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Weight gain and obesity rates in transgender and gender-diverse adults before and during hormone therapy

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BACKGROUND: Obesity rates and weight changes in adults on gender-affirming hormone therapy are lacking or limited by small sample sizes, duration, and location.
SUBJECTS/METHODS: This longitudinal study followed the body mass index and body weights of 470 transgender and gender-diverse adult patients (247 transfeminine and 223 transmasculine; mean age, 27.8 years) seen at a Federally Qualified Health Center and an academic endocrinology practice, both in Washington DC USA. Body weight and body mass index were recorded at baseline and at multiple follow-up clinical visits up to 57 months after the initiation of gender-affirming hormone therapy. The outcomes of this study were the changes to body weight and obesity rates following hormone therapy.
RESULTS: Within 2–4 months of starting gender-affirming hormone therapy, the mean body weight increased in the transmasculine group by 2.35 (1.15–3.55) kg and further increased beyond 34 months. Among the transfeminine group, the mean body weight was stable for the first 21 months of hormone therapy and then began to steadily increase, particularly in those under 30 years old. The prevalence of obesity at baseline was 25% in the transfeminine group and 39% in the transmasculine group. Following the initiation of hormone therapy, rates of obesity ranged from 42 to 52% among the transmasculine group and 21 to 30% among transfeminine group. Following 11–21 months of hormone therapy, weight gain ≥5 kg was seen among 21% of transfeminine individuals and 30% of transmasculine individuals.
CONCLUSIONS: As compared with transfeminine individuals, transmasculine individuals have greater rates of obesity and weight gain before and during hormone therapy. Body weight and body mass index should be routinely monitored before and after the initiation of gender-affirming hormone therapy. Multidisciplinary weight-reduction interventions should be promoted where appropriate.

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INTRODUCTION

Gender-affirming hormone therapy (GAHT) is a foundation of medical therapy for many transgender and gender-diverse individuals. Adult transmasculine individuals are prescribed testosterone and adult transfeminine individuals generally are prescribed a combination of estrogen and an antiandrogen if they have not had an orchiectomy. GAHT is taken for its desired physical and psychological effects. The physical effects include changes to body composition, skin, facial and body hair, breast size and composition, voice, reproductive function, and sexual function [1, 2].

The obesity epidemic is adversely affecting the health of hundreds of millions of people worldwide. Excess body weight reduces average life expectancy and is associated with increased rates of hypertension, diabetes, heart disease, dyslipidemia, certain cancers, arthritis, gallbladder disease, and nonalcoholic steatohepatitis [3]. In the United States, limited data from Medicare beneficiaries and self-report suggest that transgender people may have higher rates of obesity than cisgender people [4, 5].

The effects of GAHT on body weight have primarily been studied in populations in several Western European countries including Belgium, Germany, Italy, the Netherlands, and Spain. These studies have generally reported body weight and/or body mass index (BMI) at baseline and at one follow-up period varying from 3 to 24 months. The largest study to date ($n = 430$) was conducted by the European Network for the Investigation of Gender Incongruence (ENIGI) in Belgium and the Netherlands. This study reported that body mass index (BMI) slightly increased in both trans men and trans women over 1 year and did not vary by routes of hormone administration [6]. Out of the 7 studies in trans men that report pre and post-GAHT body weights, there is a consistent increase in mean body weight of 0.9–3.5 kg over 6, 12, or 24 months [7–13]. Out of the 4 studies in trans women that report pre- and post-body GAHT weights, the European studies found an increase in mean body weight of 1.3–3.9 kg over 12 or 24 months, whereas a small US study [$n = 16$] found no change over 6 months [7–9, 13]. In trans women, treatment with a

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combination of intramuscular (IM) estrogen and a gonadotropin-releasing hormone agonist was associated with an increase in fat mass and a decrease in lean mass over 24 months according to dual-energy X-ray absorptiometry [14]. On average, the fat mass increased from 10.7 kg at baseline to 13.1 kg at 12 months and to 14.3 kg at 24 months. The lean mass decreased from 59.6 kg at baseline to 57.2 kg at 12 months and to 55.4 kg at 24 months.

Given the paucity of studies pertaining to GAHT and body weight, particularly in transwomen, we aimed to conduct the largest and longest observational study to date using multiple body weight measurements among a racially and ethnically diverse population of gender-diverse individuals in the United States. We used the BMI to calculate the proportion of individuals having normal weight, underweight, overweight, obesity, and severe obesity.

METHODS

Study population

A chart review was performed on adult transgender and gender-diverse patients who initiated GAHT while under the care of the senior author at the Medical Faculty Associates (MFA) of The George Washington University or the medical staff at Whitman-Walker Health (WWH), a nonprofit community health center, both in Washington DC. Nonbinary individuals were grouped with transmasculine individuals if they were treated with testosterone and with transfeminine individuals if they were treated with estrogen. Inclusion criteria were age ≥17 years old, a noncisgender gender identity, GAHT initiation at either clinic or follow-up visits for ≥3 months for MFA patients, and ≥2 years for WWH patients. Given the large number of eligible patients at WWH, we selected a similar number of transfeminine and transmasculine patients by initial visit date and limited the data set to patients whose baseline visits fell between 1/1/2007 and 6/1/2015. Exclusion criteria included use of GAHT within the six months prior to the baseline visit or HIV positivity as HIV medications can affect lipid parameters and body composition. The Institutional Review Board of George Washington University deemed the study exempt from informed consent collection and approved this study for analysis of de-identified data. The study had no external funding.

