

# Characterising body composition and bone health in transgender individuals receiving gender-affirming hormone therapy

Ky Ford<sup>1</sup> | Elizabeth Huggins<sup>2</sup>  | Patricia Sheean<sup>1</sup> 

<sup>1</sup>Department of Applied Health Sciences, Loyola University Chicago, Maywood, Illinois, USA

<sup>2</sup>Loyola University Chicago, Maywood, Illinois, USA

## Correspondence

Patricia Sheean, Department of Applied Health Sciences, Loyola University Chicago, 2160 S First Ave, Bldg 115, Room 344, Maywood, IL 60153, USA.  
Email: [psheean1@luc.edu](mailto:psheean1@luc.edu)

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## Abstract

**Background:** Gender-affirming hormone therapy (GAHT) is prescribed to produce secondary sex characteristics aligning external anatomy with gender identity to mitigate gender dysphoria. Transgender women are generally treated with oestrogens and anti-androgens, whereas transgender men are treated with testosterone. The objective of this narrative review was to characterise the influence of GAHT on body composition and bone health in the transgender population to help address weight concerns and chronic disease risk.

**Methods:** Studies were extracted from PubMed and Scopus and limited to only those utilising imaging technologies for precise adipose tissue, lean mass, and bone mineral density (BMD) quantification.

**Results:** Although methodologies differed across the 20 investigations that qualified for inclusion, clear relationships emerged. Specifically, among transgender women, most studies supported associations between oestrogen therapy and decreases in lean mass and increases in both, fat mass and body mass index (BMI). Within transgender men, all studies reported associations between testosterone therapy and increases in lean mass, and although not as consistent, increases in BMI and decreases in fat mass. No consistent changes in BMD noted for either group.

**Conclusions:** Additional research is needed to appropriately assess and evaluate the implications of these body composition changes over time (beyond 1 year) in larger, more diverse groups across all BMI categories. Future studies should also seek to evaluate nutrient intake, energy expenditure and other important lifestyle habits to diminish health disparities within this vulnerable population. Policies are needed to help integrate registered dietitians into the routine care of transgender individuals.

## KEYWORDS

adipose tissue, body composition, hormone replacement therapy, lean mass, narrative review, transgender persons

## Key points

- Among transgender women, most studies support associations between oestrogen therapy and decreases in lean mass, increases in fat mass, increases in body mass index (BMI) and no changes in bone mineral density (BMD).

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- Among transgender men, most studies support associations between testosterone therapy and increases in lean mass, decreases in fat mass, increases in BMI and no changes in BMD.
- There is an urgency to evaluate and adapt hospital, clinic and insurance policies supporting improved integration of registered dietitians into the routine care of transgender patients, especially for those undergoing gender-affirming hormone therapy and gender-affirming surgeries.

## INTRODUCTION

Transgender is an umbrella term for people whose gender identity and/or expression is different from cultural expectations based on their sex assigned at birth.<sup>1</sup> By contrast, cisgender is a term for people whose gender identity aligns with cultural expectations based on their sex assigned at birth.<sup>1</sup> Over one million adults identify as transgender in the USA.<sup>2</sup> However, only a few national population-based surveys collect information regarding gender identity. As a result, many transgender individuals go unreported or are not accurately captured during the data collection process; thus, current approximations likely underestimate this visibly growing population. Gender-affirming hormone therapy (GAHT) is prescribed to produce secondary sex characteristics aligning external anatomy with gender identity to mitigate gender dysphoria, comprising the psychological distress transgender individuals experience because of incongruence. The initiation of GAHT is significantly and positively associated with improvements in emotional well-being, social functioning and quality of life.<sup>3,4</sup> Transgender women are generally treated with oestrogens and anti-androgens, whereas transgender men are treated with testosterone. The long-term physiological impacts of GAHT are not well studied.

