlinear trends) as continuous variables. Because percent weight change was, by definition, zero for all subjects at baseline (time = 0), we fitted models without an intercept term. The effect of amputation status and matching variables (see **Figure 1**) was modeled by interactions with time. In addition, we included a three-way interaction of amputation level with BMI and time to allow for the possibility that the association between BMI and percent weight change varied by amputation level. Repeated measurements within person were accommodated using generalized estimating equations.

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We conducted a number of sensitivity analyses to evaluate the robustness of our findings. Since it was also reasonable to consider absolute (rather than percent) weight change as the outcome measure, we examined regression models with weight as the outcome measure. Because comorbidities and overall health status may differ between those with and without an amputation and may be associated with weight change, we conducted further analyses adjusting for disease burden as measured by DCG (in categories). We also conducted analyses limited to those who lived at least 39 mo after baseline. Finally, because of the imbalance in numbers of weights, we created a dichotomous variable (≥3 follow-up weight measures including ≥1 follow-up weight measure(s) from year 2 or 3 [more complete follow-up] vs not [less complete follow-up]) and analyzed results in those with more complete follow-up. Results from all sensitivity analyses were qualitatively similar to our main model results; consequently, we focus our presentation on our primary analyses. Statistical analyses were conducted using Stata 13.1 (StataCorp LP; College Station, Texas), and statistical significance was based on a $p < 0.05$.

RESULTS

A total of 759 men with incident amputations met the inclusion criteria (**Figure 1**). To form the comparison group of men without an amputation, we matched 5:1 on the factors described in the "Methods" section; we were unable to find a match for one person, leaving a total of 3,790 men.

As expected based on our matching, the distribution of ages, BMI, reference years, and presence of a diabetes diagnosis was similar between persons with and without an amputation: 65 percent of individuals were between the ages of 55 and 74 yr, 73 percent had diabetes, and 40 percent were obese (**Table 1**). Compared with men without an amputation, a greater proportion of individuals with an amputation had a ≥50 percent SCD rating, had DCG > 1, and died or were censored during follow-up. Median number of follow-up measures was greater in persons with amputation than persons without amputation (7 vs 5), and among persons with amputation, was greater among those with a PFA than a TFA (medians of 8 and 5, respectively). However, the median number of measures was stable over time in persons without amputation (median of 2 measures each year), while it decreased over time in persons with amputation (median of 4 in year 1, 2 in year 2, and 1 in year 3; data not presented), such that 35.7 percent of men with amputation (vs 19.9% of men without amputation) did not have a measure in year 3. When considering a composite measure of number of measures and duration of record, a similar proportion of those with and without an amputation (66% and 68%, respectively) had more complete follow-up, as defined in the "Methods" section (chi-square $p = 0.26$).

The most frequent diagnoses present at the time of amputation were diabetes (72.1%), peripheral vascular disease (64.2%), and local significant infection (60.2%). Only 12.9 percent had a diagnosis code indicating trauma, and 0.6 percent had a code indicative of a lower-limb cancer. Diabetes was less common and peripheral vascular disease diagnosis was more common in men with a TFA (55.2% and 74.0%, respectively) than men with a more distal amputation (data not presented).

In unadjusted analyses, mean percent weight change and the proportion of men gaining ≥10 percent of their baseline weight approximately 1, 2, and 3 yr after baseline was greater in men with amputation versus without, and among men with an amputation, it was greater in those with a TTA and TFA than a PFA (**Tables 2** and **3**). Over 45 percent of men who had a TTA or a TFA gained ≥10 percent of their body weight by the end of the second year of follow-up, compared with 9.2 percent of men without amputation and 22.7 percent of men with a PFA (**Table 3**). By the end of the third year of follow-up, the percentage of individuals who gained ≥10 percent of body weight was similar to those at the end of the second year, but there was a slight increase in the proportion of individuals who lost ≥5 percent of their body weight since baseline (18.5% among men without amputation and 19.7%, 13.0%, and 22.5% among men with a PFA, TTA, and TFA, respectively).