Collected data

The medical history of each subject was reviewed to ensure that they met the inclusion and exclusion criteria. Extracted data included age, gender identity, Latinx ethnicity, race, history of prior GAHT, weight, height, blood pressure, the presence of selected comorbidities (hypertension, diabetes, anxiety, depression, and HIV), the use of selected medications for these diagnoses, and the use of GAHT. Extracted data were independently entered into a spreadsheet by two individuals and discrepancies were adjudicated by the senior author. Data from follow-up visits were grouped into seven time periods (2–4 months, 5–7 months, etc.). If patients had multiple visits within the same time period, data were averaged from the visits. The formulations, doses, and routes of administration of GAHT were recorded for all visits. Serum sex steroid hormone concentrations (estradiol and testosterone) were measured at most follow-up visits.

Body weight readings

Medical assistants collected weight and height measurements at the initial visit and weight only at subsequent visits. There was no standardized protocol for measuring weight and height at the clinical sites. For weight measurements, patients were instructed to remove heavy clothing and encouraged to remove their shoes. The scales used were the Health o meter professional at WWH and the Seca digital column scale at the MFA.

Outcomes

The outcomes of this study were changes to body mass index and body weight and percent change to body weight following the initiation of GAHT and the percentage of patients with normal weight, underweight, overweight, obesity, and severe obesity throughout the study.

Statistical analyses

Baseline characteristics were reported separately by gender as means and standard deviation, or median and interquartile range where appropriate, for continuous variables. Frequency and percentage were reported for categorical variables. Descriptive statistics of treatment regimens and body weight across follow-up visits were also reported separately by gender. Further analysis of the time trends for body weight and percentage change in body weight from baseline was performed using the generalized additive mixed models with gender, months since baseline visit, and their

Table 1. Baseline Characteristics of Study Population.

Characteristic	Overall	Trans Feminine	Trans Masculine
	$N = 470$	$n = 247$	$n = 223$
Number of visits: Median (IQR)	4 (3–6)	4 (3–6)	4 (3 6)
Age (years): Mean (SD)	27.8 (8.9)	29.3 (10.1)	26.1 (7.1)
Category: *N* (%)			
17–29	330 (70.2)	160 (64.8)	170 (76.2)
30–39	89 (18.9)	52 (21.1)	37 (16.6)
≥40	51 (10.9)	35 (14.2)	16 (7.2)
Ethnicity: *N* (%)			
Non-Latinx	356 (75.7)	182 (73.7)	174 (78.0)
Latinx	66 (14.0)	46 (18.6)	20 (9.0)
Missing	48 (10.2)	19 (7.7)	29 (13.0)
Race: *N* (%)			
Black	85 (18.1)	36 (14.6)	49 (22.0)
White	302 (64.3)	164 (66.4)	138 (61.9)
Asian	8 (1.7)	6 (2.4)	2 (0.9)
Other	21 (4.5)	9 (3.6)	12 (5.4)
Missing	54 (11.5)	32 (13.0)	22 (9.9)
Insurance: *N* (%)			
Commercial/private	292 (62.1)	138 (55.9)	154 (69.1)
Medicare	11 (2.3)	3 (1.2)	8 (3.6)
Medicaid/ low income	67 (14.3)	43 (17.4)	24 (10.8)
Self-pay	95 (20.2)	61 (24.7)	34 (15.2)
Missing	5 (1.1)	2 (0.8)	3 (1.3)
Clinic *N* (%)			
Medical Faculty Assoc	56 (11.9)	29 (11.7)	27 (12.1)
Whitman-Walker	414 (88.1)	218 (88.3)	196 (87.9)
Weight (kg): Mean (SD)	80.2 (21.7)	82.0 (21.8)	78.2 (21.5)
Body mass index: N (%)			
<18.5	20 (4.3)	10 (4.0)	10 (4.5)
18.5–24.9	160 (34.0)	94 (38.1)	66 (29.6)
25–30	143 (30.4)	82 (33.2)	61 (27.4)
≥30	147 (31.3)	61 (24.7)	86 (38.6)
Blood Pressure (mm Hg)			
Systolic Mean (SD)	124.2 (12.9)	127.9 (13.3)	120.2 (11.3)
Diastolic Mean (SD)	77.6 (8.3)	78.1 (8.8)	77.1 (7.8)
Comorbidities: *N* (%)			
Hypertension	57 (12.1)	39 (15.8)	18 (8.1)
Diabetes	10 (2.1)	7 (2.8)	3 (1.3)
Depression	87 (18.5)	43 (17.4)	44 (19.7)
Anxiety	65 (13.8)	29 (11.7)	36 (16.1)

Trans transgender, SD standard deviation, kg kilogram, mm Hg millimeters of mercury.

Table 2. Treatment regimens and doses at each visit.