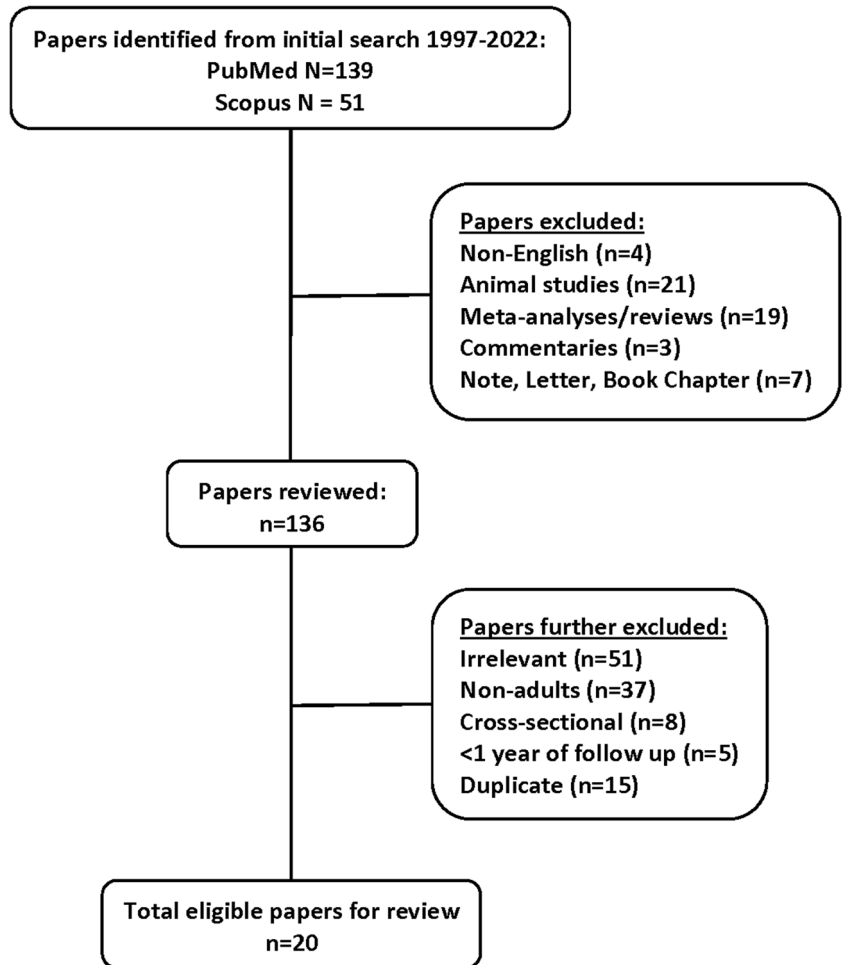
Over the past 30 years, clinicians have been trained to calculate body mass index (BMI) routinely, using a  $\text{BMI} \geq 30 \text{ kg m}^{-2}$  to indicate the presence of obesity.<sup>5</sup> Currently, 42.4% of the US population has obesity; a condition disproportionately affecting the transgender community.<sup>6–10</sup> Theoretically, BMI aligns linearly with total adiposity; however, BMI is considered a crude measure of body composition because it fails to differentiate between lean and adipose compartments. Precise tools to quantify body composition are becoming more readily available and can easily distinguish these tissues, relaying important information concerning total and regional adiposity (abdominal vs. gluteal), as well as lean mass.<sup>11</sup> Determining the influence of feminising and masculinising hormone therapies on body composition in the transgender population is essential for appropriately addressing weight concerns before and after GAHT and to evaluate eligibility for surgical treatments. Cruz *et al.*<sup>12</sup> demonstrated simple metrics, such as body weight, cannot detect favourable improvements after attempting

lifestyle changes in nearly one-third of people whose body weight remains the same and in one-third of people who gain weight. Clinicians must start to look beyond crude measures of obesity to more precisely assess future chronic disease risk, specifically cardiovascular disease (CVD) or hormonally-derived cancers. Therefore, the objective of this narrative review was to characterise the patterns of body composition changes occurring in persons receiving GAHT focusing on investigations employing imaging technologies for precise adipose tissue and lean mass quantification. This information will inform future research pertaining to weight concerns and body composition changes in the transgender community, aiding in achieving health equity and more precise chronic disease risk stratification.

