Association of Hot Tea Consumption with Regional Adiposity Measured by Dual-energy X-ray Absorptiometry in NHANES 2003-2006

Justin Roberts[1†], Qinran Liu[2†], Chao Cao[3], Sarah E Jackson[4], Xiaoyu Zong[2], Gretchen A Meyer[3], Lin Yang[5], W. Todd Cade[3], Xiaobin Zheng[6,7,*], Guillermo F. López-Sánchez[8], Xiaojian Wu[6,7,*], Lee Smith[1*]

[1] The Cambridge Centre for Sport and Exercise Sciences, Anglia Ruskin University, East Road, Cambridge CB1 1PT, UK;

[2] Division of Public Health Sciences, Department of Surgery, Washington University School of Medicine, St Louis, MO, USA;

[3] Program in Physical Therapy, Washington University School of Medicine, St Louis, MO, USA;

[4] Department of Behavioural Science and Health, University College London, London, UK;

[5]Cancer Epidemiology and Prevention Research, Alberta Health Services, Calgary, Canada

[6] Department of Colorectal Surgery, the Sixth Affiliated Hospital, Sun Yat-sen University, Guangzhou, P.R. China

[7] Guangdong Provincial Key Laboratory of Colorectal and Pelvic Floor Diseases, the Sixth Affiliated Hospital, Sun Yat-sen University, Guangzhou, P.R. China

[8] Faculty of Sport Sciences, University of Murcia, Spain.

Keywords: Hot tea; Central adiposity; DXA; Body fat; NHANES

Running title: Hot Tea and Regional Adiposity

Author contribution: Dr. Roberts and Ms. Liu contributed equally to the manuscript.

Funding: This research received no external funding.

Disclosure: The authors declare no conflict of interest.

Word count of main text: 3313.

Correspondence:

Xiaobin Zheng, MD, PhD and Xiaojian Wu, MD, PhD
Department of Colorectal Surgery,
The Sixth Affiliated Hospital,
Sun Yat-sen University,
Guangzhou, P.R. China
Email: zhengxbn@mail3.sysu.edu.cn
wuxjian@mail.sysu.edu.cn

Lee Smith, PhD
Cambridge Centre for Sport and Exercise Sciences,
Anglia Ruskin University, East Road, Cambridge CB1 1PT, UK
Email: lee.smith@anglia.ac.uk

*** What is already known about this subject?**

- Regular consumption of tea has been associated with reduced incidence of various cancers and cardio-metabolic risk factors.
- Tea catechins have been proposed to have anti-obesity properties, with a recent meta-analysis highlighting a small, yet positive effect on weight loss and weight maintenance.
- There has been minimal research investigating whether total and central body fat levels are typically lower based on regular consumption of tea in large-scale population studies.

*** What does this study add?**

- Compared with non-tea drinkers, men who consumed 0.25-1 cup /day of hot tea had 1.5 % and 1.7 % less total and trunk body fat, respectively.
- In women, those who drank 1 or more cups per day had 1.5% lower trunk body fat compared with non-tea drinkers.
- Consumption of hot tea might be considered as part of healthy diet in supporting parameters associated with metabolic health, and may be particularly important in older male age groups in supporting reduced central adiposity.

Abstract

Objective: To investigate the potential anti-obesity benefits of hot tea consumption at the population level.

Methods: Using data from the National Health and Nutrition Examination Survey (NHANES) 2003–2006, we examined the association between hot tea consumption and DXA measured body fat in a large representative sample of U.S. adults (n=5681, 51.9 % women).

Results: Compared with non-tea drinkers, men who consumed 0.25-1 cup /day of hot tea had 1.5 % (95% CI, 0.4% to 2.6%) and 1.7 % (95% CI, 0.4% to 3.0%) less total and trunk body fat, respectively. The associations were stronger among men 45-69 years old compared with younger men (20-44 years). For men who consumed 1+ cup/day of hot tea, lower total (-1.2%, 95% CI, -2.3% to -0.2%) and trunk body fat (-1.3%, 95% CI, -2.6 to -0.1%) were observed among men 45-59 years, only. In women, those who drank 1 or more cups per day had 1.5% lower (95% CI, -2.7% to -0.3%) trunk body fat compared with non-tea drinkers.

Conclusions: Consumption of hot tea might be considered as part of a healthy diet in supporting parameters associated with metabolic health, and may be particularly important in older male age groups in supporting reduced central adiposity.

Association of Hot Tea Consumption with Regional Adiposity Measured by Dual-energy X-ray Absorptiometry in NHANES 2003-2006

Introduction

Tea beverages are amongst the most popular daily drinks consumed globally, second only to water. Global tea consumption in 2018 was estimated at 273 billion liters per annum and projected to increase to 297 billion liters by 2021 (three times as much as coffee consumption rates) (1). The Tea Association of the US estimate that some 159 million Americans consume tea on a daily basis (2) partly due to the beverage satisfaction, as well as perceived health benefits (3-5). All tea comes from the leaves/buds of the *Camellia sinensis* plant, and based on fermentation processing results in the main black, white, oolong, green, yellow and pu-erh tea classifications. Tea, in particular green tea, contains phytonutrient phenolic compounds, or flavonoids (namely the flavan-3-ols and flavonols) (6) well known for their anti-oxidative, anti-inflammatory and anti-carcinogenic health benefits (7). The antioxidant properties of tea are affected by both temperature (infusion with hot water) or time of steeping (e.g. steeped ice tea) (8). As such, regular consumption of tea has been associated with reduced incidence of various cancers and cardio-metabolic risk factors (9,10,11,12). The increase in plasma antioxidant capacity (TRAP) associated with tea consumption typically occurs within 60 minutes of consumption, and rapidly reduces within 90 minutes (13), hence supporting the potential benefits of regular daily consumption. Of note, the addition of milk to tea appears to limit or minimize its antioxidant potential (13).

With increasing rates of overweight and obesity in the US, there is current interest in strategic practices to support weight management in conjunction with both caloric restriction and exercise regimens. Tea catechins have been proposed to have anti-obesity properties, with a recent meta-analysis highlighting a small, yet positive effect on weight loss and weight maintenance (14). However, the authors also indicated that prior habitual caffeine intake and/or ethnicity may be

potential moderators of catechin effectiveness. The majority of research investigating anti-obesity properties of tea consumption have largely focused on green tea. Mechanistically, tea catechins (including caffeine) have been shown to enhance 24-h energy expenditure, indicating a thermogenic effect favoring fat oxidation over carbohydrate oxidation (15). Regular consumption of a green tea catechin beverage (containing 625mg of catechins and 39mg caffeine) has been shown to favorably improve body composition assessed via dual X-ray absorptiometry (DXA) and computed tomography, through reductions in both total and subcutaneous abdomen fat area, as well as reduce fasting serum triglycerides (16,17). Whilst it is possible that an increased hepatic fat oxidation rate may contribute to the reduction in central fat storage observed in these studies, there has been minimal research investigating whether total and central body fat levels are typically lower based on regular consumption of tea in large-scale population studies. This has potential implications considering the cardio-metabolic risks associated with increased visceral adiposity. Therefore, the focus of this study was to assess the associations of regular hot tea consumption with total and central (trunk) body fat levels in US adults.

Methods

Study population

The National Health and Nutrition Examination Survey (NHANES) is a major study conducted by the National Center for Health Statistics, collecting nationally representative samples to monitor the prevalence of the health, nutritional status and potential risk factors for diseases among non-institutionalized civilians in the US (18). The data are collected on a continual basis and released in two-year increments. Survey participants completed a written informed consent form, as well as a household interview and underwent a physical examination at the mobile examination center. We extracted and aggregated data on sociodemographic characteristics, DXA, dietary patterns, medical conditions, and lifestyle behaviors in the two waves of 2003-2004 and 2005-2006 among those aged 20-69 years, because the DXA examination was only carried

out on this age group and both hot tea consumption and DXA data were measured at same time in these waves, only (19).

Assessment of exposure

The NHANES food frequency questionnaire (FFQ) was developed by the National Cancer Institute (NCI) and revised from the widely used NCI Diet History Questionnaire measuring 124-item food frequency in nutritional epidemiology research (20). Daily hot tea consumption frequency over the past 12 months was assessed in 10 categories, ranging from 0 to 6 or more cups per day, and collapsed into four groups (no hot tea, 0-0.25, 0.25-1, 1 more cups per day) (21). These categories, have been previously used in other studies (12). Additional questions on whether drinking decaffeinated hot tea ("How often was the hot tea you drank decaffeinated or herbal tea?") and frequency of adding sugar/honey, artificial sweetener and non-dairy creamer was used to control potential confounding components.