	Duration on hormone therapy (months)						
	2–4	5–7	8–10	11–21	22–33	34–45	46–57
Transfeminine (n)	211	179	160	200	139	78	49
Estradiol formulation							
Oral: *N* (%)	195 (92.4)	164 (91.6)	145 (90.6)	171 (85.5)	112 (80.6)	55 (70.5)	35 (71.4)
mg/day: Mean (SD)	3.4 (1.3)	3.9 (1.3)	4.4 (1.3)	4.9 (1.5)	4.9 (1.6)	5.4 (1.9)	4.8 (1.5)
Intramuscular: *N* (%)	8 (3.8)	10 (5.6)	11 (6.9)	21 (10.5)	17 (12.2)	18 (23.1)	9 (18.4)
mg/week: Mean (SD)	12.5 (4.6)	13.0 (4.8)	14.5 (6.5)	12.7 (5.8)	11.2 (4.7)	11.8 (4.7)	9.4 (1.7)
Other: *N* (%)	8 (3.8)	5 (2.8)	4 (2.5)	8 (4.0)	10 (7.2)	5 (6.4)	5 (10.2)
Spironolactone: *N* (%)	195 (93.3)	162 (92.0)	148 (94.3)	187 (91.2)	122 (87.1)	62 (78.5)	36 (72.0)
mg/day: Mean (SD)	72.8 (36.7)	106.3 (52.1)	121.5 (55.9)	136.7 (60.6)	152.7 (61.1)	161.7 (54.3)	168.1 (52.3)
	Duration on hormone therapy (months)						
	2–4	5–7	8–10	11–21	22–33	34–45	46–57
Transmasculine (*n*)	184	162	142	179	125	75	32
Testosterone formulation							
Intramuscular: *N* (%)	141 (76.6)	139 (85.8)	124 (87.3)	160 (89.4)	114 (91.2)	66 (88.0)	28 (87.5)
mg/2 weeks: Mean (SD)	140.7 (58.9)	151.0 (58.9)	159.9 (47.4)	158.8 (47.2)	156.2 (46.5)	155.0 (40.4)	144.9 (53.2)
Transdermal: *N* (%)	40 (21.7)	22 (13.6)	15 (10.6)	16 (8.9)	9 (7.2)	7 (9.3)	2 (6.2)
mg/day: Mean (SD)	46.0 (35.6)	43.7 (10.3)	57.6 (57.9)	67.9 (59.1)	42.3 (26.9)	66.7 (25.3)	83.5 (23.3)
Other: *N* (%)	3 (1.6)	1 (0.6)	3 (2.1)	3 (1.7)	2 (1.6)	2 (2.7)	2 (6.2)

mg: milligram

interaction terms. Random intercepts for each individual were also included. Nonlinear relationships were fitted using restricted cubic splines on months since baseline visit with five degrees of freedom.

A separate linear mixed effect model with gender, follow-up months since baseline (as categorical month intervals), and their interaction terms was also fitted to allow for comparisons of body weight at follow-up visits to baseline. Post hoc custom contrasts for each follow-up month intervals vs baseline were constructed separately by gender, with Dunnett's *p*-value for multiple-comparison adjustments.

All mixed-effect models were fitted using restricted maximum likelihood, assuming an unstructured covariance matrix, and bootstrapped 95% confidence intervals were reported. Analyses were performed using R version 4.0.2 (R Foundation for Statistical Computing, Vienna, Austria) and R packages lme4, bootpredictlme4, splines, and emmeans [15].

RESULTS

Baseline characteristics

Baseline characteristics are listed in Table 1. Among the sample population of 470 individuals, 247 were transfeminine and 223 were transmasculine. The mean age was 27.8 years, 27% were nonwhite, and 16% were Latinx.

Hormone therapy

The formulations, administration routes, and mean doses of prescribed estrogen and testosterone are shown in Table 2. A history of previous GAHT ≥6 months prior to the baseline visit was reported by 15% of transfeminine individuals and 5% of transmasculine individuals.

For transfeminine patients, 92% were initially started on oral estradiol and the mean dose generally increased over time. The second most common estrogen regimen was intramuscular with rates steadily increasing over time. Other formulations of estrogen included transdermal, sublingual, and conjugated. Spironolactone usage was >90% over the first 2 years of the study. After 1–2 years of hormone therapy, spironolactone usage declined as some individuals underwent orchiectomy or had an adverse effect to the medication. We found chart documentation of 10 orchiectomies but this number is likely an underestimate. The mean estradiol levels were 24 pg/mL at baseline and ranged from 131 to 240 pg/mL on GAHT. The mean total testosterone levels were 411 ng/dL at baseline and ranged from 107 to 186 ng/dL on GAHT.

For transmasculine patients, 77–91% were on intramuscular testosterone esters (cypionate or enanthate) with the remainder on transdermal or other (subcutaneous, pellets) formulations. The mean estradiol levels were 74 pg/mL at baseline and ranged from 40 to 63 pg/mL on GAHT. The mean total testosterone levels were 71 ng/dL at baseline and ranged from 477 to 646 ng/dL on GAHT.