## METHODS

A literature search was conducted in PubMed and Scopus (February 2022) to include studies from 1997 to 2022. This timeframe parallels the expansion and wider availability of body composition imaging technologies, predominantly dual energy X-ray absorptiometry (DXA). PubMed and Scopus were selected because of their extensive coverage of biomedical sciences literature. Scopus includes social, physical and life sciences journals in addition to health sciences. The concepts of gender-affirming hormone therapy, transgender, body composition and imaging were searched in each database utilising the appropriate keywords and controlled vocabulary, when available. The texts of the searches are presented in Supporting information (Table S1). The results were filtered to include studies published in the English language and human participants. Abstracts were further reviewed excluding studies stating a cross-sectional design or lacking body composition parameters prior to initiating GAHT. Studies were required to include adult participants (> 18 years of age), a quantifiable measure of body composition applying imaging methodologies, specifically DXA or magnetic resonance imaging (MRI) and have > 1 year of follow-up. The use of bioelectrical impedance analyses (BIA) was accepted if complementary to MRI or DXA imaging. Figure 1 depicts the article selection process. No ethical approval was required for the conduct of this work.

**FIGURE 1** Methodology depicting the article selection process to assess body composition in transgender individuals following gender affirming hormone therapy



## RESULTS

In total, 20 studies met all inclusion criteria; 14 used DXA,<sup>13–26</sup> three used MRI,<sup>27–29</sup> and three used a combination of MRI and BIA.<sup>30–32</sup> Collectively, 1099 participants (586 transgender men and 513 transgender women) were represented. The majority of studies reviewed were prospective cohorts, apart from two retrospective investigations<sup>13,24</sup> and one randomised controlled trial.<sup>23</sup> Three studies included cisgender controls<sup>14,15,25</sup> and one study included cisgender reference values.<sup>17</sup> All of the investigations were conducted in European countries (five studies in the Netherlands, one study in the Netherlands and Belgium, four studies in Belgium, one study in Belgium and Norway, five studies in Italy, one study in Sweden, one study in Spain, one study in Norway and one study in Germany.) In general, the follow-up period was 1 year, although a few studies included data for 2–5 years after GAHT initiation.

Variations in feminising and masculinising hormone therapy were noted across studies. Transgender women were most frequently treated with 100 µg of ethinyl oestradiol daily or 4 mg of oestradiol valerate daily in combination with 50–100 mg of cyproterone acetate

daily. Transgender men were most frequently treated with intramuscular injections of 250 mg of testosterone undecanoate every 12 weeks or 250 mg of testosterone esters every 2 weeks. Summary findings for transgender women and transgender men are presented in Tables 1 and 2, respectively.

Despite differences in methodologies and treatments, obvious relationships are appreciated across investigations. Specifically, among transgender women, clear collective associations between oestrogen therapy and decreases in lean mass,<sup>14–19,24,26,27,29,31</sup> concomitant increases fat mass<sup>14,17,18,29</sup> and BMI<sup>15,16,24,27,31</sup> were observed. Within transgender men, testosterone therapy was associated with increases in lean mass in every study (except two investigations not measuring lean mass<sup>30,32</sup> and with increases in BMI.<sup>13,16,19,20,22,25,30–32</sup> Eleven studies also demonstrated associations between testosterone treatment and decreases in fat mass<sup>16–20,22,23,25,27,29,30</sup>, specifically subcutaneous fat.<sup>28,31,32</sup> In most of the studies, no changes in bone mineral density were noted. One study assessed energy intake, reporting no changes among transgender men but decreased energy intake among transgender women.<sup>31</sup> Five studies assessed physical activity,<sup>15,16,18,25,29</sup> noting no significant changes over time. Overall,

TABLE 1 Studies evaluating body composition in transgender women following gender affirming hormone therapy