DXA scan

The whole body DXA scans were obtained using a Hologic QDR 4500A fan-beam densitometer (Hologic, Inc., Bedford, Massachusetts) in accordance with the manufacturer's manual (19). Pregnant or menstruating women, those who self-reported a body-mass over 300 pounds or height over 6'5'', and those who had self-reported history of radiographic contrast material with barium using the past 7 days were excluded due to their ineligibility for the DXA examination (22). The DXA scan results were reviewed and analyzed by the Department of Radiology using standard radiologic techniques and study-specific protocols developed for the NHANES at the University of California, San Francisco (UCSF Hologic Discovery software version 12.1 was used to analyze DXA exams and provided body composition data). The magnitudes and distributions of body fat were represented using fat percentage (%) of the trunk (only the trunk area of the human body) and fat % of the total body (including head, limbs, and trunk area of the body).

Covariates

Self-reported sociodemographic characteristics included age, gender, race/ethnicity (non-Hispanic white, non-Hispanic black, Hispanic, Hispanic and others), annual household income ($25,000 or less, $25,000 to $74,999, and $75,000 or above), and education (less than high school, high school, and above high school). Lifestyle behaviors included physical activity, smoking status, TV watching (hours/day), PC use (hours/day) and intention to lose/control weight. Physical activity level was defined by whether one participated in moderate-to-vigorous physical activity (MVPA) in the past 30 days or not. We used TV watching time and PC using time to reflect the sedentary behaviors (23). Comorbidity was identified by self-reports of six highly prevalent excess adiposity-associated chronic conditions: hypertension, high blood cholesterol, coronary heart diseases, osteoarthritis, stroke, and diabetes (24). Participants' weight and height were measured according to standard procedures during the physical examination. Body mass index (BMI) was calculated as weight in kilograms divided by height in meters squared and categorized into: underweight (<18.5 kg/m^2), normal weight (18.5–24.9 kg/m^2), overweight (25.0–29.9 kg/m^2), and obesity (≥30 kg/m) based on the standard classification. Last, we derived data on dietary covariates from both the FFQ (including alcohol beverage (beer, liquor, and wine and coffee consumption), dietary supplement use (EGCG and green tea extracts), and 24-hour recall data (including total calorie intake and the Healthy Eating Index-2010) (20).

Statistical analysis

We used the DXA examination data set as released by the National Center for Health Statistics (https://wwwn.cdc.gov/nchs/nhanes/dxa/dxa.aspx). Because missing DXA data were related to age, BMI, weight, and height and possibly to other characteristics, participants with missing data could not be considered as a random subset of the original sample. As such, analytic results could be biased toward participants with the least amount of missing data (19, 20). To reduce potential bias, multiple imputation was applied at the National Center for Health Statistics to reflect the

additional variability due to the use of imputed values for the missing data (19). In brief, each participant underwent five DXA scans. The NHANES program imputed any missing scan for individuals based on a complex list of variables including sociodemographic characteristics, geographic variables, body measurements, health status, dietary pattern, medications use and lab test results. The five completed DXA datasets were collapsed into a single file for each cycle and released to the public (25). We followed NHANES technical guideline to conduct the present analyses. Due to established biological gender differences in metabolism (26,27), we conducted all analyses separately by gender. We further conducted all the analyses among each age group since age is an important factor of changes in energy metabolism and lifestyle behaviors (26). We used 45 years old as the cut-off for the age group since it is a cut-off of middle adulthood (28). It is also the approximated mean age of our sample population. First, we calculated the descriptive characteristics of study population according to frequency of daily hot tea consumption among men and women. Secondly, we examined the association of frequency of daily hot tea consumption with body fat % using age-adjusted and multivariable-adjusted linear regression models. SAS-callable SUDAAN 11.0 (RTI International) was adapted for the complex survey design and analyzed a multiply imputed dataset to reduce bias. Sample weights adhered to the National Center for Health Statistics recommendations (29). Our estimation procedure was carried out five times, once for each version of the completed data. We conducted sensitivity analyses by restricting the study sample to those self-reported drinking caffeinated tea more than half of the time. All statistical tests were 2-sided and statistical significance was set at $P < .05$.

Results

In the NHANES 2003-2006, 13760 eligible participants had reliable data on DXA. While excluding 5726 individuals under 20 years old and 2353 subjects without information on hot tea consumption, 5681 adults aged ≥20 years (51.9 % women) were included in the final analysis. Characteristics of the participants are presented according to frequency of daily tea consumption

and gender (**Table 1**). In both men and women, frequent hot tea drinkers (1+ cup/day) were older than those who were less frequent (0-0.25 cup, 0.25-1 cup/day) consumers and those who reported no hot tea consumption. In addition, "other" racial/ethnic groups were more likely to report consuming one or more cups of tea (men: 14.8%; women: 20.0%) compared with non-Hispanic white, non-Hispanic black, and Hispanic groups (men: all groups ≤7.7%; women: all groups ≤8.9%)). Overall, frequent hot tea drinkers were more likely to keep a healthy diet behavior compared with non-drinkers (HEI-2010, men: 56.6 vs. 46.6; women: 57.1 vs. 47.9). The weighted mean of body fat % (total and trunk) by weight status are shown in eTable 1.

The associations of hot tea consumption with body fat % are presented in **Table 2** (Men) and **Table 3** (Women). Among men, those who drank 0.25-1 cup/day had the lowest body fat % after adjusting multiple covariates across all age groups. For example, compared with non-tea drinkers, men who consumed 0.25-1 cup /day of hot tea had 1.5 % (95% CI, 0.4% to 2.6%) and 1.7 % (95% CI, 0.4% to 3.0%) less body fat in total and trunk, respectively. However, there was no significant difference in body fat between non-drinkers and those drinking 1+ cup/day. With respect to women, those drinking 1+ cup/day of hot tea had the lowest body fat % (Age-adjusted β-coefficient, total fat %: -2.3 % (95% CI, -3.2% to -1.4%); trunk fat %: -3.3 % (95% CI, -4.5% to -2.1%)). With the further adjustment, women participants who drank 1 or more cups per day had -1.5% lower (95% CI, -2.7% to -0.3%) trunk body fat.

Our findings were similar when restricting the study sample to those who self-reported drinking caffeinated tea more than half of the time in sensitivity analyses (data not reported).

Discussion

This study provides epidemiological evidence that regular hot tea consumption may be associated with reduced body fat levels. After adjustment for a range of sociographic characteristics, health behaviors, comorbidity status and other dietary covariates, men who reported consuming 0.25-1 cups of hot tea per day and women who consumed 1 or more cups of hot tea per day had

significantly lower total body fat than those who reported no hot tea consumption (1.5% and 0.8% lower, respectively). Age-stratified analyses indicated a stronger association between hot tea consumption and body fat in older (45-69y) than younger (20-44y) men, but no notable differences were noted by age in women. The findings therefore suggest a potential benefit of regular tea consumption, particularly in men who were 45-59 years old.

A similar pattern was also established between hot tea consumption and trunk body fat reduction. In the multivariable adjusted model, men who reported consuming up to 1 cup of hot tea per day had significantly lower trunk body fat compared with those who reported no hot tea consumption (1.7% and 1.5% lower, respectively). These associations attenuated to null among younger (20-44y) men, yet remained significant among older (45-69 y) men. These differences between age groups suggest that the effect of tea in body fat reduction may be a long-term process (12). Overall, the findings suggest an association of regular hot tea consumption with adiposity, particularly for men; and that volumes consumed in excess of 1 cup a day are more likely associated with lower trunk body fat, with the exception of young aged males (20-44 years category), in which lower volumes may suffice.

These findings support the contention that regular hot tea consumption, even in relatively small volumes, may provide pertinent cardio-metabolic health benefits through a modulation in body fat storage (12). This supports a recent meta-analysis indicating that catechins found in tea, particularly green tea, have a small, positive effect on both weight loss and weight maintenance (14). However, in the current study, factors such as ethnicity and habitual caffeine intake which were proposed to be moderators of catechin availability (14) were taken into consideration using multivariable adjusted models. Despite potential moderators, regular hot tea consumption was associated with both lower total body fat and trunk fat in men and women. This supports previous findings highlighting that regular hot tea consumption is associated with lower bodyweight, subcutaneous skinfold measures and BMI in a US population cohort (12). In contrast, iced tea

consumption was associated with negative modulation of inflammatory and cardiovascular disease risk biomarkers aligned with development of metabolic syndrome (MetS) (12). In the current study, consumption of >1 cup of hot tea per day was also associated with lower prevalence of diabetes in both men and women, as well as higher dietary quality (based on the Healthy Eating Index 2010). This suggests that regular tea consumption may be associated with other lifestyle/dietary choices in line with improved health status, and may be an important constituent of a healthy diet.