Body mass index and body weight

Mean body mass index and body weight readings at the various follow-up visits are listed in Tables 3 and 4. The percentages of patients with normal weight, underweight, overweight, obesity, and severe obesity are also shown in Tables 3 and 4. Figure 1 shows the percentage change in body weight compared with baseline and mean body mass index over time. For transfeminine patients, the mean body weight, percent change in body weight, and BMI were stable for the first 21 months on GAHT. Beyond 22 months, statistically significant weight gain of 2.0–4.9 kg was seen in transfeminine patients between the ages of 17and 29 years but not in those ≥30 years old. The mean BMI and obesity rates were higher in the Latina group as compared with the other two groups. For transmasculine patients, within 2–4 months of starting testosterone, the mean body weight increased by 3–4% with a mean weight gain of 2.4 kg. The prevalence of obesity increased from 39 to 44%. The mean body weight and BMI were then relatively stable and increased again after 34 months of testosterone therapy. Weight gain was more pronounced in transmasculine patients between the ages of 17–29 as compared with those ≥30 years old. The mean BMI and obesity rates were lower in the Latino group as compared with the other two groups. Throughout the study, the prevalence of obesity and severe obesity was much higher for the transmasculine group than the transfeminine group. Over half of the transmasculine patients had obesity beyond 34 months of testosterone therapy. Among the 10

Table 3. Mean body weight and body weight categories for transfeminine participants by race and Latinx ethnicity by visit.

	Follow-up months since baseline							
	Baseline	2–4	5–7	8–10	11–21	22–33	34–45	46–57
All (*n*)	247	212	182	165	209	153	88	53
Body weight (kg): Mean (SD)	82.0 (21.8)	80.9 (22.0)	81.9 (21.5)	80.9 (21.9)	82.4 (22.5)	83.3 (23.9)	83.5 (24.5)	83.7 (19.8)
Body mass index (kg/m^2) Mean (SD)	26.8 (6.6)	26.4 (6.8)	26.7 (6.4)	26.5 (6.6)	27.0 (6.9)	27.5 (7.5)	27.2 (7.2)	27.5 (6.4)
<18.5: *N* (%)	10 (4.0)	11 (5.2)	5 (2.7)	8 (4.8)	5 (2.4)	9 (5.9)	6 (6.8)	1 (1.9)
18.5–24.9: *N* (%)	94 (38.1)	87 (41.0)	69 (37.9)	66 (40.0)	75 (35.9)	52 (34.0)	28 (31.8)	18 (34.0)
25–30: *N* (%)	82 (33.2)	69 (32.5)	70 (38.5)	57 (34.5)	80 (38.3)	48 (31.4)	28 (31.8)	19 (35.8)
≥30: *N* (%)	61 (24.7)	45 (21.2)	38 (20.9)	34 (20.6)	49 (23.4)	44 (28.8)	26 (29.5)	15 (28.3)
≥40: *N* (%)	13 (5.3)	10 (4.7)	8 (4.4)	11 (6.7)	10 (4.8)	9 (5.9)	5 (5.7)	2 (3.8)
White (*n*)	164	146	124	110	136	97	56	29
Body weight (kg): Mean (SD)	82.5 (20.7)	81.4 (20.9)	82.5 (20.2)	80.1 (19.6)	82.5 (20.7)	83.3 (22.8)	83.4 (22.3)	83.9 (15.8)
Body mass index (kg/m^2) Mean (SD)	26.8 (6.1)	26.4 (6.1)	26.7 (5.9)	26.2 (5.9)	26.8 (5.9)	27.2 (6.5)	27.0 (6.0)	27.5 (5.4)
<18.5: *N* (%)	6 (3.7)	7 (4.8)	2 (1.6)	5 (4.5)	3 (2.2)	5 (5.2)	3 (5.4)	1 (3.4)
18.5–24.9: *N* (%)	59 (36.0)	56 (38.4)	47 (37.9)	44 (40.0)	48 (35.3)	34 (35.1)	16 (28.6)	7 (24.1)
25–30: *N* (%)	58 (35.4)	53 (36.3)	47 (37.9)	38 (34.5)	53 (39.0)	31 (32.0)	22 (39.3)	14 (48.3)
≥30: *N* (%)	41 (25.0)	30 (20.5)	28 (22.6)	23 (20.9)	32 (23.5)	27 (27.8)	15 (26.8)	7 (24.1)
≥40: *N* (%)	7 (4.3)	6 (4.1)	4 (3.2)	5 (4.5)	5 (3.7)	5 (5.2)	3 (5.4)	1 (3.4)
Black (*n*)	36	28	27	23	33	25	20	16
Body weight (kg): Mean (SD)	82.3 (28.6)	77.1 (27.5)	82.5 (28.9)	79.9 (29.8)	82.3 (28.7)	79.6 (24.1)	84.8 (34.0)	83.5 (26.4)
Body mass index (kg/m^2) Mean (SD)	26.6 (8.5)	25.1 (8.6)	26.7 (8.7)	25.5 (8.1)	26.6 (8.8)	26.1 (8.3)	27.4 (10.2)	26.9 (8.0)
<18.5: *N* (%)	2 (5.6)	2 (7.1)	2 (7.4)	2 (8.7)	1 (3.0)	1 (4.0)	1 (5.0)	0 (0.0)
18.5–24.9: *N* (%)	17 (47.2)	18 (64.3)	10 (37.0)	14 (60.9)	18 (54.5)	12 (48.0)	10 (50.0)	8 (50.0)
25–30: *N* (%)	10 (27.8)	4 (14.3)	11 (40.7)	4 (17.4)	9 (27.3)	8 (32.0)	5 (25.0)	5 (31.2)
≥30: *N* (%)	7 (19.4)	4 (14.3)	4 (14.8)	3 (13.0)	5 (15.2)	4 (16.0)	4 (20.0)	3 (18.8)
≥40: *N* (%)	4 (11.1)	2 (7.1)	3 (11.1)	3 (13.0)	2 (6.1)	1 (4.0)	2 (10.0)	1 (6.2)
Latina (*n*)	46	37	28	35	42	31	16	12
Body weight (kg): Mean (SD)	81.2 (19.4)	83.3 (20.3)	79.1 (16.0)	81.8 (20.1)	81.4 (20.2)	83.8 (24.9)	76.6 (13.8)	82.8 (17.5)
Body mass index (kg/m^2)	28.0 (6.7)	28.6 (7.2)	27.4 (5.1)	28.3 (7.1)	28.3 (7.1)	29.3 (8.8)	27.1 (5.4)	28.5 (5.7)
<18.5: *N* (%)	1 (2.2)	1 (2.7)	0 (0.0)	1 (2.9)	1 (2.4)	1 (3.2)	1 (6.2)	0 (0.0)
18.5–24.9: *N* (%)	14 (30.4)	12 (32.4)	9 (32.1)	8 (22.9)	10 (23.8)	8 (25.8)	4 (25.0)	3 (25.0)
25-30: *N* (%)	16 (34.8)	11 (29.7)	11 (39.3)	16 (45.7)	18 (42.9)	10 (32.3)	5 (31.2)	4 (33.3)
≥30: *N* (%)	15 (32.6)	13 (35.1)	8 (28.6)	10 (28.6)	13 (31.0)	12 (38.7)	6 (37.5)	5 (41.7)
≥40: *N* (%)	2 (4.3)	2 (5.4)	0 (0.0)	2 (5.7)	2 (4.8)	2 (6.5)	0 (0.0)	0 (0.0)