Article	Country/year	Study design	Treatment	N	Lean mass	Fat mass	WHR	BMI	Method	Duration
Gava <i>et al.</i> <sup>24</sup>	Italy 2016	Retrospective	1–2 mg transdermal oestradiol with 50 mg oral cyproterone acetate daily or 3.75 mg leuprolide (IM) monthly	40	↓ (NS)	↑	↔	↑ (NS)	DXA	1 year
Haraldsen <i>et al.</i> <sup>14</sup>	Norway 2007	Prospective	50 µg ethinyl oestradiol daily for 3 months then 100 µg daily	12	↓	↑	–	–	DXA	1 year
Van Caenegem <i>et al.</i> <sup>15</sup>	Belgium 2015	Prospective	< 45 years old: 4 mg oral oestradiol valerate daily with 50 mg oral cyproterone acetate daily > 45 years old: 100 µg transdermal 17β-oestradiol every 24 h with 50 mg oral cyproterone acetate daily	49	↓	↑	↓	↑	DXA	2 years
Wiik <i>et al.</i> <sup>29</sup>	Sweden 2020	Prospective	Transdermal oestradiol gel 1–2 mg daily or patch 100–200 µg every 24 h, 4–8 mg oral oestradiol daily or 80 mg oestradiol (IM) every 2–4 weeks	11	↓ (NS)	↑	–	–	MRI	1 year
Elbers <i>et al.</i> <sup>31</sup>	The Netherlands 1999	Prospective	100 µg ethinyl oestradiol with 100 mg cyproterone acetate daily	20	↓	↑	↔	↑	MRI and BIA	1 year
Giltay <i>et al.</i> <sup>27</sup>	The Netherlands 1998	Prospective	100 µg ethinyl oestradiol daily with 100 mg cyproterone acetate daily	18	↓ (NS)	↑	↑	↑	MRI	1 year
Elbers <i>et al.</i> <sup>30</sup>	The Netherlands 1997	Prospective	100 µg ethinyl oestradiol daily with 100 mg cyproterone acetate daily	17	–	↑	–	↑	MRI and BIA	1 year
Elbers <i>et al.</i> <sup>32</sup>	The Netherlands 2003	Prospective	100 µg ethinyl oestradiol daily with 100 mg cyproterone acetate daily	20	–	↑	–	↑	MRI and BIA	1 year
Auer <i>et al.</i> <sup>16</sup>	Belgium 2016	Prospective	< 45 years old: 50 mg oral cyproterone acetate with 4 mg oral oestradiol valerate daily > 45 years old: 50 mg cyproterone acetate daily with 100 µg transdermal 17β-oestradiol patch every 24 h	20	↓	↑	↔	↑ (NS)	DXA	1 year
Klaver <i>et al.</i> <sup>17</sup>	The Netherlands and Belgium 2018	Prospective	50 mg cyproterone acetate daily with 4 mg oral oestradiol valerate daily or 100 µg transdermal oestradiol patch every 24 h twice weekly	179	↓	↑	↓	–	DXA	1 year
Auer <i>et al.</i> <sup>18</sup>	Belgium 2018	Prospective	< 45 years old: 50 mg cyproterone acetate daily with 2 mg oestradiol valerate twice daily > 45 years old: 50 mg cyproterone acetate daily and a 100 mg transdermal 17β-oestradiol patch every 24 h	24	↓	↑	↓	↔	DXA	1 year
Wierckx <i>et al.</i> <sup>19</sup>	Belgium and Norway 2014	Prospective	< 45 years old: 50 mg cyproterone acetate daily with 4 mg oestradiol valerate daily > 45 years old: 50 mg cyproterone acetate daily with 100 µg transdermal 17β-oestradiol every 24 h	53	↓	↑	↓	↔	DXA	1 year
Gava <i>et al.</i> <sup>26</sup>	Italy 2020	Prospective	50 mg oral cyproterone acetate or 3.75 mg leuprolide acetate (IM) with 1 or 2 mg transdermal oestradiol or oral oestradiol valerate daily	50	↓ (NS)	↑ (NS)	↔	↑ (NS)	DXA	5 years

Abbreviations: BIA, bioelectrical impedance analyses; BMI, body mass index; DXA, dual energy X-ray absorptiometry; IM, intramuscular; MRI, magnetic resonance imaging; NS, not significant; WHR, waist-to-hip ratio.

