Changes in body composition and nutritional requirements of transgender people undergoing gender-affirming hormone therapy

Marius Frenser, Tobias Fischer

Abstract

Gender-affirming hormone therapy (GAHT) is an option for gender reassignment in transgender people. For the target group of transgender persons with and without GAHT, there are no official national or international recommendations for nutrient intake. Using a systematic review, the influence of GAHT on various aspects of health and body composition was examined and nutrient recommendations based on the reference values of the German Nutrition Society (DGE) and the Austrian Nutrition Society (ÖGE) were derived. After one year of GAHT, transgender women and men were between the values of cisgender men and women in terms of fat mass and lean body mass (LBM). For energy intake during the first GAHT year, orientation towards the middle of the existing reference values for cisgender women and men is recommended. An increased protein intake for transgender men appears to be appropriate. Transgender women are advised to increase their intake of calcium and vitamin D. In principle, an individualized nutritional therapy approach is recommended, taking into account target group-specific characteristics and communication.

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Marius Frenser, M.Sc.
Prof. Dr. Tobias Fischer
Fachhochschule Münster
Fachbereich Oecotrophologie • Facility Management
Corrensstraße 25, 48149 Münster
tobias.fischer@fh-muenster.de

Introduction

The sex of newborns is determined in the first moments of new life on the basis of external sexual characteristics and can vary in the course of life [1]. While the term 'transsexualism' was still used in ICD-10 (F64.0) [2], since ICD-11, the associated diagnosis of 'gender incongruence' (HA60) has been used [3]. In this context, gender incongruence that is associated with suffering is also referred to as gender dysphoria [4]. A corresponding gender adjustment is possible through various interventions, often involving treatment with sex hormones and/or hormone suppression [5]. The aim of GAHT is to adjust the sex hormone levels of the person in question so that they correspond to the hormone levels associated with gender identity [6]. In Germany, the annual number of gender reassignment surgeries almost tripled between 2012 and 2021 [7]. This development is consistent with the observation of a social change in which transgender and non-binary people are more visible and accepted in society [5, 8, 9].

Nevertheless, there still are deficits in the medical and health care of transgender people in transition and preventive care [8]. The Institute of Medicine (USA) summarizes major gaps in knowledge regarding the health needs of transgender people [10]. A look at the 'DGE/ÖGE reference values for nutrient intake', which form the basis for deriving nutritional recommendations in Germany [11], confirms this finding. There are intake recommendations for "male" and "female" people of different age groups, but not for transgender people, although the implementation of the reference values for nutrient intake "should ensure the vital metabolic, physical and mental functions of almost all healthy people in the population and protect them from diet-related health problems" [11]. In comparison to the USA, where the Academy of Nutrition and Dietetics also provides a tab for LGBTQ[IA+] (lesbian, gay, bisexual, trans, queer; intersexual, asexual) with various target group-specific information and contact persons on its homepage in addition to the "classic" target groups, this does not yet play a role for all nutrition organizations in Germany [12].

The Academy of Nutrition and Dietetics recommends adhering to the nutritional rec-

ommendations for the biological sex and points out that gender reassignment hormones can have an impact on nutritional requirements. At the beginning of hormone therapy, therefore, no special diet should be followed, although energy requirements may change slightly. Furthermore, it is pointed out that individual support from nutritionists is useful [13, 14].
Due to the circumstances described above and a predicted further increase in the transgender population in Germany, there is a clear need for action to determine reference values for nutrient intake for the transgender population [5]. The aim of this work is to derive intake recommendations for the nutrients 'protein', 'fat', 'calcium', 'vitamin D', 'sodium' and 'fiber' as well as for 'energy' based on the DGE/ÖGE reference values. To achieve this goal, a calculatory model of the body composition of transgender people was developed, which shows in particular the changes in fat mass and LBM.

Methods

The systematic literature review was carried out in accordance with the methodological standards of the PRISMA guideline (preferred reporting items for systematic reviews and meta-analyses) [15].

Systematic literature search

The aim was to achieve a high level of sensitivity in order to comprehensively record the relevant literature. Within three weeks, the online databases PubMed, Web of Science and Cochrane Library were searched for relevant literature. The keywords and MeSH terms used are listed in ◆ Table 1. Concepts 2a and 2b were linked using the operator "OR", whereas concept 1 was linked to concepts 2a and 2b using the operator "AND".
After deduction of duplicates, those studies that investigated the effects of GAHT on body composition, body growth, blood, bone mineral density and/or bone metabolism on various clinical pictures with a direct/indirect relationship to nutrition or on athletic performance were included first. The study participants had to be healthy adolescent or adult transgender persons.

Concept 1: transgender persons	
Key terms	transgender OR two-spirit person OR two spirit person OR transwomen OR transmen OR trans identity OR transsexual OR transexual OR transsexualism
MeSH-Terms	transgender persons, health services for transgender persons
Concept 2a: nutrition	
Key terms	*nutrition OR diet*
MeSH-Terms	*reference values OR diet OR diet therapy*
Concept 2b: gender reassignment hormone therapy	
Key terms	hormone therapy OR estrogen replacement therapy OR testosterone replacement therapy OR GAHT
MeSH-Terms	hormone replacement therapy

Tab. 1: **Key terms and mesh terms used**
GAHT = gender-affirming hormone therapy

Furthermore, the studies had to be published within the last five years and have at least seven test subjects. Studies were excluded if they focused on gender reassignment surgery other than GAHT, examined people with serious pre-existing conditions (e.g. HIV) or were self-reported as having very low validity. Reviews and meta-analyses were also not included. Following a thematic categorization, studies investigating the influence of GAHT on cancer, kidney function, blood, rheumatism and diabetes were also excluded.