transmasculine patients who were underweight at baseline, only 2 remained so following 8–10 months of testosterone therapy.

Although the transmasculine group showed a clear increase in mean weight over time, on an individual level there was significant variability in both the direction and magnitude of change in body weight as compared to baseline among both gender identities (Table 5). Weight gain in the transmasculine group within 2–4 months of testosterone therapy was also associated with an increase in mean systolic blood pressure of 2.6 mm Hg ($P = 0.02$).

DISCUSSION

In this longitudinal study of 470 racially and ethnically diverse patients, treatment with gender-affirming hormone therapy was associated with an increase in mean body weight within 2–4 months in the transmasculine group and after 22 months in the transfeminine group. Following 11–21 months of GAHT, weight gain ≥5 kg was seen among 21% of transfeminine individuals and 30% of transmasculine individuals. Following the initiation of hormone therapy, rates of obesity ranged from 42 to 52% among the transmasculine group and 21 to 30% among the transfeminine group.

The weight gain associated with 3–24 months of testosterone therapy in transmasculine individuals is consistent with most previous studies [8–13, 16]. In a body composition study using dual energy x-ray absorptiometry, trans men had an increase in lean body mass and decrease in fat mass at multiple sites following testosterone therapy for one year [17]. Testosterone is the most likely reason for the weight gain as it occurred within 2–4 months of initiation of GAHT. Two small studies in Germany and the United States, however, reported no change to BMI among trans men treated with either testosterone undecanoate for 24 months or IM testosterone esters or transdermal testosterone [18, 19]. Our study population differs from the European and Japanese populations whose baseline body weights

Table 4. Mean body weight and body weight categories for transmasculine participants by race and Latinx ethnicity by visit.