TABLE 2 Studies evaluating body composition in transgender men following gender affirming hormone therapy

Article	Country/year	Study design	Treatment	Lean mass	N	Fat mass	WHR	BMI	Method	Duration
Gava <i>et al.</i> <sup>13</sup>	Italy 2018	Retrospective	1000 mg testosterone undecanoate (IM) at Weeks 0 and 6 then every 12–16 weeks or 250 mg testosterone enanthate (IM) every 3–4 weeks	↑	50	↔	↑ (NS)	↑ (NS)	DXA	5 years
Haraldsen <i>et al.</i> <sup>14</sup>	Norway 2007	Prospective	250 mg testosterone enanthate (IM) every 3 weeks	↑	21	↑ (NS)	–	–	DXA	1 year
Van Caenegem <i>et al.</i> <sup>25</sup>	Belgium 2015	Prospective	1000 mg testosterone undecanoate (IM) every 12 weeks	↑	23	↓	↔	↑ (NS)	DXA	1 year
Wiik <i>et al.</i> <sup>29</sup>	Sweden 2020	Prospective	1000 mg testosterone undecanoate (IM) at weeks 0 and 6 then every 10 weeks with GnRH analogue (IM) every 3 months	↑	12	↓	–	–	MRI	1 year
Elbers <i>et al.</i> <sup>31</sup>	The Netherlands 1999	Prospective	250 mg testosterone esters (IM) every 2 weeks	↑	17	↑ VAT ↓ SAT	↑	↑	MRI and BIA	1 year
Giltay <i>et al.</i> <sup>27</sup>	The Netherlands 1998	Prospective	250 mg testosterone esters (IM) every 2 weeks	↑	15	↓	↑	↔	MRI	1 year
Elbers <i>et al.</i> <sup>30</sup>	The Netherlands 1997	Prospective	250 mg testosterone esters (IM) every 2 weeks	–	15	↓	–	↑	MRI and BIA	1 year
Elbers <i>et al.</i> <sup>32</sup>	The Netherlands 2003	Prospective	250 mg testosterone ester (IM) every 2 weeks	–	17	↑ VAT ↓ SAT	–	↑	MRI and BIA	1 year
Auer <i>et al.</i> <sup>16</sup>	Belgium 2016	Prospective	1000 mg testosterone undecanoate every 3 months	↑	20	↓ (NS)	↔	↑ (NS)	DXA	1 year
Klaver <i>et al.</i> <sup>17</sup>	The Netherlands and Belgium 2018	Prospective	50 mg testosterone gel daily, 1000 mg testosterone undecanoate (IM) every 12 weeks or 250 mg testosterone esters (IM) every 2 weeks	↑	162	↓	↑	–	DXA	1 year
Auer <i>et al.</i> <sup>18</sup>	Belgium 2018	Prospective	1000 mg testosterone undecanoate every 3 months	↑	45	↓	↔	↔	DXA	1 year
Wierckx <i>et al.</i> <sup>19</sup>	Belgium and Norway 2014	Prospective	1000 mg testosterone undecanoate (IM) at weeks 0, 6 then every 3 months	↑	53	↓	↑	↑	DXA	1 year
Elbers <i>et al.</i> <sup>28</sup>	The Netherlands 1997	Prospective	Preovariectomy: 250 mg testosterone esters (IM) every 2 weeks Postovariectomy: 250 mg testosterone esters (IM) every 3 weeks Two participants switched to 160 mg oral testosterone undecanoate daily	↑	10	↓ SAT (NS)	↑ VAT	–	MRI	3 years
Aranda <i>et al.</i> <sup>20</sup>	Spain 2019	Prospective	1000 mg testosterone undecanoate (IM) every 2–3 months	↑	20	↓ NS	–	↑ (NS)	DXA	1 year
Mueller <i>et al.</i> <sup>21</sup>	Germany 2010	Prospective	Two participants received 50 mg transdermal testosterone daily 1000 mg testosterone undecanoate (IM) every 12 weeks	↑	45	↔	–	↔	DXA	2 years