In terms of the potential anti-obesity effects of tea, the majority of research has focused on green tea consumption, likely due to the prevailing catechin content (particularly epigallocatechin gallate (EGCG)). Whilst effective tea dose and duration are contentious, catechin content ~600mg per day has been associated with thermogenic effects via sympathetic nervous system activity. This likely equates to >3 cups of hot tea per day, and may in part explain the higher dose requirements observed in the current study, particularly for older women. Although tea catechin consumption has been proposed to inhibit catechol-O-methyltransferase (COMT) activity (30), leading to sustained catecholamine effects on lipolysis and hence enhanced substrate oxidation, this effect may be short-lived once catechins undergo glucuronidation (31). In animal models, longer term use of tea catechins has been shown to increase mRNA expression for both lipolytic and β oxidation enzymes in liver/adipose tissue (32), and fat oxidation enzymes (e.g. NRF-1, UCP3 and PPARα) in skeletal muscle (33). However, evidence of upregulation of metabolic genes associated with enhanced fat oxidation in humans is currently lacking (30, 34), and further research investigating the impact of regular consumption of tea catechins on fat oxidation mechanisms is warranted.

However, it is important to recognize that the catechin content of tea is variable (35) and influenced by factors including where the plant is grown (quality of soil, altitude), the specific season of harvest, and leaf age/storage. During the brewing process, water temperature has also

been shown to affect polyphenol levels, with ideal temperatures > 80ºC needed to improve catechin extraction (36). In addition, brewing times (37, 38) exceeding 4 minutes potentially lend to optimal polyphenol provision, which may be an important factor considering the bioavailability of tea catechins in vivo (39). This, in part, may explain the modest differences in total and trunk body fat observed in the current study, and indeed the variability observed between participants. It is also important to note that in the current study we did not differentiate between tea classifications (i.e. black, green, yellow) to establish whether specific types of tea are more advantageous.

An interesting observation from the current study was that a higher dose of daily tea consumption in women was associated with reduced trunk body fat compared to men. This supports findings elsewhere (40) that BMI tended to be lower in women who consumed higher total flavonols/flavones and catechins in their diet, in contrast to men. The lower tea dose observed in the current study for reduced total body fat and trunk fat for men may be particularly important considering the relevance of central adiposity (visceral adipogenesis) in the chronic development of cardio-metabolic health disorders. Adipogenesis in women is typically associated with gynoid fat distribution, and reduction of central fat storage sites may require greater sympathetic nervous system stimulation (41).

It is important to note the observed lower level of body fat in this study associated with drinking hot tea. It was observed that men who reported consuming 0.25-1 cups of hot tea per day and women who consumed 1 or more cups of hot tea per day had significantly lower total body fat than those who reported no hot tea consumption (1.5% and 0.8% lower, respectively). Whereas, clinically significant weight loss has previously been defined as at least a 5% reduction in weight from the baseline level (42). However, any reduction in weight is likely to benefit health and if further research confirms present findings it is feasible that drinking hot tea could be used as an additional strategy, for example combined with exercise, to aid weight loss.

The inclusion of a large representative sample of US adults, and the adjustment for a range of social and biological covariates are important design strengths to the current study. In addition, whereas previous research (12) assessed the impact of hot tea consumption on bodyweight and selected skinfold measures, the inclusion of trunk fat derived from DXA scans provides important information pertinent to the estimation of central adiposity. However, it is also acknowledged that as a cross-sectional study, the direction of causality is not quantifiable, and it is therefore not possible to determine whether regular consumption of hot tea is directly or mechanistically causal in reducing total or central body fat, or indeed in limiting adipose storage. Furthermore, it is important to recognize that the assessment of trunk fat based on DXA analyses encompasses both visceral and subcutaneous adipose tissue, as opposed to specific abdominal visceral tissue only. Further experimental research is therefore warranted to corroborate these findings, utilizing more robust measures e.g. magnetic resonance imaging or computed tomography to establish whether regular hot tea consumption specifically modulates abdominal visceral fat reduction.

Finally, another acknowledged limitation of the current study is the use of FFQs to establish consumption levels. Whilst FFQs are widely used in epidemiological research to practically collate population specific intakes, these are nevertheless subject to methodological limitations including quantity underestimation, individual recall bias, and inter-individual variability pertinent to portion size or beverage volume. In addition, pending categories included in the FFQ, certain foods or classifications may be excluded. As such, the use of dietary estimated measures has been challenged, warranting caution when interpreting findings (43,44,45).

Conclusion

Daily consumption of hot tea is associated with lower total and trunk body fat percentage in both men and women. Multivariable adjusted models, taking into consideration in particular ethnicity,

coffee and iced tea consumption, indicate a potential dose response with women requiring more than 1 cup of hot tea per day to be associated with lower trunk body fat percentage compared to men. Therefore, further longitudinal studies are needed to investigate the potential of using hot tea as an important dietary strategy to reduce central adiposity among men.

References

1. Statista. Annual tea consumption worldwide from 2013 to 2021 (in billion liters). [Web page]. https://www.statista.com/statistics/940102/global-tea-consumption. Accessed August 14, 2019.
2. Tea Association of the USA. Tea Fact Sheet – 2018-2019. [Web page]. http://www.teausa.com/14655/tea-fact-sheet. Accessed August 14, 2019.
3. Einöther SJ, Martens VE. Acute effects of tea consumption on attention and mood. *Am J Clin Nutr* 2013;98(6 Suppl):1700S-1708S. doi: 10.3945/ajcn.113.058248.
4. Dietz C, Dekker M. Effect of Green Tea Phytochemicals on Mood and Cognition. *Curr Pharm Des* 2017;23(19):2876-2905. doi: 10.2174/1381612823666170105151800.
5. Camfield DA, Stough C, Farrimond J, Scholey AB. Acute effects of tea constituents L-theanine, caffeine, and epigallocatechin gallate on cognitive function and mood: a systematic review and meta-analysis. *Nutr Rev* 2014;72(8):507-22. doi: 10.1111/nure.12120.
6. Panche AN, Diwan AD, Chandra SR. Flavonoids: an overview. *J. Nutr. Sci* 2016; 5: e47. doi: 10.1017/jns.2016.41.
7. Mukhtar H, Ahmad N. Tea polyphenols: prevention of cancer and optimizing health. *Am. J. Clin. Nutr* 2000;71(6 Suppl):1698S-702S. doi: 10.1093/ajcn/71.6.1698S.
8. Hajiaghaalipour F, Sanusi J, Kanthimathi MS. Temperature and time of steeping affect the antioxidant properties of white, green, and black tea infusions. *J Food Sci* 2016;81(1):H246-54. doi: 10.1111/1750-3841.13149.
9. Chung FL, Schwartz J, Herzog CR, Yang YM. Tea and cancer prevention: studies in animals and humans. *J. Nutr* 2003;133(10):3268S-3274S. doi: 10.1093/jn/133.10.3268S
10. Brausi M, Rizzi F, Bettuzzi S. Chemoprevention of human prostate cancer by green tea catechins: two years later. A follow-up update. *Eur. Urol* 2008;54(2):472-3. doi: 10.1016/j.eururo.2008.03.100.

11. Briel M, Ferreira-Gonzalez I, You JJ, et al. Association between change in high density lipoprotein cholesterol and cardiovascular disease morbidity and mortality: systematic review and meta-regression analysis. *BMJ* 2009; 16;338:b92. doi: 10.1136/bmj.b92.

12. Vernarelli JA, Lambert JD. Tea consumption is inversely associated with weight status and other markers for metabolic syndrome in US adults. *Eur. J. Nutr* 2013;52(3):1039-48. doi: 10.1007/s00394-012-0410-9.

13. Serafini M, Ghiselli A, Ferro-Luzzi A. In vivo antioxidant effect of green and black tea in man. *Eur. J. Clin. Nutr* 1996;50(1):28-32.

14. Hursel R, Viechtbauer W, Westerterp-Plantenga MS. The effects of green tea on weight loss and weight maintenance: a meta-analysis. *Int. J. Obes. (Lond).* 2009;33(9):956-61. doi: 10.1038/ijo.2009.135.