As shown in **Figure 2**, in the first 2 yr of follow-up, mean estimated percentage weight gain in men with amputation was considerably greater than in men without amputation. Weight gain peaked in the second year, followed by weight loss from the peak but not a return to baseline weight, except in men without amputation. In men with an amputation, at each time point, mean percent weight change was greater among men with a TTA and TFA than men with a PFA. Percent weight changes in men with a TTA and TFA were not statistically significant different from each other at any time point.

Table 1.
Characteristics of male veterans with and without lower-limb amputation.

Characteristic	Amputation Absent (*N* = 3,790)		Amputation Present (*N* = 759)		Level of Amputation: Partial Foot *N* = 396 (52.2%)		Transtibial *N* = 267 (35.2%)		Transfemoral *N* = 96 (12.6%)	
	n	%	*n*	%	*n*	%	*n*	%	*n*	%
Age (yr)										
<55	705	18.6	141	18.6	77	19.4	52	19.5	12	12.5
55–64	1,470	38.8	294	38.7	152	38.4	110	41.2	32	33.3
65–74	995	26.3	200	26.4	106	26.8	63	23.6	31	32.3
75–89	620	16.4	124	16.3	61	15.4	42	15.7	21	21.9
Reference Years										
1997–2000	555	14.6	111	14.6	35	8.8	60	22.5	16	16.7
2001–2002	670	17.7	134	17.7	69	17.4	48	18.0	17	17.7
2003–2004	775	20.4	156	20.6	91	23.0	48	18.0	17	17.7
2005–2006	880	23.2	176	23.2	94	23.7	55	20.6	27	28.1
2007–2008	910	24.0	182	24.0	107	27.0	56	21.0	19	19.8
Percent Service Connected*										
<50	2,826	74.6	488	64.3	263	66.4	166	62.2	59	61.5
≥50	964	25.4	271	35.7	133	33.6	101	37.8	37	38.5
Diabetes Diagnosis										
No	1,010	26.6	203	26.8	86	21.7	74	27.7	43	44.8
Yes	2,780	73.4	556	73.3	310	78.3	193	72.3	53	55.2
Diagnostic Cost Group Score†										
<1	3,093	82.0	9	1.2	6	1.5	2	0.7	1	1.0
1–1.9	563	14.9	104	13.7	69	17.4	26	9.7	9	9.4
2–2.9	84	2.2	260	34.3	146	36.9	87	32.6	27	28.1
≥3	34	0.9	386	50.9	175	44.2	152	56.9	59	61.5
Time until Censoring or Death‡										
Censored 18–30 mo post baseline	456	12.0	171	22.5	89	22.5	54	20.2	28	29.2
Censored 30–39 mo post baseline	409	10.8	119	15.7	64	16.2	38	14.2	17	17.7
Amputation-free survival ≥39 mo	2,925	77.2	469	61.8	243	61.4	175	65.5	51	53.1
Body Mass Index (kg/m^2)§										
<25	935	24.7	187	24.6	93	23.5	60	22.5	34	35.4
25.0–29.9	1,325	35.0	265	34.9	139	35.1	91	34.1	35	36.5
≥30	1,530	40.4	307	40.4	164	41.4	116	43.4	27	28.1
No Follow-Up Weight Measures Available In Given Time Interval										
Year 1	290	7.7	30	4.0	11	2.8	11	4.1	8	8.3
Year 2	607	16.0	116	15.3	50	12.6	43	16.1	23	24.0
Year 3	754	19.9	271	35.7	131	33.1	93	34.8	47	49.0

Note: Matching variables were age, reference year (in categories shown), diabetes, and preamputation body mass index (in categories shown).
*<50% service connected includes those “not service connected.”
†Diagnostic cost group score represents prospective risk score based on expenditures in reference year. Risk score of Medicare population average is calibrated to be 1.
‡Individuals were censored at time of death, subsequent amputation, or August 31, 2010, whichever came first.
§Body mass index is based on measured weight and height prior to amputation in persons with amputation. When preamputation weight was not available, weight of amputated limb was estimated. See “Methods” section for more information.

Table 4 presents mean percent weight change estimates and 95 percent confidence intervals from the multivariable model at 12, 24, and 36 mo follow-up, stratified by baseline BMI (25, 30, and 35 kg/m^2). For men without amputation and men with a PFA and TTA, mean percent weight change decreased with increasing preamputation BMI (though the differences were not statistically significant for men with a TTA at 3 yr follow-up). For men with a TFA, percent weight change was similar across preamputation BMI levels.