Data transfer

The systematic review Spanos et al. (2020) [16] on the influence of GAHT on the body composition of transgender persons served as the central review for model development due to the high topicality and breadth of the overview. Of the studies listed there, 24 were included in the present study. These examined transgender people at the beginning and at different times during GAHT. Missing or additional results from our own systematic literature review (see above) were supplemented accordingly. Forest plots were created using the online tool *Cochrane RevMan* for the results on the change in fat mass and LBM of transgender women and men after one year of GAHT. The statistical analyses of the forest plots were generated programmatically by *Cochrane RevMan*.
Using the open-source 3D computer graphics middleware *MakeHuman*, exemplary body images were developed for cisgender and transgender people. To illustrate the potential changes, an average cisgender physique was used as a starting point and the percentage changes determined were integrated. Changes within the face were not made. Stereotypical hairstyles were used for purely visual illustration of the changes.

Search results

The database search yielded a total of 1787 publications. After removing duplicates, the title and abstract of 1179 publications were checked, of which 114 were included in the further review. The full-text check for inclusion and exclusion criteria enabled a total of 31 publications to be integrated (◆ Figure 1). The 31 selected studies could be assigned to the following groups: Influence of GAHT on

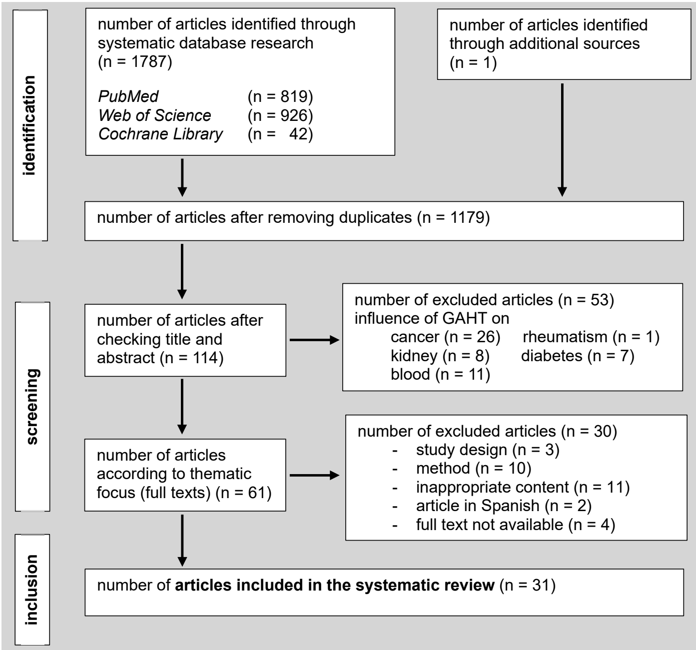


Fig. 1: **Flowchart showing the individual steps of systematic literature selection** (own illustration based on [15]).

a) body composition and growth (n = 6),
b) athletic performance (n = 6),
c) bone mineral density and bone metabolism (n = 8),
d) various determinants of the cardiovascular system (n = 17).

Changes in body composition

Based on the physical changes determined during GAHT, the average values of total fat mass and LBM after one year were compared for transgender persons and cisgender persons (transgender persons before the start of GAHT) (◆ Table 2). As shown in the forest plots (◆ Figure 2), a clearly recognizable trend for the respective development of fat mass and LBM of transgender women and men could be determined. There is maximum homogeneity for the physical changes in each case (I2 = 0–13 %). In addition, the physical changes are significant ($p < 0.00001$) [17]. The physical changes after one year of GAHT of transgender men and women are further shown as body images in ◆ Figures 3 and 4.

Sports performance

Grip strength decreased by 4.3 % in transgender women after one year of GAHT [43] and increased by an average of 17.6 % in transgender men [18, 43].

Isometric torque increased by 12 % for knee extension and 26% for knee flexion in transgender men, while both values remained stable in transgender women [44]. Another survey shows that the performance of transgender people in the disciplines 'push-ups', 'sit-ups' and '1.5 mile run' adapted to the performance values of the respective cisgender gender within four years [45].

Bone metabolism and cardiovascular system

There was a deterioration in various parameters of bone metabolism in transgender women during GAHT, including bone mineral density, Z-scores (spine, femur), bone mass, bone cross-sectional area and trabecular density.
The changes in transgender men showed a contradictory picture [18, 34, 38, 46–50]. In contrast, the cholesterol values of transgender women improved, while systolic and diastolic blood pressure reached constant to reduced values. In transgender men, these parameters worsened with increasing LDL cholesterol, total cholesterol, triglyceride and decreasing HDL cholesterol levels. Various risk parameters for cardiovascular disease, including Framingham 30-year CVD (cardiovascular disease) risk (lipid-based), systolic and diastolic blood pressure, aortic stiffness, dyslipidemia and hypertension incidence, increased to varying degrees [31, 51–65].