(Continues)

TABLE 2 (Continued)

Article	Country/year	Study design	Treatment	N	Lean mass	Fat mass	WHR	BMI	Method	Duration
Pelusi <i>et al.</i> <sup>22</sup>	Italy 2014	Prospective	100 mg testosterone esters (IM) every 10 days, 50 mg testosterone gel daily or 1000 mg testosterone undecanoate (IM) at weeks 0 and 6 then every 12 weeks	45	↑	↓	↔	↑	DXA	1 year
Gava <i>et al.</i> <sup>23</sup>	Italy 2021	Randomised controlled trial	1000 mg testosterone undecanoate (IM) at weeks 0, 6, 18, 30, 42 with oral placebo or 5 mg 5 $\alpha$ -reductase inhibitor dutasteride daily	16	↑	↓ (NS)	↔	↔	DXA	1 year

Abbreviations: BIA, bioelectrical impedance analyses; BMI, body mass index; DXA, dual energy x-ray absorptiometry; GnRH, gonadotropin-releasing hormone; IM, intramuscular; MRI, magnetic resonance imaging; NS, not significant; SAT, subcutaneous adipose tissue; VAT, visceral adipose tissue; WHR, waist hip ratio.

transgender and cisgender men were significantly more active in sports than transgender women.<sup>15,18</sup> However, transgender men experienced a significant decrease in work and overall physical activity after 1 year of GAHT.<sup>18</sup>

## Fat distribution

Excessive adiposity is presumed to predict health and chronic disease, where the health risks of obesity are considered to be dependent upon specific adipose tissue compartments. Traditionally, the waist-to-hip ratio (WHR) is considered a surrogate marker of abdominal to gynoid adiposity. This simple anthropometric measure can predict risk of myocardial infarction in the general population.<sup>33</sup> In transgender women, several studies reported decreases in WHR as a result of an increase in gynoid pattern of fat distribution.<sup>15,17–19</sup> Yet, for studies enrolling transgender men, we found a WHR increase<sup>13,17,19,27,31</sup> likely because of an increase in android pattern of fat distribution and reduced hip circumference. In general, fat mass decreased in transgender men and increased in transgender women, where transgender men displayed a tendency to gain visceral adiposity and lose subcutaneous adiposity. These observations correlate with what is expected of identified gender, reaffirming that GAHT is an important determinant of regional changes in adiposity. This has clinical significance because visceral adipose tissue is associated with early mortality, whereas subcutaneous adiposity is considered to serve as an energy reservoir of triglycerides for padding and protection.<sup>34,35</sup> Although looking beyond BMI and body weight by focusing on body composition provides greater insights into the proportion of lean and fat mass in transgender individuals, additional efforts are needed to better decipher the clinical implications of these changes on health outcomes. This review provides a needed framing for such investigations.

## Lean mass

Overall, transgender men gained lean mass, whereas transgender women lost lean mass. This change is representative of the secondary sex characteristics resulting from GAHT administration. When transgender individuals transition after puberty, hormone therapy has little effect on height because of the permanent closure of bone plates, as well as genetic factors. However, in general, individuals assigned male at birth are typically taller than those assigned female at birth. On average, studies included in this review show transgender women were approximately 178 cm in height, whereas transgender men were 165 cm in height. Thus, when clinicians apply the standard BMI metrics, transgender men are at high risk of obesity misclassification because of a higher lean mass

relative to shorter stature. This phenomenon is parallel to BMI misclassifications frequently observed in athletes.<sup>36</sup> Recent national survey data indicate that 66% of transgender men have 'overweight' or 'obesity'; however, these numbers may not be accurate. For example, in the study by Wierckx *et al.*,<sup>19</sup> BMI significantly increased in transgender men from 'normal' to 'overweight', even though lean mass significantly increased, and fat mass significantly decreased. The present study underscores the importance of measuring body composition in transgender individuals.