Table 2.
Unadjusted (observed) percentage weight changes from baseline.

Time Window*	No Amputation		Level of Amputation					
			Partial Foot		Transtibial		Transfemoral	
	M	IQR	M	IQR	M	IQR	M	IQR
~1 yr	0.5	–2.6, 4.0	3.0	–2.3, 8.3	7.7	0.2, 15.0	7.7	0.0, 16.0
~2 yr	0.5	–3.2, 4.6	3.2	–2.2, 8.9	8.4	0.1, 16.0	9.8	1.2, 17.0
~3 yr	0.5	–3.6, 4.7	2.2	–2.9, 9.5	9.7	–0.1, 18.0	9.7	0.6, 17.0

Note: See **Table 1** for *N* at each time interval.
*Time windows for ~1, ~2, and~3 yr: 10–18 mo, 22–30 mo, and 31–39 mo, respectively.
IQR = interquartile range, M = median.

Table 3.
Unadjusted (observed) categories of percentage weight changes.

Change from Baseline*	No Amputation		Level of Amputation					
			Partial Foot		Transtibial		Transfemoral	
	n	%	*n*	%	*n*	%	*n*	%
~1 yr								
>5% Weight Loss	405	13.0	51	14.5	27	12.1	11	16.9
Stable Weight	2,105	67.4	163	46.4	64	28.7	16	24.6
5 to <10% Weight Gain	400	12.8	72	20.5	43	19.3	10	15.4
≥10% Weight Gain	215	6.9	65	18.5	89	39.9	28	43.1
~2 yr								
>5% Weight Loss	489	16.9	47	15.7	24	12.4	9	13.8
Stable Weight	1,743	60.3	129	43.1	51	26.3	14	21.5
5 to <10% Weight Gain	392	13.6	55	18.4	30	15.5	11	16.9
≥10% Weight Gain	266	9.2	68	22.7	89	45.9	31	47.7
~3 yr								
>5% Weight Loss	513	18.5	45	19.7	21	13.0	9	22.5
Stable Weight	1,600	57.8	94	41.2	35	21.7	4	10.0-
5 to <10% Weight Gain	369	13.3	36	15.8	25	15.5	8	20.0
≥10% Weight Gain	288	10.4	53	23.2	80	49.7	19	47.5

*Time windows for ~1, ~2, and~3 yr: 10–18 mo, 22–30 mo, and 31–39 mo, respectively.

DISCUSSION

Excess weight gain can have both immediate and long-term adverse consequences in people with LLA. Data from our study indicate that weight gain in the 2 yr after amputation is substantial. Specifically, men with more proximal amputations (e.g., TTA and TFA) gained more weight after amputation, approximately 8 to 9 percent body weight (7–8 kg [16–18 lb], assuming a starting weight of 90 kg [200 lb]) than men with a more distal amputation (approximately 3%–6% or 3–4 kg [6–8 lb]). Furthermore, weight gain in men with a PFA (and all other amputation groups) was significantly more than in a demographically similar population of men without an amputation. Generally, weight gain peaked at around 2 yr, followed by weight loss. However, estimates in the third year were relatively imprecise because of missing data. For men with PFA and TTA (but not men with a TFA), percent weight gain was inversely proportional to baseline BMI.

Although our data were inadequate for understanding the mechanisms behind the weight changes, there are a number of plausible explanations. Weight gain in the first 2 yr after amputation may have occurred because of decreased activity and/or overeating. Other investigators have found the most popular leisure time activities among people with LLA were sedentary (e.g., watching television, going to restaurants, and playing cards) even in individuals who were active before their amputation [16]. The wound healing process may take weeks or