Discussion

The values of fat mass and LBM for transgender women and men are between the values of cisgender women and men, so that the mean value of the energy intake recommendations for women and men of the DGE/ÖGE reference values can be recommended depending on the age group and the PAL (physical activity level) during the first GAHT year. Little study data was available for the period beyond one

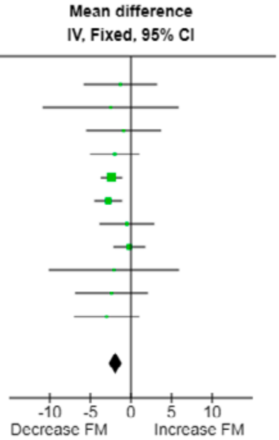
	cisgender woman	transgender man	cisgender man	transgender woman
Ø total fat mass (kg)	19.9 ± 3.2	18.5 ± 2.8	16.6 ± 4.6	19.8 ± 5.4
Ø total fat mass (%)	29.9 ± 4.5	26.3 ± 3.5	18.9 ± 0.4	24.1 ± 0.2
Ø total LBM (kg)	43.9 ± 2.6	48.4 ± 4.9	55.6 ± 5.4	54.8 ± 2.7
Ø total LBM (%)	66.8 ± 5.9	69.7 ± 4.6	77.8 ± 0.4	72.6 ± 0.1

Tab. 2: **Comparison of total fat mass (Ø) and LBM (Ø) of cisgender and transgender persons after one year of GAHT** ([18– 38], own illustration)

a

Study or Subgroup	Fat mass in kg (after 1 year) Mean	SD	Total	Fat mass in kg (start) Mean	SD	Total	Weight	Mean difference IV, Fixed, 95% CI
Auer et al. (2016)	16.6	6.4	20	17.9	8.1	20	3.1%	-1.30 [-5.82 , 3.22]
Auer et al. (2017)	16.5	15.4	24	19	14.2	24	0.9%	-2.50 [-10.88 , 5.88]
Elbers et al. (1997a)	15.7	6.2	15	16.6	6.7	15	2.9%	-0.90 [-5.52 , 3.72]
Gava et al. (2016)	19	8	50	21	7.5	50	6.8%	-2.00 [-5.04 , 1.04]
Klaver et al. (2018)	21.7	3.9	162	24.1	7.7	162	35.4%	-2.40 [-3.73 , -1.07]
Klaver et al. (2022)	23.2	4.2	162	26	10.3	162	21.3%	-2.80 [-4.51 , -1.09]
Meriggiola et al. (2008)	15.6	4.2	15	16.1	5.2	15	5.5%	-0.50 [-3.88 , 2.88]
Mueller et al. (2011)	17.6	4.4	45	17.8	5.1	45	16.2%	-0.20 [-2.17 , 1.77]
Pelusi et al. (2014)	16.2	15.3	45	18.3	22.8	45	1.0%	-2.10 [-10.12 , 5.92]
Van Caenegem et al. (2015a)	17.5	6.7	23	19.9	8.7	23	3.1%	-2.40 [-6.89 , 2.09]
Wierckx et al. (2014)	19.9	9.7	53	22.9	11.4	53	3.9%	-3.00 [-7.03 , 1.03]
Total (95% CI)			**614**			**614**	**100.0%**	**-1.94 [-2.73 , -1.15]**

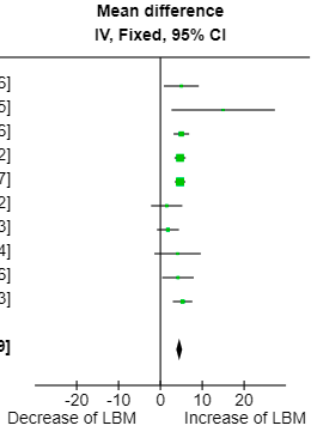
Heterogeneity: Chi² = 5.73, df = 10 (P = 0.84); I² = 0%
Test for overall effect: Z = 4.81 (P < 0.00001)
Test for subgroup differences: Not applicable



b

Study or Subgroup	LBM in kg (after 1 year) Mean	SD	Total	LBM in kg (start) Mean	SD	Total	Weight	Mean difference IV, Fixed, 95% CI
Auer et al. (2016)	48.3	6.2	20	43.3	7.2	20	2.8%	5.00 [0.84 , 9.16]
Auer et al. (2017)	60.3	25.5	24	45.3	17.4	24	0.3%	15.00 [2.65 , 27.35]
Gava et al. (2016)	45.5	4.5	50	40.5	5	50	14.0%	5.00 [3.14 , 6.86]
Klaver et al. (2018)	51.6	2.9	162	46.9	8.1	162	27.8%	4.70 [3.38 , 6.02]
Klaver et al. (2022)	51.6	2.9	162	46.9	7.7	162	30.4%	4.70 [3.43 , 5.97]
Meriggiola et al. (2008)	46	5.4	15	44.5	5	15	3.5%	1.50 [-2.22 , 5.22]
Mueller et al. (2011)	46.3	6.1	45	44.5	6.6	45	7.1%	1.80 [-0.83 , 4.43]
Pelusi et al. (2014)	45.8	12.8	45	41.7	14	45	1.6%	4.10 [-1.44 , 9.64]
Van Caenegem et al. (2015a)	47.7	6.1	23	43.5	6.9	23	3.4%	4.20 [0.44 , 7.96]
Wierckx et al. (2014)	48.3	5.6	53	43	6.6	53	9.0%	5.30 [2.97 , 7.63]
Total (95% CI)			**599**			**599**	**100.0%**	**4.49 [3.79 , 5.19]**

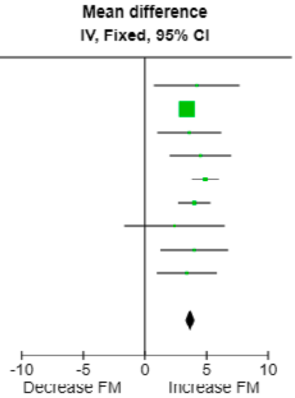
Heterogeneity: Chi² = 10.34, df = 9 (P = 0.32); I² = 13%
Test for overall effect: Z = 12.60 (P < 0.00001)
Test for subgroup differences: Not applicable