	Follow-up months since baseline							
	Baseline	2–4	5–7	8–10	11–21	22–33	34-45	46-57
All (*n*)	223	186	164	143	183	130	79	39
Body weight (kg): Mean (SD)	78.2 (21.5)	80.6 (21.1)	81.0 (22.0)	82.3 (22.2)	81.5 (21.0)	81.4 (21.0)	83.9 (23.6)	84.0 (24.7)
Body mass index (kg/m^2) Mean (SD)	28.5 (7.7)	29.4 (7.6)	29.7 (7.8)	30.0 (7.9)	29.8 (7.5)	29.6 (7.4)	30.6 (8.1)	30.6 (7.9)
<18.5: *N* (%)	10 (4.5)	4 (2.2)	4 (2.4)	2 (1.4)	1 (0.5)	0 (0.0)	0 (0.0)	0 (0.0)
18.5–24.9: *N* (%)	66 (29.6)	53 (28.5)	44 (26.8)	35 (24.5)	53 (29.0)	40 (30.8)	24 (30.4)	10 (25.6)
25–30: *N* (%)	61 (27.4)	47 (25.3)	44 (26.8)	46 (32.2)	47 (25.7)	32 (24.6)	14 (17.7)	9 (23.1)
≥30: *N* (%)	86 (38.6)	82 (44.1)	72 (43.9)	60 (42.0)	82 (44.8)	58 (44.6)	41 (51.9)	20 (51.3)
≥40: *N* (%)	22 (9.9)	19 (10.2)	18 (11.0)	19 (13.3)	25 (13.7)	12 (9.2)	10 (12.7)	6 (15.4)
White (*n*)	138	117	103	87	112	76	41	18
Body weight (kg): Mean (SD)	78.3 (21.0)	80.7 (20.6)	80.9 (21.3)	81.5 (21.4)	81.3 (21.2)	81.5 (22.3)	86.3 (26.6)	88.6 (32.3)
Body mass index (kg/m^2) Mean (SD)	28.7 (7.4)	29.6 (7.2)	29.7 (7.4)	29.8 (7.4)	29.9 (7.3)	29.7 (7.4)	31.5 (8.5)	32.3 (10.1)
<18.5: *N* (%)	7 (5.1)	3 (2.6)	2 (1.9)	1 (1.1)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
18.5–24.9: *N* (%)	35 (25.4)	29 (24.8)	27 (26.2)	18 (20.7)	31 (27.7)	22 (28.9)	12 (29.3)	6 (33.3)
25–30: *N* (%)	40 (29.0)	32 (27.4)	29 (28.2)	35 (40.2)	29 (25.9)	19 (25.0)	5 (12.2)	1 (5.6)
≥30: *N* (%)	56 (40.6)	53 (45.3)	45 (43.7)	33 (37.9)	52 (46.4)	35 (46.1)	24 (58.5)	11 (61.1)
≥40: *N* (%)	13 (9.4)	11 (9.4)	10 (9.7)	11 (12.6)	13 (11.6)	7 (9.2)	8 (19.5)	4 (22.2)
Black (*n*)	49	41	35	32	44	34	23	13
Body weight (kg): Mean (SD)	78.4 (20.3)	80.5 (19.0)	81.4 (21.0)	84.8 (22.7)	82.6 (19.9)	81.9 (16.1)	81.0 (15.1)	78.4 (10.0)
Body mass index (kg/m^2) Mean (SD)	28.3 (7.5)	29.0 (7.0)	29.6 (7.5)	30.6 (8.0)	29.8 (7.4)	29.8 (5.9)	29.3 (5.4)	28.2 (3.0)
<18.5: *N* (%)	1 (2.0)	0 (0.0)	1 (2.9)	1 (3.1)	1 (2.3)	0 (0.0)	0 (0.0)	0 (0.0)
18.5–24.9: *N* (%)	16 (32.7)	13 (31.7)	8 (22.9)	7 (21.9)	9 (20.5)	6 (17.6)	5 (21.7)	2 (15.4)
25–30: *N* (%)	15 (30.6)	11 (26.8)	10 (28.6)	7 (21.9)	16 (36.4)	13 (38.2)	8 (34.8)	6 (46.2)
≥30: *N* (%)	17 (34.7)	17 (41.5)	16 (45.7)	17 (53.1)	18 (40.9)	15 (44.1)	10 (43.5)	5 (38.5)
≥40: *N* (%)	4 (8.2)	3 (7.3)	3 (8.6)	4 (12.5)	7 (15.9)	2 (5.9)	1 (4.3)	0 (0.0)
Latino (*n*)	20	17	12	14	15	9	7	1
Body weight (kg): Mean (SD)	72.9 (17.7)	74.4 (19.5)	73.0 (16.4)	76.5 (19.7)	74.0 (17.0)	76.5 (17.4)	78.0 (21.4)	-*
Body mass index (kg/m^2) Mean (SD)	27.4 (6.8)	28.0 (7.8)	27.2 (6.3)	28.7 (7.7)	27.9 (7.3)	29.1 (7.7)	29.5 (8.5)	-*
<18.5: *N* (%)	1 (5.0)	1 (5.9)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
18.5–24.9: *N* (%)	6 (30.0)	5 (29.4)	4 (33.3)	5 (35.7)	6 (40.0)	3 (33.3)	2 (28.6)	0 (0.0)
25–30: *N* (%)	7 (35.0)	6 (35.3)	5 (41.7)	5 (35.7)	4 (26.7)	3 (33.3)	1 (14.3)	0 (0.0)
≥30: *N* (%)	6 (30.0)	5 (29.4)	3 (25.0)	4 (28.6)	5 (33.3)	3 (33.3)	4 (57.1)	1 (100.0)
≥40: *N* (%)	1 (5.0)	1 (5.9)	1 (8.3)	3 (21.4)	1 (6.7)	1 (11.1)	1 (14.3)	0 (0.0)

*Mean (SD) not reported due to $n = 1$.

and BMIs were much lower. In these studies the mean body weight was between 56.8 and 70.3 kg and the mean BMI was between 21.7 and 25.0 [8, 10, 16–18, 20]. Rates of overweight and obesity status were not provided in these studies.

There are only four studies ($n = 16$, 19, 28, and 53) that report pre and post GAHT body weights in transfeminine populations [7–9, 13]. Whereas our study found no increase in mean body weight associated with 12 months of GAHT and the ENIGI study found a non-statistically significant increase of 1.3 kg, a Dutch study found a significant increase of 3.8 kg and an Italian study found a significant increase of 3.9 kg [8, 9, 13]. The onset of weight gain beyond 12 months indicates that GAHT is not the reason for the weight gain which could be due to aging and other factors. Similar to the transmasculine population, our transfeminine population had higher mean baseline body weights and BMIs than the European populations [8, 9, 13, 14, 17]. In these studies the mean body weight was between 65.3 and 74.5 kg and the mean BMI was between 20.8 and 23.3 [8, 9, 13, 14, 17]. In one of the ENIGI publications of 179 transfeminine patients, 23% were overweight and 10% were obese [17].