## DISCUSSION

The origins of obesity are multifactorial, yet clearly influenced by environment, lifestyle habits and genetics. Based on the results of this review, the potential contribution of GAHT as an etiologic factor of obesity and societal factors impacted after GAHT warrants consideration. Transgender women appear to be exceptionally at risk following GAHT due to observed increases in body weight, specifically fat mass. In general, transgender people with obesity are at increased risk for CVD and body dissatisfaction,<sup>37</sup> and likely obesity-related cancers. The study by Martinson *et al.*<sup>8</sup> reported that 26% of the transgender sample had obesity compared to just 18% of the cisgender sample. Furthermore, despite being highly motivated, the efficacy of a self-monitored weight management program did not significantly decrease average BMI and transgender patients remained ineligible for gender-affirming surgeries because of elevated BMI. Obesity can exclude transgender individuals from gender-affirming surgeries that effectively treat gender dysphoria, improve overall wellbeing and quality of life, and have the potential to be lifesaving.<sup>38</sup> Identifying methods to combat or address obesity are critical to improving the overall health of this population. Such actions are consistent with the Healthy People 2030 goals to reduce the proportion of adults with obesity and increase the proportion of healthcare visits pertaining to weight loss, nutrition or physical activity counselling.<sup>39,40</sup>

### Role of registered dietitians and other clinicians

Registered dietitians have an important role in the management of transgender patients and possess a unique skillset to contribute to improved care. First, they should be encouraged to collaborate with surgeons to improve screening and treatment, similar to that of a Registered Dietitian on the bariatric team.<sup>41</sup> Second, registered dietitians can work with patients directly, providing evidence-based weight loss strategies to set realistic expectations, improve body composition and image, and support favourable surgical outcomes. Unfortunately,

transgender individuals report high levels of mistreatment when seeking health care and when accessing gender-affirming treatments;<sup>38</sup> thus, registered dietitians and other clinicians need to focus on inclusivity to broaden their reach and impact in this visibly growing community. Although most transgender adults largely identify as white, data from the Behavior Risk Factor Surveillance System shows that the proportion of transgender adults who are Black or Latinx/e are higher than that of the general population.<sup>2</sup> This is concerning because these individuals reflect two marginalized identities (gender and race),<sup>42</sup> widening the gap on health disparities and obesity-related conditions. Implementing educational resources to reduce stigma in all communities is important with respect to providing culturally competent, equitable care to the transgender population. Third, in healthcare settings, intake forms should include gender identity and pronouns. Transgender individuals are unique in what language they use to describe themselves. Rather than assuming pronouns and language used to describe their anatomy, health professionals should ask what language best affirms transgender patients.

### Applying and adapting gender-specific equations

Registered dietitians are encouraged to use a variety of techniques to conduct a comprehensive nutrition assessment; however, many of the tools we apply in daily clinical practice are based on assumptions of the cisgender population. For example, the Durnin–Womersley formula to calculate percentage body fat considers gender, using the sum of four skinfold thicknesses. BMI-for-age percentile growth charts, waist circumference cut-points and energy calculations, specifically Mifflin St-Jeor Method, Ireton-Jones and Harris Benedict, are all gender based. Furthermore, dietary recommendations for total energy, fibre, calcium, vitamin D, potassium and iron levels are also stipulated applying a male or female context. These are a small sample of the many calculations registered dietitians and other health professional utilise to create nutrition care plans, yet they may not be transferable to the transgender population. Linsenmeyer *et al.*<sup>43</sup> discussed potential approaches on how to navigate nutrition assessments with transgender patients. It is recommended clinicians use values aligned with a patient's gender identity after being on GAHT for 1 year or use the estimated energy requirement equation and calculate needs for both sexes to provide a transgender patient with the range of the difference between both sexes. The findings from our review also support the adaption and routine implementation of body composition assessment to help gauge the effectiveness of GAHT. Ultrasonography is a low cost, portable, non-invasive and widely available body composition tool that does not expose patients to radiation and can easily be adapted in the clinical setting with training.<sup>44</sup> Regardless of the approach

taken, transgender patients will need to be closely monitored to make appropriate adjustments in their treatment plan, considering body composition changes over time.