c

Study or Subgroup	Fat mass in kg (after 1 year) Mean	SD	Total	Fat mass in kg (start) Mean	SD	Total	Weight	Mean difference IV, Fixed, 95% CI
Auer et al. (2016)	18.9	5.4	20	14.7	5.8	20	1.1%	4.20 [0.73 , 7.67]
Auer et al. (2017)	18	1.1	45	14.6	1	45	70.9%	3.40 [2.97 , 3.83]
Elbers et al. (1997a)	13	3.9	17	9.4	3.8	17	2.0%	3.60 [1.01 , 6.19]
Gava et al. (2016)	19.6	5.8	40	15.1	5.6	40	2.1%	4.50 [2.00 , 7.00]
Klaver et al. (2018)	22.5	4.7	179	17.6	5.8	179	11.2%	4.90 [3.81 , 5.99]
Klaver et al. (2022)	23.1	4.4	179	19.1	7.8	179	7.8%	4.00 [2.69 , 5.31]
Mueller et al. (2011)	13.1	13.1	84	10.7	13.8	84	0.8%	2.40 [-1.67 , 6.47]
Van Caenegem et al. (2015b)	18.9	6.9	44	14.9	6.6	49	1.8%	4.00 [1.25 , 6.75]
Wierckx et al. (2014)	19.4	6.4	53	16	6.4	53	2.3%	3.40 [0.96 , 5.84]
Total (95% CI)			**661**			**666**	**100.0%**	**3.65 [3.29 , 4.02]**

Heterogeneity: Chi² = 7.57, df = 8 (P = 0.48); I² = 0%
Test for overall effect: Z = 19.57 (P < 0.00001)
Test for subgroup differences: Not applicable



d

Study or Subgroup	LBM in kg (after 1 year) Mean	SD	Total	LBM in kg (start) Mean	SD	Total	Weight	Mean difference IV, Fixed, 95% CI
Auer et al. (2016)	56.5	10	20	59.5	10.7	20	0.6%	-3.00 [-9.42 , 3.42]
Auer et al. (2017)	56.5	1.8	45	59.5	1.3	45	63.0%	-3.00 [-3.65 , -2.35]
Gava et al. (2016)	49.9	7.8	40	51	7.7	40	2.3%	-1.10 [-4.50 , 2.30]
Klaver et al. (2018)	55.5	4.1	179	57.2	8.3	179	14.4%	-1.70 [-3.06 , -0.34]
Klaver et al. (2022)	55.5	2.7	179	57.2	8.1	179	17.0%	-1.70 [-2.95 , -0.45]
Mueller et al. (2011)	57.2	23.3	84	59.6	23	84	0.5%	-2.40 [-9.40 , 4.60]
Van Caenegem et al. (2015b)	55.1	8.7	44	57.4	8.7	49	2.1%	-2.30 [-5.84 , 1.24]
Total (95% CI)			**591**			**596**	**100.0%**	**-2.53 [-3.05 , -2.02]**

Heterogeneity: Chi² = 5.87, df = 6 (P = 0.44); I² = 0%
Test for overall effect: Z = 9.63 (P < 0.00001)
Test for subgroup differences: Not applicable

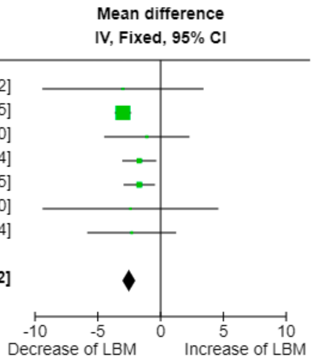


Fig. 2: **Forest plots for the changes in LBM and fat mass in transgender persons within one year GAHT;** a = fat mass of transgender men, b = LBM of transgender men, c = fat mass of transgender women, d = LBM transgender women (own figure created with *RevMan*)

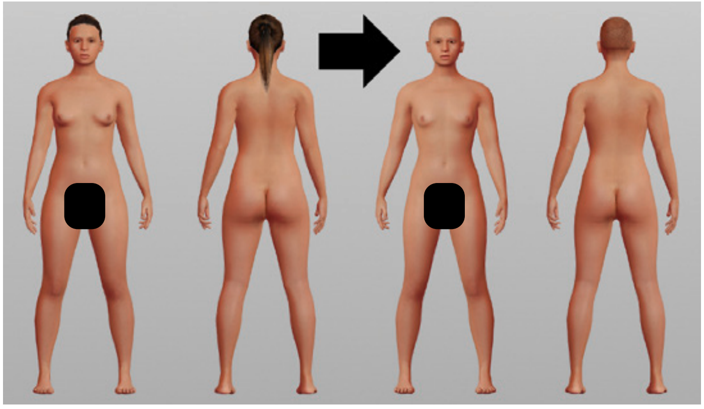


Fig. 3: **Body images created using the data basis [18 -42] and MakeHuman for the representation of changes after one year of GAHT in a transgender man** (own illustration).

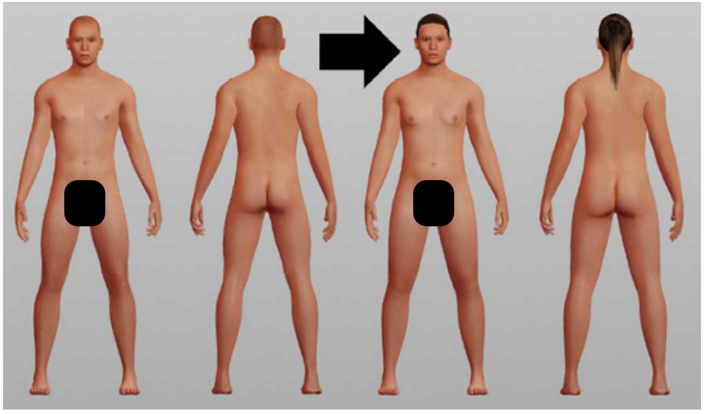


Fig. 4: **Body images created using the data basis [18-41] and MakeHuman for the representation of changes after one year of GAHT in a transgender woman** (own illustration).