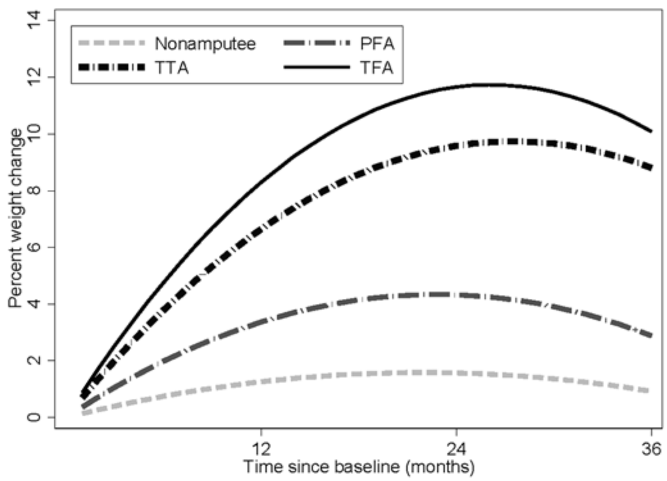

Figure 2.

Estimated mean percent weight change from baseline by amputation group. Predicted percent weight change estimates are based on linear regression model that used generalized estimating equations to account for within-person correlation. Model included parameters for time and time squared and interactions of time and time squared with age (<55, 55–64, 65–74, ≥ 75 yr), diabetes, reference year, amputation level (none, partial foot amputation [PFA], transtibial amputation [TTA], transfemoral amputation [TFA]), body mass index (BMI) (continuous, centered at the mean of 30) and BMI × amputation level. Estimates presented are for reference years 2001–2002, 55–64 yr, with diabetes and BMI = 30.

months, and individuals may be unable or unmotivated to be physically active at this time. Additionally, it may take up to 12 mo to obtain a properly fitting prosthesis, and physical activity tends to decrease during this time [17]. Barriers related to prosthesis fitting are likely more limiting for people with a TTA and TFA than a PFA and may explain the differential weight gain by amputation level. Comorbid depression, which is highly prevalent in this population [18–19], may also contribute to inactivity and overeating. Our prior work suggested that high BMI and weight gain are associated with impaired mobility [11], resulting in lower levels of physical activity. The inverse association between preamputation BMI and relative weight gain may be because those with a lower BMI preamputation may have been more active and decreased their activity more postamputation than those with a higher BMI, though future studies are needed to replicate and better understand this finding. The slowing of weight gain and possible weight loss in the third year may be explained by improvement in depressive symptoms [19] as individuals come to accept their amputation and become more adept and comfortable with ambulating and increase their physical activity. An alternative explanation for the weight loss is illness; though we constructed our study to include a healthier population, mortality is high in this population.

We are aware of only one other study that investigated weight change following amputation [11]. In that study, mean weight gain in 87 people with a dysvascular major amputation was 6 lb over 12 mo, which is somewhat less than that observed in this study and may reflect different inclusion criteria [11]. Nevertheless, the two studies are in agreement regarding the direction of weight change. Our study builds on the prior literature by documenting, in a relatively heterogeneous population that included amputations from multiple etiologies, how percent weight change varies by amputation level and preamputation BMI and provides comparative data in demographically similar men without an amputation. Together, these studies highlight the magnitude of this problem, reinforce the detrimental consequences of excess weight gain, and indicate a need for further research to identify effective weight management interventions.

While use of medical record data allowed assessment of weight change on a relatively large, population-based sample of VA users, it also led to a number of limitations. The weight data were obtained from routine clinical practice and not collected at predefined time intervals using standardized data collection procedures as would be specified in a study protocol. To eliminate weights that might introduce statistical noise and reduce our ability to detect patterns, we carefully cleaned the data before selecting median values. However, when individuals had few weights, it was more difficult to identify and remove plausible but potentially erroneous weights. Additionally, the availability of recorded weights varied in this population; some men had weight data in year 1 only, while others had measurements in all years. While our modeling technique allowed us to take greatest advantage of the data that were available, substantial missing data in the third year of follow-up resulted in less precision in these estimates, and this was particularly evident in men with a TFA. In sensitivity analyses comparing weight changes in those with more versus fewer weight measures, the prevailing trends of overall weight gain were apparent, though less marked. The attenuation of weight gain may

Table 4.
Predicted percent weight changes from baseline at 12, 24, and 36 mo in persons with and without a lower-limb amputation with body mass index (BMI) = 25, 30, and 35 kg/m^2.