As compared to the general population in United States, baseline rates of obesity were similar in the transmasculine group but much lower in the transfeminine group. Data from the National Health and Nutrition Examination Survey from 2017 to 2018 for adults aged 20–39 reported obesity rates of 40.3% in men and 39.7% in women [21]. One possible explanation for the lower rate of obesity in the transfeminine group could be greater preoccupation with body image and weight. In the Massachusetts Youth Health Survey, trans adolescents had higher rates of fasting, using diet pills and using laxatives as compared to cisgender male adolescents [22]. The National Health and Nutrition Examination Survey data also found differences in obesity by race and ethnicity with Asians having the lowest rate and black women having the highest rate [21].

Our study is the first to describe the time course of the associations between body weight changes and GAHT and to

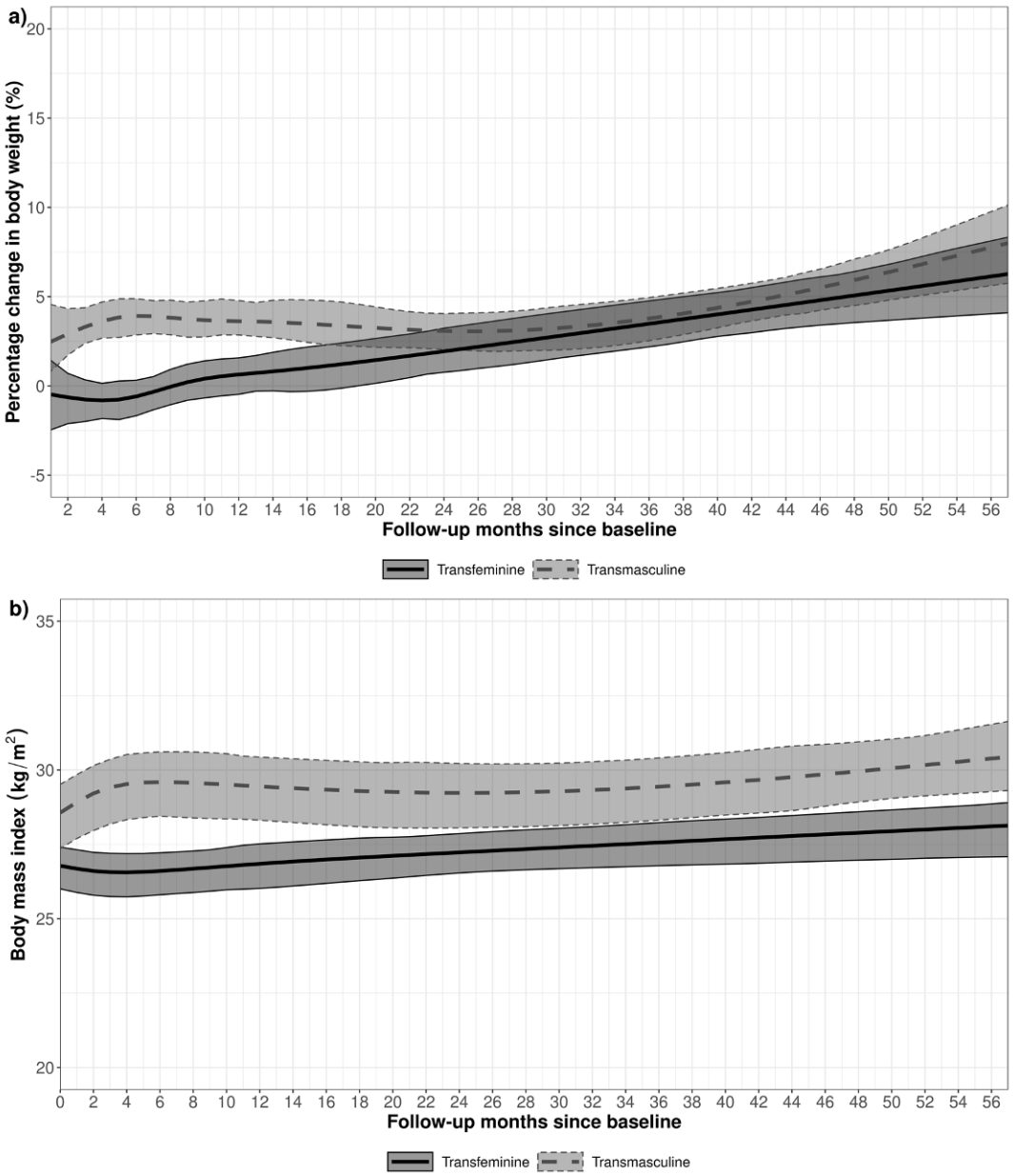

Fig. 1 % Change in body weight compared to baseline and mean body mass index across time in gender-diverse patients on hormone therapy. Estimated marginal means with bootstrapped 95% confidence intervals in the shaded areas from generalized additive mixed model for **a** percentage change in body weight from baseline and **b** body mass index by gender (solid line: trans feminine, dashed line: trans masculine).

compare the rates of normal weight, underweight, overweight, obesity and severe obesity using measurements pre and post GAHT. The strengths of our study are the sample size, duration of up to 57 months, multiple body weight measurements over seven time periods and high racial/ethnic diversity. This study is also novel as it compares body weight values pre- and post-GAHT that correspond to the categories of normal weight, underweight, overweight, obesity and severe obesity. Another novel aspect is the comparison of the direction and magnitude of body weight changes for each individual across the study duration.