year of GAHT. As there are no direct gender-specific differences for the protein intake recommendations (0.8 g/kg body weight) from adulthood onwards [11], the existing DGE/ÖGE reference values can be used for transgender people.
For transgender men, a protein-rich diet to support muscle building may be appropriate. A protein intake of approx. 1.2-2.0 g/kg body weight is recommended within a DGE position paper for athletes depending on their training status and goals [66], which transgender men can use as a guide depending on their physical stature and personal body goals.
Due to the increased risk of cardiovascular disease in transgender men, care should be taken to adhere to the existing intake recommendations for omega-3 and omega-6 fatty acids, saturated fatty acids, sodium and fiber.
Transgender women are also recommended to adhere to the corresponding intake recommendations to prevent nutrition-dependent diseases. Due to the contradictory study situation, transgender men can be advised to adhere to the existing, gender-unspecific calcium and vitamin D supplementation recommendations.
Transgender women show a parallel to cisgender women during/after the menopause due to an increased risk of osteoporosis. Although oestrogen levels increase in the former as a result of GAHT and decrease in women during the menopause [64], both groups are subject to an increased, spontaneous onset risk. In addition, the decreasing levels of osteoanabolic testosterone in transgender women during GAHT can lead to decreasing estrogen levels due to the lack of aromatization of testosterone to estrogen [67]. Based on various sources for the prevention of (post-)menopausal osteoporosis, the intake of 1000–1500 mg calcium and 800–1200 IU vitamin D per day can be recommended for transgender women [67–69]. The diverse physical adaptation processes in transgender people require a balanced diet to maintain health. In this context, the DGE reports: "Eating and drinking whole foods keeps you healthy, promotes performance and well-being" [70].
It should be noted that all recommendations must be individually adapted to the respective requirements, ideally on the basis of anthropometric and clinical measurements.

Limitations

A qualitative weakness of the present literature selection mainly concerns the available study designs. All of the studies evaluated were observational studies, no surveys with a high level of evidence were available. Accordingly, the study results in this paper were classified and interpreted as indicative observational values, but not as definitive findings. In addition to the qualitative aspects, there was an obvious overall lack of nutritional studies in connection with transgender people, which currently makes it very difficult to establish recommendations on nutrition, nutrition communication and counseling for this group of people.
Furthermore, the question arises as to how feasible the nutrient intake recommendations determined are for transgender people.
It is unclear, to what extent transgender people adapt their diet to their gender identity and whether this has an influence on their body composition, i.e. whether stereotypical eating behavior ("typically" male or female) is assumed and whether this can contribute to negative effects on the cardiovascular system in transgender men, among other things. "Typical" male eating behavior includes an increased consumption of meat and sausage products, generally hearty food and often pleasure-driven eating decisions, while women typically prefer foods from the fruit and vegetable groups, among others, and maintain controlled eating behavior [71]. Linsenmeyer reports a lack of evidence for such behavior and sees an opportunity for future research in this area. Nutritionists can help individuals to decide what food means for their gender identity [72].

A review of 37 studies shows that transgender people often suffer from body dissatisfaction, eating disorders and dietary restrictions, depending on the stage of gender reassignment. In addition, there is an increased prevalence of overweight and obesity during or after GAHT [73]. In another study, the diet of transgender subjects was characterized as unbalanced and high in calories and fat [74].

Compliance with the implementation of the developed nutrient recommendations can therefore be classified as critical without active support from target group-oriented trained nutritionists. Although there are no significant differences to the existing DGE/ÖGE reference values, the target group of transgender people represents a little-researched population group with special needs from the nutritional-psychological perspective presented, which, in addition to the strong physical adaptations, is a highly complex group due to a high risk of psychological stress, discrimination, stigmatization by the outside world, negative memories from childhood etc. [75] as a highly complex group. In future, nutritionists should also be included in the current interdisciplinary teams for the treatment and support of transgender people. In addition, consideration should be given to whether German nutrition organizations should also take up the topic of LGBTQIA+ in the present day, in line with the American model.

Conclusion

The body composition of transgender women and men after one year of GAHT is in the middle between the equivalents of cisgender women and men, so that an orientation towards the middle of the existing reference values for energy intake for cisgender women and men can be made during the first year of GAHT. Transgender men are also advised to increase their protein intake due to the increase in LBM. Due to an increased risk of cardiovascular disease, transgender men are advised to adhere to the existing associated reference values. Transgender women should be advised to increase their intake of vitamin D and calcium based on risk markers for osteoporosis. With regard to the reference values mentioned, it should be noted that the current study situation has massive qualitative limitations in some cases and that the needs of the respective person – as is usual in practice – can vary individually and must be determined accordingly. There is a particular need for research concerning the physical changes in transgender people after one year of GAHT and for differentiated research concerning the nutrient requirements during and after periods of gender reassignment hormone therapy.

Disclosure of conflict of interest and use of AI
The authors declare that there is no conflict of interest and that no AI applications were used in the preparation of the manuscript.