15. Dulloo AG, Duret C, Rohrer D, et al. Efficacy of a green tea extract rich in catechin polyphenols and caffeine in increasing 24-h energy expenditure and fat oxidation in humans. *Am. J. Clin. Nutr.* 1999 Dec;70(6):1040-5. doi: 10.1093/ajcn/70.6.1040.

16. Maki KC, Reeves MS, Farmer M, et al. Green tea catechin consumption enhances exercise-induced abdominal fat loss in overweight and obese adults. *J. Nutr.* 2009;139(2):264-70. doi: 10.3945/jn.108.098293.

17. Hase T, Komine Y, Meguro S, et al. Anti-obesity Effects of Tea Catechins in Humans. *J. Oleo Sci.* 2001; 50 (7): 599-605. doi: https://doi.org/10.5650/jos.50.599.

18. Curtin LR, Mohadjer LK, Dohrmann SM, et al. The National Health and Nutrition Examination Survey: Sample Design, 1999-2006. *Vital Health Stat 2.* 2012(155):1-39.

19. Center for Disease Control. Technical Documentation for the 1999-2004 Dual Energy X-Ray Absorptiometry (DXA) Multiple Imputation Data files 2008.

20. Subar AF, Thompson FE, Kipnis V, et al. Comparative Validation of the Block, Willett, and National Cancer Institute Food Frequency Questionnaires : The Eating at America's Table Study. *Am J Epidemiol.* 2001;154(12):1089-1099.

21. NHANES. 2003-2004 Data Documentation, Codebook, and Frequencies: Food Frequency Questionnaire. [Web page]. https://wwwn.cdc.gov/Nchs/Nhanes/2003-2004/FOODLK_C.htm. Accessed September 4, 2019.

22. NHANES. Documentation, Codebook, and Frequencies: Dual-Energy X-ray Absorptiometry. [Web page]. https://wwwn.cdc.gov/nchs/data/nhanes/dxa/dxx_c.pdf. Accessed August 14, 2019.

23. Yang L, Cao C, Kantor ED, et al. Trends in Sedentary Behavior Among the US Population, 2001-2016. *JAMA*. 2019;321(16):1587-1597. doi: 10.1001/jama.2019.3636.

24. Grabovac I, Smith L, Stefanac S, et al. Health Care Providers' Advice on Lifestyle Modification in the US Population: Results from the NHANES 2011-2016. *Am J Med*. 2019; 132(4), 489-497. doi: 10.1016/j.amjmed.2018.11.021

25. NHANES. Technical Documentation for the 1999-2004: Dual Energy X-Ray Absorptiometry (DXA) Multiple Imputation Data files. [Web page]. https://wwwn.cdc.gov/Nchs/data/nhanes/dxa/dxa_techdoc.pdf. Accessed September 4, 2019.

26. Flegal KM, Shepherd JA, Looker AC, et al. Comparisons of percentage body fat, body mass index, waist circumference, and waist-stature ratio in adults. *Am J Clin Nutr*. 2009;89(2):500-508.

27. Geer EB, Shen W. Gender differences in insulin resistance, body composition, and energy balance. *Gender medicine.* 2009;6 Suppl 1(Suppl 1):60-75.

28. Sachdev PS, Mohan A, Taylor L, et al. DSM-5 and mental disorders in older individuals: an overview. *Harv Rev Psychiatry*. 2015;23(5):320–328.

29. NHANES. National Health and Nutrition Examination Survey: Analytic Guidelines, 1999–2010, [Web page]. https://www.cdc.gov/nchs/data/series/sr_02/sr02_161.pdf. Accessed August 14, 2019.

30. Hodgson AB, Randell RK, Jeukendrup AE. The Effect of Green Tea Extract on Fat Oxidation at Rest and during Exercise: Evidence of Efficacy and Proposed Mechanisms. *Adv. Nutr.* 2013; 4(2): 129–140. doi: 10.3945/an.112.003269.

31. Zhu BT. Catechol-O-Methyltransferase (COMT)-mediated methylation metabolism of endogenous bioactive catechols and modulation by endobiotics and xenobiotics: importance in pathophysiology and pathogenesis. *Curr. Drug Metab.* 2002;3:321–49.

32. Wolfram S, Raederstorff D, Wang Y, Teixeira SR, Elste V, Weber P. TEAVIGO (epigallocatechin gallate) supplementation prevents obesity in rodents by reducing adipose tissue mass. *Ann. Nutr. Metab.* 2005;49:54–63. doi: 10.1159/000084178.

33. Friedrich M, Petzke KJ, Raederstorff D, Wolfram S, Klaus S. Acute effects of epigallocatechin gallate from green tea on oxidation and tissue incorporation of dietary lipids in mice fed a high-fat diet. *Int. J. Obes. (Lond).* 2011;36:735–43. doi: 10.1038/ijo.2011.136.

34. Huang J, Wang Y, Xie Z, Zhou Y, Zhang Y, Wan X. The anti-obesity effects of green tea in human intervention and basic molecular studies. *Eur. J. Clin. Nutr.* 2014;68(10):1075-87. doi: 10.1038/ejcn.2014.143.

35. Henning SM, Fajardo-Lira C, Lee HW, Youssefian AA, Go VL, Heber D. Catechin content of 18 teas and a green tea extract supplement correlates with the antioxidant capacity. *Nutr. Cancer.* 2003;45(2):226-35. doi: 10.1207/S15327914NC4502_13.

36. Komes D, Horžić D, Belščak A, Ganić KK, Vulić I. Green tea preparation and its influence on the content of bioactive compounds. *Food Res. Int.* 2010; 43 (1):167-176. doi : 10.1016/j.foodres.2009.09.022.

37. Shishikura Y, Khokhar S. Factors affecting the levels of catechins and caffeine in tea beverage: estimated daily intakes and antioxidant activity. *J. Sci Food Agri.* 2005; 85 (12): 2125-2133. doi: https://doi.org/10.1002/jsfa.2206.

38. Labbé DP,Tremblay A, Bazinet L. Effect of Brewing Temperature and Duration on Green Tea Catechin Solubilization: Basis for Production of EGC and EGCG-Enriched Fractions. *Sep Purif Technol* 2006; 49(1):1-9. doi: 10.1016/j.seppur.2005.07.038.

39. Warden BA, Smith LS, Beecher GR, Balentine DA, Clevidence BA. Catechins are bioavailable in men and women drinking black tea throughout the day. *J. Nutr*. 2001; 131(6):1731-7. doi: 10.1093/jn/131.6.1731.

40. Hughes LA, Arts IC, Ambergen T, et al. Higher dietary flavone, flavonol, and catechin intakes are associated with less of an increase in BMI over time in women: a longitudinal analysis from the Netherlands Cohort Study. *Am J Clin Nutr.* 2008;88(5):1341-52. doi:: 10.3945/ajcn.2008.26058.

41. Karastergiou K, Smith SR, Greenberg AS, Fried SK. Sex differences in human adipose tissues – the biology of pear shape. *Biol. Sex Differ*. 2012; 3: 13. doi: 10.1186/2042-6410-3-13.

42. Donnelly JE, Blair SN, Jakicic JM, et al. American College of Sports Medicine Position Stand. Appropriate physical activity intervention strategies for weight loss and prevention of weight regain for adults. *Med Sci Sports Exerc.* 2009;41(2):459-71. doi: 10.1249/MSS.0b013e3181949333.

43. Archer E, Pavela G, Lavie CJ. The Inadmissibility of What We Eat in America and NHANES Dietary Data in Nutrition and Obesity Research and the Scientific Formulation of National Dietary Guidelines. *Mayo Clin Proc*. 2015;90(7):911-26. doi: 10.1016/j.mayocp.2015.04.009.

44. Schoeller DA. Limitations in the assessment of dietary energy intake by self-report. *Metabolism*. 1995;44(2 Suppl 2):18-22. doi: 10.1016/0026-0495(95)90204-x

45. Schoeller DA, Thomas D, Archer E. Self-report-based estimates of energy intake offer an inadequate basis for scientific conclusions. *Am J Clin Nutr.* 2013;97(6):1413-5. doi: 10.3945/ajcn.113.062125.