This study also has several limitations. First, there was no external control group which is similar to all of the other studies on body weight among gender-diverse populations. Second, there was no standard protocol for body weight measurement. Third, our study did not collect information on other confounding factors that can affect body weight such as changes to diet, exercise, medications, smoking status, and mental health status. Fourth, we did not perform body composition analyses although such data is available from another study [17]. In our study transmasculine individuals were primarily on intramuscular testosterone esters and transfeminine individuals on oral estradiol plus spironolactone. The findings of this study should therefore not be generalized to individuals on different formulations of GAHT (i.e., transdermal testosterone or transdermal or injectable estrogens). Finally, this study was underpowered to detect statistically significant changes to body weight and BMI among black and Latinx patients.

Our study identified a large difference in obesity rates between the transfeminine and transmasculine groups at baseline. Research is needed to identify the reasons for this disparity. Although our study is underpowered to detect differences in body weight and BMI among the different racial and ethnic groups, the

Table 5. Magnitude and direction of changes to body weight since baseline by visit.

		Follow-up months since baseline						
	Baseline	2–4	5–7	8–10	11–21	22–33	34–45	46–57
Transfeminine (*n*)	247	212	182	165	209	153	88	53
(-)≥5 kg	–	20 (9.4)	20 (11.0)	25 (15.2)	34 (16.3)	21 (13.7)	13 (14.8)	6 (11.3)
(-)>0 to <5 kg	–	100 (47.2)	69 (37.9)	50 (30.3)	55 (26.3)	37 (24.2)	23 (26.1)	12 (22.6)
No change		17 (8.0)	10 (5.5)	8 (4.8)	7 (3.3)	6 (3.9)	2 (2.3)	1 (1.9)
(+)>0 to <5 kg	–	67 (31.6)	68 (37.4)	56 (33.9)	70 (33.5)	41 (26.8)	17 (19.3)	12 (22.6)
(+)≥5 kg	–	8 (3.8)	15 (8.2)	26 (15.8)	43 (20.6)	48 (31.4)	33 (37.5)	22 (41.5)
Transmasculine (*n*)	223	186	164	143	183	130	79	39
(-)≥5 kg	–	3 (1.6)	3 (1.8)	4 (2.8)	20 (10.9)	23 (17.7)	11 (13.9)	9 (23.1)
(-)>0 to <5 kg	–	32 (17.2)	36 (22.0)	34 (23.8)	40 (21.9)	18 (13.8)	13 (16.5)	5 (12.8)
No change		10 (5.4)	5 (3.0)	4 (2.8)	5 (2.7)	3 (2.3)	3 (3.8)	0 (0.0)
(+)>0 to <5 kg	–	110 (59.1)	89 (54.3)	61 (42.7)	64 (35.0)	45 (34.6)	19 (24.1)	9 (23.1)
(+)≥5 kg	–	31 (16.7)	31 (18.9)	40 (28.0)	54 (29.5)	41 (31.5)	33 (41.8)	16 (41.0)

Data are presented as number (%).

data suggests that Latin transmasculine individuals have a lower mean body weight than their white and black counterparts and that the opposite is true for Latin transfeminine individuals. Further research is needed to evaluate weight gain and obesity rates among other gender-diverse populations, particularly those in Africa, Asia, and the Middle East. Additional research is needed to compare different formulations of estrogen and testosterone to determine whether there are different rates of weight gain and obesity. Long term studies are needed to see how weight changes may affect clinical outcomes such as heart disease and cancer.

CONCLUSION

Our study demonstrates that GAHT was associated with an increase in mean body weight and body mass index within 2–4 months in the transmasculine group, likely due to testosterone therapy. Weight gain ≥5 kg following 11–21 months of GAHT was seen among 21% of transfeminine individuals and 30% of transmasculine individuals. Following the initiation of GAHT, rates of obesity ranged from 42 to 52% among transmasculine individuals and 21 to 30% among transfeminine individuals. Given that gender-diverse people have a higher burden of cardiovascular disease than cisgender people, identifying individuals with obesity is important so that weight reduction interventions can be promoted. Monitoring body weight and BMI is particularly warranted after the initiation of GAHT as this treatment is associated with increases in weight in most transmasculine individuals and in a subset of transfeminine individuals. The results of this study can be used to inform monitoring recommendations in the various treatment guidelines for transgender and gender-diverse patients.

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AUTHOR CONTRIBUTIONS

MI, DG, and ES designed the study. MK and KB collected the study data. SL performed the statistical analyses. MI drafted the paper. All authors read and contributed to the final paper.

COMPETING INTERESTS

The authors declare no competing interests.

ADDITIONAL INFORMATION

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