References

1. *Schreiber G: Das Geschlecht in mir. Neurowissenschaftliche, lebensweltliche und theologische Beiträge zu Transsexualität. Berlin Boston: De Gruyter 2019, XI.*
2. *Bundesinstitut für Arzneimittel und Medizinprodukte: ICD-10-GM Version 2023. Kapitel V: Psychische Verhaltensstörungen. www.dimdi.de/static/de/klassifikationen/icd/icd-10-gm/kode-suche/htmlgm2023/block-f60-f69.htm (last accessed on 19 September 2023).*
3. *Bundesinstitut für Arzneimittel und Medizinprodukte: ICD-11 in Deutsch – Entwurfsfassung. ICD-11 für Mortalitäts- und Morbiditätsstatistiken (MMS). www.bfarm.de/DE/Kodiersysteme/Klassifikationen/ICD/ICD-11/uebersetzung/_node.html (last accessed on 19 September 2023).*
4. *Turner D, Briken P, Nieder O: Geschlechtsinkongruenz, Geschlechtsdysphorie und Trans-Gesundheit. Psych 2020; 14: 347–63.*
5. *Deutsche Gesellschaft für Sexualforschung: Geschlechtsinkongruenz, Geschlechtsdysphorie und Trans-Gesundheit: S3-Leitlinie zur Diagnostik, Beratung und Behandlung. Version 1.1, Online: 2019, 9, 52, 100. https://register.awmf.org/de/leitlinien/detail/138-001 (last accessed on 27 February 2024).*
6. *Coleman E, Radix AE, Bouman WP, et al.: Standards of care for the health of transgender and gender diverse people, Version 8. Int J Transgend Health 2022; 23(1): 110.*
7. *Statista: Anzahl von Operationen zur Geschlechtsumwandlung in Deutschland in den Jahren 2012 bis 2021. https://de-statista-com.ezproxy.fh-muenster.de/statistik/daten/studie/272600/umfrage/anzahl-von-operationen-fuer-geschlechtsumwandlungen-in-deutschland/ (last accessed on 7 August 2023).*
8. *Poretsky L, Hembree WC: Transgender medicine. A multidisciplinary approach. Cham: Springer International Publishing 2019, Imprint: Human Press, 51.*
9. *Linsenmeyer W, Garwood S, Waters J: An examination of the sex-specific nature of nutrition assessment within the nutrition care process: Considerations for nutrition and dietetics practitioners working with transgender and gender diverse clients. J Acad Nutr Diet 2022; 122(6): 1081–86.*
10. *Feit MN, Erdtmann F, Joseph J, et al.: The health of lesbian, gay, bisexual, and transgender people. Building a foundation for better understanding. Washington (DC): National Academies Press (US) 2011.*
11. *Deutsche Gesellschaft für Ernährung, Österreichische Gesellschaft für Ernährung, Schweizerische Gesellschaft für Ernährung: Referenzwerte für die Nährstoffzufuhr. 2. Auflage, Bonn: DGE 2021, Einführung/1, Energieliefernde Nährstoffe/1.*
12. *Academy of Nutrition and Dietetics: LGBTQ. www.eatright.org/for-lgbtq (last accessed on 15 September 2023).*
13. *Academy of Nutrition and Dietetics: Nutrition for transgender individuals. www.eatright.org/health/wellness/weight-and-body-positivity/nutrition-for-transgender-individuals (last accessed on 6 December 2023).*
14. *Academy of Nutrition and Dietetics: What to eat when transitioning with hormone therapy. www.eatright.org/health/wellness/weight-and-body-positivity/what-to-eat-when-transitioning-with-hormone-therapy (last accessed on 6 December 2023).*
15. *Page MJ, McKenzie JE, Bossuyt PM, et al.: The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. BMJ 2021; 372: n71.*