### Address previous shortcomings to support advancement

As with any research area, there are inherent limitations that merit mentioning and offer novel opportunities for improvement and progress. First, almost all study participants in this review were relatively young, non-Hispanic white, non-obese and recruited from the Netherlands, Belgium and other European countries. Therefore, these findings are not representative of the global population and greatly limit generalisability. Better efforts are needed going forward to include and investigate the impact of GAHT on a more diverse, representative transgender population.<sup>42</sup> Second, the average study duration was approximately 1 year. GAHT produces maximum effects after 2–5 years of initiation.<sup>45</sup> This short time of observation impacts a comprehensive appreciation of body composition changes and future chronic disease risk. It also greatly impedes the ability to observe meaningful changes on bone architecture. Third, based on the relatively small sample sizes across studies, the probability of committing a type 2 error cannot be ruled out and may be reflected in several of the non-significant findings (Tables 1 and 2). Larger, adequately powered studies of longer duration are needed to overcome these shortcomings. Fourth, all but one study was a randomised controlled trial. The predominance of observational study designs diminishes the ability to make causal inferences; however, the precision of imaging techniques, relative uniformity in treatment regimens and follow-up period of at least 1 year elevate the overall quality of evidence depicted in this review. Finally, language is ever evolving in the transgender community. Transgender is an overarching term encompassing many genders beyond the traditional gender binary. As humans evolve, language evolves to describe the complexity of gender. Studies including transgender participants may be difficult to find in research databases given that there is no standardised language. If language is standardised in future research, periodic reevaluation is required to best reflect and represent the transgender population in this field. Some studies have incorrectly referred to transgender women as men and transgender men as women.<sup>14,24</sup>

### CONCLUSIONS

Overall, the findings of this review support body composition changes for individuals receiving GAHT are gender-affirming and align secondary sex characteristics with gender identity. The impact on GAHT on

bone health appears minimal; however, the relatively short period of observation precludes definitive conclusions. Additional research is needed to appropriately assess and evaluate the implications of these body composition changes over time (beyond 1 year) in larger, more diverse groups across all BMI categories. Future studies should also seek to evaluate nutrient intake, energy expenditure and other important lifestyle habits to diminish the health disparities and adverse health outcomes within this vulnerable population. Hospital, clinic and insurance policies require immediate evaluation and adaptation to help integrate registered dietitians into the routine care of transgender patients, especially for those undergoing GAHT and gender-affirming surgeries.

### CONFLICTS OF INTEREST

The authors declare that there are no conflicts of interest.

### AUTHOR CONTRIBUTIONS

Ky Ford, Elizabeth Huggins and Patricia Sheean contributed to the conceptual design, interpretation and drafting of the manuscript. Ky Ford, Elizabeth Huggins and Patricia Sheean have read and approve the final version of this manuscript submitted for publication.

### ORCID

Elizabeth Huggins  <http://orcid.org/0000-0002-1837-9552>

Patricia Sheean  <http://orcid.org/0000-0003-0032-514X>

### PEER REVIEW

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## AUTHOR BIOGRAPHIES

**Ky Ford** (he/ze) is a research assistant. His/Zis interests include transgender nutrition, body composition and health equity.

**Elizabeth Huggins** (she/her) is a research and education librarian.

**Patricia Sheean** (she/her) is a clinical nutrition epidemiologist. Her research interests focus on body composition, cancer survivorship and minority health.

## SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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