Table 1. Characteristics of the US Adults 20-69 Years from the NHANES 2003-2006, According to Daily Hot Tea Consumption[a]

Characteristic	Men (N=2,734)				Women (N=2,947)			
	No hot tea (N=1,412)	0-0.25 cup (N=910)	0.25-1 cup (N=206)	1+ cup (N=206)	No hot tea (N=1,073)	0-0.25 cup (N=1,116)	0.25-1 cup (N=396)	1+ cup (N=352)
Age (yr)								
Mean (s.e.)	44.8 (0.4)	46.0 (0.7)	48.1 (1.1)	50.9 (1.5)	44.4 (0.7)	46.2 (0.6)	49.6 (1.2)	51.7 (0.9)
Race/ethnicity (%)								
Non-Hispanic White	53.3	34.4	6.2	6.1	35.4	39.9	13.3	11.4
Non-Hispanic Black	48.8	35.5	8.0	7.7	34.8	41.6	14.8	8.9
Hispanic	59.8	26.7	7.5	6.0	41.7	36.2	11.2	10.9
Other	38.1	39.2	8.0	14.8	37.0	31.6	11.4	20.0
Annual Household Income (%)								
<$25,000	54.6	30.0	8.8	7.1	42.3	32.0	11.7	14.1
$25,000-74,999	57.0	32.7	5.3	5.1	36.8	40.0	13.6	9.0
≥$75,000	54.8	38.2	7.2	8.8	29.2	44.5	14.2	12.2
Education (%)								
<High School	64.8	22.3	6.7	6.2	48.2	28.0	11.4	12.5
High School	65.1	26.6	3.8	4.5	42.6	37.3	10.4	9.7
>High school	43.6	40.7	7.9	7.9	30.3	42.9	14.8	12.0
MVPA (%)								
No	61.1	27.6	6.0	5.3	44.6	33.7	11.3	10.4
Yes	49.2	36.7	6.8	7.3	32.1	41.8	14.0	12.1
Smoke status (%)								
Never	49.4	35.5	8.2	6.9	34.2	39.7	15.2	11.0
Former	47.8	38.4	5.1	8.7	30.0	41.6	13.0	15.3
Current	62.9	27.1	5.6	4.4	47.1	35.5	8.0	9.7
Diabetes (%)								
No	52.8	33.9	6.6	6.7	35.8	39.5	13.1	11.5
Yes	51.9	34.8	6.7	6.7	39.0	35.6	14.0	11.5
TV Watching (hours/day)								
Mean (s.e.)	2.5 (0.05)	2.3 (0.06)	2.2 (0.11)	2.1 (0.12)	2.4 (0.07)	2.2 (0.06)	2.2 (0.08)	2.3 (0.09)
PC Use (hours/day)								
Mean (s.e.)	0.8 (0.04)	0.9 (0.06)	0.9 (0.07)	0.8 (0.07)	0.7 (0.04)	0.8 (0.03)	0.8 (0.07)	0.7 (0.06)
HEI-2010[b]								

Mean (s.e.)	46.6 (0.4)	51 (0.8)	53.2 (1.4)	56.6 (1.2)	47.9 (0.7)	52.6 (0.5)	56.7 (1.0)	57.1 (0.9)

[a] All estimates were weighted to be nationally representative.

[b] The Healthy Eating Index 2010

Table 2. Association of Hot Tea Consumption and Body Fat Percentage Among Men from the NHANES 2003-2006, by Age Group

	β-Coefficient (95% CI)					
	All age		20-44 years		45-69 years	
	Age-adjusted	MV-adjusted[a]	Age-adjusted	MV-adjusted[a]	Age-adjusted	MV-adjusted[a]
Total body fat %						
None	0 [Reference]	0 [Reference]	0 [Reference]	0 [Reference]	0 [Reference]	0 [Reference]
0-0.25 cup/day	-0.8 (-1.4 to -0.2)	-0.7 (-1.3 to -0.1)	-1.4 (-2.3 to -0.5)	-1.4 (-2.2 to -0.5)	-0.3 (-1.0 to 0.5)	-0.1 (-0.9 to 0.6)
0.25-1 cup/day	-2.3 (-3.4 to -1.3)	-1.5 (-2.6 to -0.4)	-2.4 (-4.1 to -0.8)	-1.2 (-2.9 to 0.5)	-2.2 (-3.5 to -0.9)	-1.6 (-3.0 to -0.3)
1+ cup/day	-1.5 (-2.5 to -0.5)	-0.7 (-1.6 to 0.3)	-1.5 (-3.3 to 0.3)	-0.3 (-2.3 to 1.8)	-1.3 (-2.5 to -0.1)	-1.2 (-2.3 to -0.2)
Trunk body fat %						
None	0 [Reference]	0 [Reference]	0 [Reference]	0 [Reference]	0 [Reference]	0 [Reference]
0-0.25 cup/day	-1.0 (-1.7 to -0.3)	-0.8 (-1.5 to -0.1)	-2.0 (-3.0 to -0.9)	-1.8 (-2.8 to -0.8)	-0.2 (-1.1 to 0.7)	0.01 (-0.8 to 0.8)
0.25-1 cup/day	-2.7 (-4.0 to -1.5)	-1.7 (-3.0 to -0.4)	-3.2 (-5.2 to -1.3)	-1.7 (-3.6 to 0.2)	-2.3 (-3.8 to -0.8)	-1.5 (-3.0 to 0)
1+ cup/day	-1.7 (-2.9 to -0.5)	-0.7 (-1.9 to 0.4)	-1.6 (-4.0 to 0.7)	-0.1 (-2.6 to 2.3)	-1.5 (-2.9 to -0.1)	-1.3 (-2.6 to -0.1)

[a] All multivariable (MV) adjusted models were adjusted for age (continuous), race/ethnicity (non-Hispanic White, non-Hispanic Black, Hispanic, Asian, others), household income, leisure time physical activity, education level, smoking status, comorbidity (hypertension, high blood cholesterol, coronary heart diseases, osteoarthritis, stroke, and diabetes), added sugar/creamer/milk use, sugar-added beverage, alcohol intake (wine, beer, and liquor), coffee, ice tea, dietary supplement use (EGCG and green tea extracts), the Healthy Eating Index-2010(continues) and intention to lose/control weight.

Table 3. Association of Hot Tea Consumption and Body Fat Percentage Among Women from the NHANES 2003-2006, by Age Group

	β-Coefficient (95% CI)					
	All age		20-44 years		45-69 years	
	Age-adjusted	MV-adjusted[a]	Age-adjusted	MV-adjusted[a]	Age-adjusted	MV-adjusted[a]
Total body fat %						
None	0 [Reference]	0 [Reference]	0 [Reference]	0 [Reference]	0 [Reference]	0 [Reference]
0-0.25 cup/day	-0.9 (-1.6 to -0.3)	-0.1 (-0.7 to 0.6)	-1.3 (-2.2 to -0.3)	0.1 (-1.0 to 1.1)	-0.6 (-1.6 to 0.4)	-0.3 (-1.2 to 0.7)
0.25-1 cup/day	-1.3 (-2.2 to -0.4)	-0.1 (-1.1 to 1.0)	-1.7 (-3.5 to 0.1)	0.2 (-1.4 to 1.8)	-1.0 (-2.0 to -0.1)	-0.3 (-1.4 to 0.8)
1+ cup/day	-2.3 (-3.2 to -1.4)	-0.8 (-1.7 to 0.1)	-3.3 (-4.8 to -1.8)	-1.0 (-2.6 to 0.5)	-1.7 (-2.8 to -0.5)	-0.7 (-1.8 to 0.4)
Trunk body fat %						
None	0 [Reference]	0 [Reference]	0 [Reference]	0 [Reference]	0 [Reference]	0 [Reference]
0-0.25 cup/day	-1.1 (-2.0 to -0.2)	-0.01 (-0.7 to 0.7)	-1.7 (-2.9 to -0.4)	-0.02 (-1.3 to 1.3)	-0.7 (-1.9 to 0.6)	-0.02 (-1.0 to 0.9)
0.25-1 cup/day	-1.6 (-2.8 to -0.3)	-0.01 (-1.4 to 1.3)	-2.2 (-4.5 to 0.1)	0.4 (-1.7 to 2.4)	-1.2 (-2.5 to 0.1)	-0.3 (-1.7 to 1.1)
1+ cup/day	-3.3 (-4.5 to -2.1)	-1.5 (-2.7 to -0.3)	-4.7 (-6.8 to -2.6)	-1.9 (-4.0 to 0.1)	-2.4 (-3.6 to -1.1)	-1.3 (-2.7 to 0.1)