16. Spanos C, Bretherton I, Zajac JD, Cheung, AS: Effects of gender-affirming hormone therapy on insulin resistance and body composition in transgender individuals: A systematic review. World J Diabetes 2020; 11(3): 66–77
17. Deeks JJ, Higgins JPT, Altman DG: Chapter 10: Analysing data and undertaking meta-analyses. Chapter 10.10.2. In: Higgins JPT, Thomas J, Chandler J, et al.: Cochrane handbook for systematic reviews of interventions. Version 6.3, Online: 2022.
18. van Caenegem E, Wierckx K, Taes Y, et al.: Body composition, bone turnover, and bone mass in trans men during testosterone treatment: 1-year follow-up data from a prospective case–controlled study (ENIGI). Eur J Endocrinol 2015; 172: 163–71.
19. Auer MK, Ebert T, Pietzner M, et al.: Effects of sex hormone treatment on the metabolic syndrome in transgender individuals: focus on metabolic cytokines. J Clin Endocrinol Metab 2019; 103(2): 790–802.
20. Gava G, Mancini I, Cerpolini S, Baldassarre M, Seracchioli R, Meriggiola M: Testosterone undecanoate and testosterone enanthate injections are both effective and safe in transmen over five years of administration. Clin Endocrinol 2018; 89(6): 878–86.
21. Auer MK, Cecil A, Roepke Y, et al.: 12-months metabolic changes among gender dysphoric individuals under cross-sex hormone treatment: a targeted metabolomics study. Sci Rep 2016; 6: 37005.
22. Pelusi C, Costantino A, Martelli V, et al.: Effects of three different testosterone formulations in female-to-male transsexual persons. J Sex Med 2014; 11(12): 3002–11.
23. Wierckx K, van Caenegem E, Schreiner T, et al.: Cross-sex hormone therapy in trans persons is safe and effective at short-time follow-up: results from the european network for the investigation of gender incongruence. J Sex Med 2014; 11(8): 1999–2011.
24. Mueller A, Haeberle L, Zollver H, et al.: Effects of intramuscular testosterone undecanoate on body composition and bone mineral density in female-to-male transsexuals. J Sex Med 2010; 7(9): 3190–8.
25. Berra M, Armillotta F, D'Emidio L, et al.: Testosterone decreases adiponectin levels in female to male transsexuals. Asian J Androl 2006; 8(6): 725–9.
26. Elbers JMH, Asscheman H, Seidell JC, et al.: Reversal of the sex difference in serum leptin levels upon cross-sex hormone administration in transsexuals*. J Clin Endocrinol Metab 1997; 82(10): 3267–70.
27. Haraldsen IR, Haug E, Falch J, Egeland T, Opjordsmoen S: Cross-sex pattern of bone mineral density in early onset gender identity disorder. Horm Behav 2007; 52: 334–343.
28. Klaver M, de Blok CJM, Wiepjes CM, et al.: Changes in regional body fat, lean body mass and body shape in trans persons using cross- sex hormonal therapy: results from a multicenter prospective study. Eur J Endocrinol 2018; 178: 163–71.
29. Klaver M, van Velzen D, de Blok C, et al.: Change in visceral fat and total body fat and the effect on cardiometabolic risk factors during transgender hormone therapy. J Clin Endocrinol Metab 2022; 107(1): 153–64.
30. Meriggiola MC, Armillotta F, Costantino A, et al.: Effects of testosterone undecanoate administered alone or in combination with letrozole or dutasteride in female to male transsexuals. J Sex Med 2008; 5: 2442–53.
31. Aranda G, Mora M, Hanzu FA., Vera J, Ortega E, Halperin I: Effects of sex steroids on cardiovascular risk profile in transgender men under gender affirming hormone therapy. Endocrinol Diabetes Nutr 2019; 66(6): 385–92.
32. Auer MK, Ebert T, Pietzner M, et al.: Effects of sex hormone treatment on the metabolic syndrome in transgender individuals: focus on metabolic cytokines. J Clin Endocrinol Metab 2016; 103(2): 790–802.
33. Poldermann KH, Gooren LJG, Asscheman H, Bakker A, Heine RJ: Induction of insulin resistance by androgens and estrogens. J Clin Endocrinol Metab 1994; 79(1): 265–71.
34. Fighera TM, da Silva E, Lindenau JDR, Spritzer PM: Impact of cross-sex hormone therapy on bone mineral density and body composition in transwomen. Clin Endocrinol 2018; 88(6): 856–62.
35. Gava G, Cerpolini S, Martelli V, Battista G, Seracchioli R, Meriggiola MC: Cyproterone acetate vs leuprolide acetate in combination with transdermal oestradiol in transwomen: a comparison of safety and effectiveness. Clin Endocrinol 2016; 85: 239–46.
36. van Caenegem E, Wierckx K, Taes Y, et al.: Preservation of volumetric bone density and geometry in trans women during cross-sex hormonal therapy: a prospective observational study. Osteoporos Int 2015; 26: 35–47.
37. Mueller A, Zollver H, Kronawitter D et al.: Body composition and bone mineral density in male-to-female transsexuals during cross-sex hormone therapy using gonadotrophin-releasing hormone agonist. Exp Clin Endocrinol Diabetes 2011; 119: 95–100.
38. Yun Y, Kim D, Lee ES: Effect of cross-sex hormones on body composition, bone mineral density, and muscle strength in trans women. J Bone Metab 2021; 28(1): 59–66.
39. Aranda G, Fernández-Rebollo E, Pradas-Juni M, et al.: Effects of sex steroids on the pattern of methylation and expression of the promoter region of estrogen and androgen receptors in people with gender dysphoria under cross-sex hormone treatment. J Steroid Biochem Mol Biol 2017; 172: 20–8.
40. Colizzi M, Costa R, Scaramuzzi F, et al.: Concomitant psychiatric problems and hormonal treatment induced metabolic syndrome in gender dysphoria individuals: A 2 year follow-up study. J Psychosom Res 2015; 78: 399–406.
41. Elbers JMH, Giltay EJ, Teerlink T, et al.: Effects of sex steroids on components of the insulin resistance syndrome in transsexual subjects. Clin Endocrinol 2003; 58(5): 562–71.
42. Elbers JMH, Asscheman H, Seidell JC, Megens JAJ, Gooren LJG: Long-term testosterone administration increases visceral fat in female to male transsexuals. J Clin Endocrinol Metab 1997; 82(7): 2044–47.
43. Scharff M, Wiepjes CM, Klaver M, Schreiner T, T'Sjoen G, den Heijer M: Change in grip strength in trans people and its association with lean body mass and bone density. Endocr Connect 2019; 8(7): 1020–28.
44. Wiik A, Lundberg TR, Rullman E, et al.: Muscle strength, size and composition following 12 months of gender-affirming treatment in transgender individuals. J Clin Endocrinol Metab 2020; 105(3): 805–13.
45. Chiccarelli ME, Aden J, Ahrendt D, Smalley J: Fit transitioning: when can transgender airmen fitness test in their affirmed gender? Mil Med 2022; usac320.
46. Bretherton I, Ghasem-Zadeh A, Leemaqz SY: Bone microarchitecture in transgender adults: a cross-sectional study. J Bone Miner Res 2022; 37(4): 643–48.
47. Wiepjes CM, Vlot MC, de Blok CJM, et al.: Bone geometry and trabecular bone score in transgender people before and after short- and long-term hormonal treatment. Bone 2019; 127: 280–6.
48. Broulik PD, Urbánek V, Libanský P: Eighteen-year effect of androgen therapy on bone mineral density in trans(gender) men. Horm Metab Res 2018; 50: 133–7.
49. Chrisostomo KR, Skare TL, Chrisostomo HR, Litenski Barbosa EJ, Nisihara R: Transwomen and bone mineral density: a cross- sectional study in Brazilian population. Br J Radiol 2020; 93(20190935).
50. Dobrolinska M, van der Tuuk K, Vink P, et al.: Bone mineral density in transgender individuals after gonadectomy and long-term gender-affirming hormonal treatment. J Sex Med 2019; 16: 1469–77.
51. Liu, YH, Wu TH, Chu CH, Lin YC, Lin LY: Metabolic effects of