BMI (kg/m^2)	Percent Weight Change					
	12 mo		24 mo		36 mo	
	Estimate	95% CI	Estimate	95% CI	Estimate	95% CI
BMI = 25						
No Amputation	+2.2	1.5 to 2.9	+3.0	2.1 to 3.9	+2.4	1.4 to 3.4
Partial Foot Amputation	+4.4	3.2 to 5.6	+6.0	4.4 to 7.6	+4.7	2.7 to 6.6
Transtibial Amputation	+8.1	6.5 to 9.8	+11.4	9.3 to 13.5	+9.8	7.6 to 12.1
Transfemoral Amputation	+9.3	6.4 to 12.2	+11.9	8.4 to 15.4	+7.8	2.8 to 12.8
BMI = 30						
No Amputation	+1.3	0.7 to 1.8	+1.6	0.8 to 2.4	+1.0	0.0 to 1.9
Partial Foot Amputation	+3.4	2.5 to 4.4	+4.4	3.1 to 5.7	+3.0	1.4 to 4.6
Transtibial Amputation	+6.9	5.6 to 8.2	+9.9	8.2 to 11.6	+9.0	7.1 to 11.0
Transfemoral Amputation	+8.7	6.1 to 11.4	+12.2	8.8 to 15.6	+10.2	5.7 to 14.9
BMI = 35						
No Amputation	+0.4	–0.2 to 0.9	+0.2	–0.5 to 0.9	–0.5	–1.5 to 0.5
Partial Foot Amputation	+2.4	1.4 to 3.5	+2.9	1.4 to 4.4	+1.3	–0.5 to 3.2
Transtibial Amputation	+5.7	4.3 to 7.1	+8.4	6.5 to 10.4	+8.2	6.0 to 10.5
Transfemoral Amputation	+8.2	4.7 to 11.7	+12.4	7.6 to 17.3	+12.8	5.6 to 19.9

Note: Predicted percent weight change estimates are based on linear regression model that used generalized estimating equations to account for within-person correlation. Model included parameters for time and time squared, interactions of time and time squared with age (<55, 55–64, 65–74, ≥ 75 yr), diabetes, reference year, amputation level (none, partial foot, transtibial, transfemoral), BMI (continuous, centered at the mean of 30), and BMI × amputation level. Estimates presented are for reference years 2001–2002, 55–64 yr, and with diabetes.
CI = confidence interval.

be because approximately 13 percent of persons with amputation died in the 18 to 39 mo after baseline (see Appendix, **Table 1**), and death is typically preceded by weight loss. Thus, our findings are likely more reflective of the healthier population of people with lower-limb loss. Furthermore, it was not possible to determine whether weight was measured with the individual wearing his prosthesis, how much that prosthesis weighed, and if prosthesis use changed over time. However, the mean weight gain observed at 2 yr in persons with a TTA and TFA was on average more than the potential error introduced by a prosthesis (which weighs approximately 3 and 5 kg, respectively, for a transtibial and transfemoral prosthesis) and cannot explain any of the weight gain observed in men with a PFA. Future longitudinal studies employing standardized assessment of weight, body composition measures, physical activity, and comorbidities could eliminate the errors noted here and would also be helpful in expanding our understanding of the predictors of body weight changes and may help to identify targets for intervention. Finally, though we constructed a comparison cohort of individuals who were very similar to the persons with amputation in terms of age, reference year, BMI, and diabetes, there were large differences in their morbidity, as assessed by DCG scores and the percent that died during follow-up. However, results from sensitivity analyses adjusting for DCG were similar.

CONCLUSIONS

It is well documented that obesity is related to many health conditions to which this sample is susceptible, including additional amputations, heart disease, and stroke [20]. Thus, using the time of amputation to promote improved lifestyle habits and weight loss could result in a range of physical, mental, and social benefits. Our preliminary findings suggest that LLA is often followed by clinically important weight gain, but future studies will need to verify our results using standardized measures of BMI, larger samples, and longer follow-up periods. It would also be informative to measure lifestyle habits such as physical activity, mode of ambulation (e.g., prosthesis, crutches, manual wheelchair, motorized wheelchair), sedentary behaviors, dietary behaviors, and health status changes in order to accurately identify the likely causal factors. Finally, future studies are also needed to determine whether promoting weight loss following amputation is feasible and can result in health and quality of life benefits.

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