[a] All multivariable (MV) adjusted models were adjusted for age (continuous), race/ethnicity (non-Hispanic White, non-Hispanic Black, Hispanic, Asian, others), household income, leisure time physical activity, education level, smoking status, menopause status, comorbidity (hypertension, high blood cholesterol, coronary heart diseases, osteoarthritis, stroke, and diabetes), added sugar/creamer/milk use, sugar-added beverage, alcohol intake (wine, beer, and liquor), coffee, ice tea, dietary supplement use (EGCG and green tea extracts), the Healthy Eating Index-2010(continues) and intention to lose/control weight.

eTable 1. Weighted Body Fat Percentage Among Adults from the NHANES 2003-2006, by Weight Status

	Body fat %, mean (95% CI)					
	Normal		Overweight		Obese	
	Men	Women	Men	Women	Men	Women
Total body fat %						
Overall	23.1 (22.6 to 23.6)	34.3 (33.9 to 34.8)	28.1 (27.7 to 28.5)	40.9 (40.5 to 41.3)	33.4 (33.1 to 33.7)	46.0 (45.6 to 46.4)
None	22.8 (22.2 to 23.4)	34.8 (34.1 to 35.5)	28.2 (27.6 to 28.9)	40.8 (40.4 to 41.3)	33.6 (33.2 to 34.0)	45.9 (45.4 to 46.4)
0-0.25 cup/day	23.3 (22.6 to 24.0)	34.0 (33.3 to 34.7)	28.0 (27.6 to 28.5)	40.9 (40.3 to 41.4)	33.1 (32.7 to 33.6)	46.1 (45.6 to 46.7)
0.25-1 cup/day	22.8 (21.6 to 24.1)	34.6 (33.2 to 36.0)	27.0 (26.1 to 27.9)	40.8 (39.8 to 41.8)	33.5 (32.3 to 34.7)	45.7 (44.9 to 46.4)
1+ cup/day	24.1 (22.6 to 25.5)	34.0 (33.1 to 34.8)	28.1 (26.7 to 29.6)	41.6 (40.6 to 42.6)	33.2 (32.1 to 34.3)	46.3 (45.4 to 47.2)
Trunk body fat %						
Overall	22.6 (22.0 to 23.2)	30.6 (30.2 to 31.1)	29.3 (28.9 to 29.8)	39.3 (39.0 to 39.7)	35.6 (35.3 to 36.0)	45.9 (45.6 to 46.3)
None	22.2 (21.5 to 22.9)	31.1 (30.4 to 31.8)	29.5 (28.8 to 30.2)	39.4 (38.8 to 40.0)	35.7 (35.3 to 36.2)	45.9 (45.3 to 46.5)
0-0.25 cup/day	22.7 (21.9 to 23.6)	30.2 (29.2 to 31.1)	29.3 (28.8 to 29.8)	39.4 (38.9 to 39.8)	35.4 (34.7 to 36.0)	46.2 (45.6 to 46.8)
0.25-1 cup/day	22.5 (20.8 to 24.3)	31.2 (29.6 to 32.9)	28.2 (27.1 to 29.2)	39.1 (37.9 to 40.4)	35.8 (34.3 to 37.3)	45.5 (44.7 to 46.4)
1+ cup/day	24.6 (23.0 to 26.3)	30.3 (29.2 to 31.5)	29.1 (27.5 to 30.8)	39.5 (38.3 to 40.7)	35.7 (34.3 to 37.0)	45.8 (44.8 to 46.8)

eTable 2.Weighted multivariable adjusted models of Body Fat Percentage Among Men from the NHANES 2003-2006, by Age Group

	β-Coefficient (95% CI)					
	Total body fat %			Trunk body fat %		
	All age	20-44 years	45-69 years	All age	20-44 years	45-69 years
Hot tea consumption						
None	0 [Reference]	0 [Reference]	0 [Reference]	0 [Reference]	0 [Reference]	0 [Reference]
0-0.25 cup/day	-0.7 (-1.3 to -0.1)	-1.4 (-2.2 to -0.5)	-0.1 (-0.9 to 0.6)	-0.8 (-1.5 to -0.1)	-1.8 (-2.8 to -0.8)	0 (-0.8 to 0.8)
0.25-1 cup/day	-1.5 (-2.6 to -0.4)	-1.2 (-2.9 to 0.5)	-1.6 (-2.9 to -0.3)	-1.7 (-3 to -0.4)	-1.7 (-3.6 to 0.2)	-1.5 (-3 to 0)
1+ cup/day	-0.7 (-1.6 to 0.3)	-0.3 (-2.3 to 1.8)	-1.2 (-2.3 to -0.2)	-0.7 (-1.9 to 0.4)	-0.1 (-2.6 to 2.3)	-1.3 (-2.6 to -0.1)
Age (yr)	0.1 (0 to 0.1)	0.1 (0 to 0.2)	0 (0 to 0.1)	0.1 (0.1 to 0.1)	0.2 (0.1 to 0.3)	0 (0 to 0.1)
Race/ethnicity (%)						
Non-Hispanic White	0 [Reference]	0 [Reference]	0 [Reference]	0 [Reference]	0 [Reference]	0 [Reference]
Non-Hispanic Black	-1.3 (-1.8 to -0.7)	-0.6 (-1.5 to 0.4)	-2.2 (-3.4 to -1)	-1.7 (-2.4 to -1)	-1 (-2.1 to 0.1)	-2.9 (-4.3 to -1.5)
Hispanic	0.8 (0 to 1.5)	1.1 (0 to 2.2)	-0.3 (-1.5 to 0.9)	1.7 (0.7 to 2.7)	2.1 (0.8 to 3.4)	0.4 (-1 to 1.8)
Other	0.5 (-0.6 to 1.5)	0.4 (-1.2 to 1.9)	0.6 (-0.7 to 1.9)	1 (-0.3 to 2.3)	1.1 (-0.9 to 3)	1.2 (-0.2 to 2.6)
Smoke status						
Never	0 [Reference]	0 [Reference]	0 [Reference]	0 [Reference]	0 [Reference]	0 [Reference]
Former	-0.2 (-0.8 to 0.5)	0.5 (-0.6 to 1.6)	-0.5 (-1.2 to 0.2)	-0.3 (-1.1 to 0.6)	0.3 (-0.9 to 1.6)	-0.4 (-1.2 to 0.4)
Current	-1.7 (-2.4 to -0.9)	-1.7 (-2.9 to -0.6)	-1.5 (-2.6 to -0.5)	-2.1 (-2.9 to -1.2)	-2.1 (-3.4 to -0.8)	-2 (-3.2 to -0.7)
MVPA						
No	1.1 (0.6 to 1.7)	1.3 (0.5 to 2.1)	0.9 (0.2 to 1.5)	1.3 (0.6 to 1.9)	1.4 (0.5 to 2.3)	0.9 (0.2 to 1.6)
Yes	0 [Reference]	0 [Reference]	0 [Reference]	0 [Reference]	0 [Reference]	0 [Reference]
TV Watching (hours/day)	0.3 (0.1 to 0.4)	0.3 (0.2 to 0.7)	0.3 (0.1 to 0.5)	0.3 (0.1 to 0.5)	0.4 (0.2 to 0.7)	0.3 (0.1 to 0.6)
PC Use (hours/day)	0.3 (0.1 to 0.5)	0.2 (0.1 to 0.5)	0.5 (0.1 to 0.8)	0.3 (0.1 to 0.6)	0.2 (0.2 to 0.6)	0.6 (0.2 to 0.9)
Annual Household Income						
<$25,000	0 [Reference]	0 [Reference]	0 [Reference]	0 [Reference]	0 [Reference]	0 [Reference]
$25,000-74,999	0.8 (0.3 to 1.2)	1.2 (0.4 to 2.1)	0.1 (-0.6 to 0.8)	1.1 (0.5 to 1.6)	1.8 (0.7 to 2.8)	0.1 (-0.9 to 1)
≥$75,000	0.9 (0.2 to 1.5)	1 (0.1 to 1.9)	0.3 (-0.8 to 1.3)	1.5 (0.7 to 2.3)	1.6 (0.6 to 2.7)	0.4 (-0.9 to 1.7)
Education						
<High School	0 [Reference]	0 [Reference]	0 [Reference]	0 [Reference]	0 [Reference]	0 [Reference]
High School	0.8 (0 to 1.7)	0.4 (-0.7 to 1.5)	0.9 (-0.1 to 2)	1.2 (0.1 to 2.2)	0.4 (-0.8 to 1.7)	1.2 (0 to 2.4)
>High school	0 (-0.9 to 0.8)	-0.3 (-1.7 to 1.1)	0.1 (-1.1 to 1.3)	0 (-1.1 to 1)	-0.4 (-2 to 1.2)	0 (-1.4 to 1.4)