cross-sex hormone therapy in transgender individuals in Taiwan. J Chin Med Assoc 2021; 84(3): 267–72.
52. *Cocchetti C, Castellini G, Iacuaniello D et al.: Does gender-affirming hormonal treatment affect 30-year cardiovascular risk in transgender persons? A two-year prospective european study (ENGI). J Sex Med 2021; 18(4): 821–9.*
53. *Leemaqz SY, Kyinn M, Banks K, Sarkodie E, Goldstein D, Irwig MS: Lipid profiles and hypertriglyceridemia among transgender and gender diverse adults on gender-affirming hormone therapy. J Clin Lipidol 2023; 17: 103–11.*
54. *van Velzen DM, Paldino A, Klaver M, et al.: Cardiometabolic effects of testosterone in transmen and estrogen plus cyproterone acetate in transwomen. J Clin Endocrinol Metab 2019; 104(6): 1937–47.*
55. *Millington K, Chan YM: Lipoprotein subtypes after testosterone therapy in transmasculine adolescents. J Clin Lipidol 2021; 15(6): 840–4.*
56. *Allen AN, Jiao R, Day P, Pagels P, Gimpel N, SoRelle JA: Dynamic impact of hormone therapy on laboratory values in transgender patients over time. J Appl Lab Med 2021; 6(1): 27–40.*
57. *van Velzen DM, Adornib MP, Zimettic F, et al.: The effect of transgender hormonal treatment on high density lipoprotein cholesterol efflux capacity. Atherosclerosis 2021; 323: 44–53.*
58. *Banks K, Kyinn M, Leemaqz SY, Sarkodie E, Goldstein D, Irwig MS: Blood pressure effects of gender-affirming hormone therapy in transgender and gender-diverse adults. Hypertension 2021; 77: 2066–74.*
59. *Martinez-Martin FJ, Kuzior A, Hernandez-Lazaro A, et al.: Incidence of hypertension in young transgender people after a 5-year follow-up: association with gender-affirming hormonal therapy. Hypertens Res 2023; 46: 219–25.*
60. *Pyra M, Casimiro I, Rusie L et al.: An observational study of hypertension and thromboembolism among transgender patients using gender-affirming hormone therapy. Transgend Health 2020; 5(1): 1–9.*
61. *Cunha FS, Sanchez Bachega TAS, Costa EMF, et al.: Arterial stiffness in transgender men receiving long-term testosterone therapy. J Endocr Soc 2023; 7: 1–7.*
62. *Kulprachakarn K, Ounjaijean S, Rerkasem K, Molinsky RL, Demmer RT: Cardiovascular disease risk factors among transgender women in Chiang Mai, Thailand. Am J Cardiovasc Dis 2020; 10(2): 124–30.*
63. *Mullins ES, Geer R, Metcalf M et al.: Thrombosis risk in transgender adolescents receiving gender-affirming hormone therapy. Pediatr 2021; 147(4): 1–9.*
64. *Valentine A, Davis S, Furniss A, et al.: Multicenter analysis of cardiometabolic-related diagnoses in transgender and gender-diverse youth: a PEDSnet study. J Clin Endocrinol Metab 2022; 107: 4004–14.*
65. *Getahun D, Nash R, Flanders W, et al.: Cross-sex hormones and acute cardiovascular events in transgender persons: a cohort study. Ann Intern Med 2018; 169(4): 205–13.*
66. *König D, Carlsohn A, Braun H, et al.: Proteins in sports nutrition. Position of the working group sports nutrition of the German Nutrition Society (DGE). Ernahrungs Umschau 2020; 67(7): 132–9.*
67. *Bartl R: Osteoporose in der Praxis. Vorsorge, Diagnostik und therapie – evidence based. Berlin: Springer 2022, 16 f., 37, 76, 105, 197.*
68. *Deutsche Gesellschaft für Gynäkologie und Geburtshilfe, Österreichische Gesellschaft für Gynäkologie und Geburtshilfe, Schweizerische Gesellschaft für Gynäkologie und Geburtshilfe: Peri- und Postmenopause – Diagnostik und Interventionen: S3-Leitlinie. Version 1.1, Online: 2022, 82.*
69. *Kraenzlin M: Postmenopausale Osteoporose. https://meno-pause.ch/osteoporose_knochenbrueche (last accessed on 7 August 2023).*
70. *Deutsche Gesellschaft für Ernährung: Vollwertig essen und trinken nach den 10 Regeln der DGE. https://www.dge.de/gesunde-ernaehrung/dge-ernaehrungsempfehlungen/10-regeln/ (last accessed on 19 September 2023).*
71. *Setzwein M: „Männliches Lustprinzip" und „weibliches Frustprinzip"? Ernährung, Emotionen und die soziale Konstruktion von Geschlecht. Ernährungs Umschau 2004; 51(12): 504–7.*
72. *Linsenmeyer W: Should clinicians care about how food behaviors express gender identity? AMA J Ethics 2023; 25(4): 287–93.*
73. *Gomes SM, Jacob MCM, Rocha C, Medeiros MFA, Lyra CO, Noro LRA: Expanding the limits of sex: a systematic review concerning food and nutrition in transgender populations. PHN 2021; 24(18): 6436–49.*
74. *Vilas MVA, Rubalcava G, Becerra A, Para MCM: Nutritional status and obesity prevalence in people with gender dysphoria. AIMS public health 2014; 1(3): 136–46.*
75. *Poteat T, Divsalar S, Streed C, Feldman J, Bockting W, Meyer IH: Cardiovascular disease in a population-based sample of transgender and cisgender adults. Am J Prev Med 2021; 61(6): 804–11.*