Hypertension						
No	0 [Reference]	0 [Reference]	0 [Reference]	0 [Reference]	0 [Reference]	0 [Reference]
Yes	1.6 (1.2 to 2.1)	2.6 (1.7 to 3.4)	1.1 (0.5 to 1.7)	2.3 (1.8 to 2.8)	3.3 (2.3 to 4.2)	1.7 (0.9 to 2.5)
High blood cholesterol						
No	0 [Reference]	0 [Reference]	0 [Reference]	0 [Reference]	0 [Reference]	0 [Reference]
Yes	0.7 (0.2 to 1.2)	0.3 (-0.4 to 1.1)	0.7 (0.1 to 1.3)	1.2 (0.6 to 1.7)	0.7 (-0.2 to 1.7)	1.1 (0.4 to 1.8)
Coronary heart diseases						
No	0 [Reference]	0 [Reference]	0 [Reference]	0 [Reference]	0 [Reference]	0 [Reference]
Yes	0.2 (-0.7 to 1.1)	-0.7 (-3.9 to 2.6)	0.5 (-0.4 to 1.4)	0.1 (-0.9 to 1)	-1.4 (-5.1 to 2.3)	0.6 (-0.4 to 1.7)
Osteoarthritis						
No	0 [Reference]	0 [Reference]	0 [Reference]	0 [Reference]	0 [Reference]	0 [Reference]
Yes	0.8 (0 to 1.6)	1.1 (-0.6 to 2.8)	0.7 (-0.2 to 1.6)	0.9 (-0.1 to 1.8)	1.1 (-0.9 to 3.1)	0.8 (-0.1 to 1.8)
Stroke						
No	0 [Reference]	0 [Reference]	0 [Reference]	0 [Reference]	0 [Reference]	0 [Reference]
Yes	0.6 (-0.8 to 1.9)	-1.2 (-7.2 to 4.7)	1 (-0.5 to 2.5)	0.4 (-1.2 to 1.9)	-0.1 (-8 to 7.8)	0.9 (-0.7 to 2.5)
Diabetes						
No	0 [Reference]	0 [Reference]	0 [Reference]	0 [Reference]	0 [Reference]	0 [Reference]
Yes	1.1 (0.1 to 2.2)	1.5 (-0.3 to 3.3)	1.2 (0.1 to 2.4)	1.7 (0.6 to 2.7)	2.1 (-0.1 to 4.3)	1.8 (0.6 to 2.9)
Added sugar*	-0.4 (0.1 to -0.2)	-0.6 (0.2 to -0.1)	-0.4 (0.2 to -0.1)	-0.4 (0.1 to -0.2)	-0.6 (0.2 to -0.1)	-0.5 (0.2 to -0.1)
Added sweetener*	0.1 (0.2 to 0.4)	-0.5 (0.3 to 0.1)	0.4 (0.2 to 0.7)	0.1 (0.2 to 0.4)	-0.5 (0.4 to 0.3)	0.4 (0.2 to 0.8)
Added creamer*	0.1 (0.1 to 0.4)	0.1 (0.3 to 0.6)	0.1 (0.2 to 0.4)	0.2 (0.2 to 0.5)	0.3 (0.3 to 0.9)	0.2 (0.2 to 0.5)
Added half & half*	0.2 (0.2 to 0.6)	0.8 (0.4 to 1.6)	-0.1 (0.2 to 0.2)	0.2 (0.2 to 0.6)	0.8 (0.4 to 1.6)	-0.2 (0.2 to 0.2)
Added milk*	-0.2 (0.2 to 0.2)	-0.3 (0.2 to 0.2)	-0.1 (0.2 to 0.3)	-0.2 (0.2 to 0.2)	-0.4 (0.3 to 0.2)	-0.1 (0.2 to 0.4)
Soda during summer*	0.3 (0.2 to 0.7)	0.5 (0.3 to 1.1)	0.1 (0.2 to 0.5)	0.5 (0.2 to 0.9)	0.7 (0.3 to 1.3)	0.2 (0.2 to 0.7)
Soda during other seasons*	-0.1 (0.2 to 0.4)	-0.2 (0.3 to 0.4)	0.1 (0.2 to 0.6)	-0.1 (0.3 to 0.4)	-0.3 (0.3 to 0.4)	0.1 (0.3 to 0.7)
Beer during summer*	-0.4 (0.2 to -0.1)	-0.2 (0.3 to 0.5)	-0.6 (0.3 to 0)	-0.4 (0.2 to 0)	-0.3 (0.4 to 0.5)	-0.5 (0.3 to 0.2)
Beer during other seasons*	0 (0.2 to 0.4)	-0.4 (0.4 to 0.4)	0.3 (0.3 to 1)	0 (0.2 to 0.4)	-0.3 (0.5 to 0.6)	0.3 (0.4 to 1)
Wine*	-0.2 (0.5 to 0.8)	0.1 (0.6 to 1.4)	-0.4 (0.8 to 1.3)	-0.4 (0.5 to 0.7)	0.1 (0.7 to 1.4)	-0.7 (0.9 to 1.2)
Liquor*	0 (0.3 to 0.6)	-0.3 (0.3 to 0.4)	0.4 (0.6 to 1.7)	0 (0.4 to 0.8)	-0.2 (0.4 to 0.6)	0.5 (0.7 to 1.9)
Intension to lose weight						
No	0 [Reference]	0 [Reference]	0 [Reference]	0 [Reference]	0 [Reference]	0 [Reference]

Yes	2.5 (1.8 to 3.1)	3.3 (2.1 to 4.5)	1.6 (0.8 to 2.3)	3.2 (2.5 to 3.9)	4.2 (2.8 to 5.6)	1.9 (1.1 to 2.7)
Intension to not gain weight						
No	0 [Reference]	0 [Reference]	0 [Reference]	0 [Reference]	0 [Reference]	0 [Reference]
Yes	1 (0.5 to 1.5)	1.1 (0.4 to 1.8)	0.9 (0.2 to 1.6)	1.2 (0.6 to 1.9)	1.1 (0.2 to 2)	1.2 (0.3 to 2.1)
HEI-2010	0 (-0.1 to 27.8)	0 (-0.1 to 27.4)	0 (-0.1 to 28)	0 (-0.1 to 28)	0 (-0.1 to 26.8)	0 (-0.1 to 27.8)
Coffee drink*	0.1 (0.1 to 0.3)	0.1 (0.2 to 0.4)	0 (0.1 to 0.2)	0.1 (0.1 to 0.3)	0.1 (0.2 to 0.4)	-0.1 (0.1 to 0.2)
Iced tea drink*	0.6 (0.2 to 0.9)	1 (0.2 to 1.5)	0.4 (0.2 to 0.7)	0.7 (0.2 to 1.1)	1.2 (0.3 to 1.7)	0.4 (0.2 to 0.9)
EGCG use						
No	0 [Reference]	0 [Reference]	0 [Reference]	0 [Reference]	0 [Reference]	0 [Reference]
Yes	-0.9 (-2 to 0.3)	-0.7 (-2.4 to 1)	-0.8 (-2.7 to 1.2)	-1 (-2.2 to 0.3)	-0.7 (-2.6 to 1.2)	-0.7 (-2.8 to 1.4)

* These variables based on the frequency of intake

eTable 3.Weighted multivariable adjusted models of Body Fat Percentage Among Women from the NHANES 2003-2006, by Age Group

	β-Coefficient (95% CI)					
	Total body fat %			Trunk body fat %		
	All age	20-44 years	45-69 years	All age	20-44 years	45-69 years
Hot tea consumption						
None	0 [Reference]	0 [Reference]	0 [Reference]	0 [Reference]	0 [Reference]	0 [Reference]
0-0.25 cup/day	-0.1 (-0.7 to 0.6)	0.1 (-1 to 1.1)	-0.3 (-1.2 to 0.7)	0 (-0.7 to 0.7)	0 (-1.3 to 1.3)	0 (-1 to 0.9)
0.25-1 cup/day	-0.1 (-1.1 to 1)	0.2 (-1.4 to 1.8)	-0.3 (-1.4 to 0.8)	0 (-1.4 to 1.3)	0.4 (-1.7 to 2.4)	-0.3 (-1.7 to 1.1)
1+ cup/day	-0.8 (-1.7 to 0.1)	-1 (-2.5 to 0.5)	-0.7 (-1.8 to 0.4)	-1.5 (-2.7 to -0.3)	-1.9 (-4 to 0.1)	-1.3 (-2.7 to 0.1)
Age (yr)	0.1 (0 to 0.1)	0.1 (0.1 to 0.2)	0 (-0.1 to 0)	0.1 (0 to 0.1)	0.2 (0.1 to 0.3)	0 (-0.1 to 0)
Race/ethnicity (%)						
Non-Hispanic White	0 [Reference]	0 [Reference]	0 [Reference]	0 [Reference]	0 [Reference]	0 [Reference]
Non-Hispanic Black	1 (-0.3 to 2.3)	0.8 (-1 to 2.6)	1.3 (-0.6 to 3.2)	0.5 (-1 to 2)	0.7 (-1.5 to 2.9)	0.2 (-1.8 to 2.2)
Hispanic	1.8 (0.5 to 3.1)	2.2 (0.3 to 4.1)	1.1 (-0.8 to 2.9)	2 (0.5 to 3.4)	3.2 (1 to 5.5)	0 (-1.9 to 1.9)
Other	2.5 (1.1 to 3.9)	2.2 (0.3 to 4.1)	2.3 (0.2 to 4.4)	3.1 (1.5 to 4.8)	3.3 (1.1 to 5.5)	2.2 (-0.1 to 4.5)
Menopause						
No	0 [Reference]	0 [Reference]	0 [Reference]	0 [Reference]	0 [Reference]	0 [Reference]
Yes	-1.6 (-2.5 to -0.7)	-1 (-3 to 1)	-2.2 (-3.2 to -1.1)	-1.8 (-3 to -0.7)	-1.6 (-4.1 to 0.9)	-2.4 (-3.8 to -1)
Smoke status						
Never	0 [Reference]	0 [Reference]	0 [Reference]	0 [Reference]	0 [Reference]	0 [Reference]
Former	0.4 (-0.3 to 1.2)	1.3 (-0.2 to 2.7)	-0.1 (-0.9 to 0.6)	0.8 (-0.1 to 1.8)	1.8 (0.1 to 3.5)	0.2 (-0.8 to 1.1)
Current	-1.1 (-2 to -0.2)	-0.6 (-1.7 to 0.4)	-2.2 (-3.5 to -0.8)	-0.8 (-1.8 to 0.3)	-0.2 (-1.6 to 1.1)	-2.1 (-3.7 to -0.6)
MVPA						
No	1.4 (0.8 to 2.1)	1.2 (0 to 2.4)	1.6 (0.8 to 2.3)	1.7 (0.9 to 2.4)	1.4 (-0.1 to 2.8)	1.8 (0.9 to 2.7)
Yes	0 [Reference]	0 [Reference]	0 [Reference]	0 [Reference]	0 [Reference]	0 [Reference]
TV Watching (hours/day)	0.1 (0.6 to 4.5)	0.2 (0.7 to 2.4)	0.1 (0.8 to 5.3)	0.1 (0.7 to 4.2)	0.2 (0.8 to 2.3)	0.1 (0.9 to 5.1)
PC Use (hours/day)	0.1 (0.6 to 2.6)	0.2 (0.7 to 2.1)	0.2 (0.7 to 2.2)	0.2 (0.7 to 2.1)	0.2 (0.8 to 1.7)	0.2 (0.8 to 1.6)
Annual Household Income						
<$25,000	0 [Reference]	0 [Reference]	0 [Reference]	0 [Reference]	0 [Reference]	0 [Reference]
$25,000-74,999	0.1 (-0.6 to 0.8)	0.3 (-0.9 to 1.5)	-0.3 (-1.2 to 0.6)	0 (-0.8 to 0.8)	0.1 (-1.3 to 1.6)	-0.5 (-1.6 to 0.7)

≥$75,000	-0.3 (-1.3 to 0.7)	-0.1 (-1.5 to 1.4)	-0.9 (-2.4 to 0.5)	-0.3 (-1.6 to 1)	-0.3 (-2.1 to 1.6)	-1.1 (-3 to 0.7)
Education						
<High School	0 [Reference]	0 [Reference]	0 [Reference]	0 [Reference]	0 [Reference]	0 [Reference]
High School	0.3 (-0.6 to 1.1)	-1.2 (-2.4 to 0.1)	0.9 (0.1 to 1.8)	0.3 (-0.8 to 1.3)	-1.6 (-3.2 to 0.1)	1 (0 to 2)
>High school	0.1 (-1 to 1.1)	-2 (-3.3 to -0.7)	1.4 (0.5 to 2.4)	-0.3 (-1.4 to 0.9)	-2.8 (-4.4 to -1.1)	1.4 (0.3 to 2.6)
Hypertension						
No	0 [Reference]	0 [Reference]	0 [Reference]	0 [Reference]	0 [Reference]	0 [Reference]
Yes	2 (1.3 to 2.7)	2 (0.8 to 3.1)	2 (1.2 to 2.8)	3.1 (2.3 to 3.9)	3.2 (1.8 to 4.7)	2.9 (2 to 3.8)
High blood cholesterol						
No	0 [Reference]	0 [Reference]	0 [Reference]	0 [Reference]	0 [Reference]	0 [Reference]
Yes	0.8 (0.2 to 1.5)	1.5 (0.4 to 2.6)	0.5 (-0.4 to 1.3)	1.5 (0.7 to 2.3)	2.5 (1.1 to 3.9)	0.9 (-0.1 to 1.9)
Coronary heart diseases		0 (0 to 0)	0 (0 to 0)	0 (0 to 0)	0 (0 to 0)	0 (0 to 0)
No	0 [Reference]	0 [Reference]	0 [Reference]	0 [Reference]	0 [Reference]	0 [Reference]
Yes	-0.7 (-1.8 to 0.4)	1.3 (-5.2 to 7.8)	-0.5 (-1.5 to 0.6)	-1.2 (-2.6 to 0.1)	1.7 (-5.5 to 8.9)	-0.8 (-2.1 to 0.4)
Osteoarthritis						
No	0 [Reference]	0 [Reference]	0 [Reference]	0 [Reference]	0 [Reference]	0 [Reference]
Yes	1.2 (0.5 to 2)	1.5 (0.2 to 2.8)	1.2 (0.3 to 2.1)	1.2 (0.5 to 2)	1.6 (-0.1 to 3.2)	1.2 (0.3 to 2.1)
Stroke						
No	0 [Reference]	0 [Reference]	0 [Reference]	0 [Reference]	0 [Reference]	0 [Reference]
Yes	-1 (-2.6 to 0.6)	-3.6 (-5.5 to -1.6)	-0.1 (-1.8 to 1.6)	-1 (-2.8 to 0.9)	-4.2 (-7.7 to -0.7)	0.2 (-1.8 to 2.2)
Diabetes						
No	0 [Reference]	0 [Reference]	0 [Reference]	0 [Reference]	0 [Reference]	0 [Reference]
Yes	0.5 (-0.6 to 1.6)	2.3 (-1 to 5.6)	0.1 (-1 to 1.1)	1.7 (0.5 to 2.9)	4.7 (1.2 to 8.3)	1.1 (-0.1 to 2.2)
Added sugar*	0 (-0.2 to 0.3)	0 (-0.4 to 0.5)	0.1 (-0.2 to 0.3)	0.1 (-0.2 to 0.4)	0 (-0.5 to 0.5)	0.2 (-0.1 to 0.4)
Added sweetener*	0.2 (-0.1 to 0.5)	0.4 (-0.4 to 1.1)	0.1 (-0.3 to 0.4)	0.3 (0 to 0.7)	0.4 (-0.4 to 1.2)	0.3 (-0.1 to 0.7)
Added creamer*	0.2 (-0.1 to 0.4)	-0.1 (-0.5 to 0.3)	0.3 (-0.1 to 0.7)	0.4 (0 to 0.7)	0 (-0.4 to 0.4)	0.4 (0 to 0.9)
Added half & half*	0.4 (-0.1 to 0.8)	0.5 (-0.1 to 1.1)	0.2 (-0.4 to 0.8)	0.4 (-0.2 to 1)	0.9 (0.1 to 1.7)	0 (-0.7 to 0.7)
Added milk*	-0.3 (-0.7 to 0.1)	-0.6 (-1.3 to 0.1)	-0.1 (-0.6 to 0.3)	-0.3 (-0.8 to 0.1)	-0.6 (-1.3 to 0.1)	-0.1 (-0.7 to 0.4)
Soda during summer*	0.6 (0.3 to 1)	0.8 (0.2 to 1.3)	0.5 (0 to 1)	0.8 (0.3 to 1.3)	1 (0.3 to 1.8)	0.6 (0.1 to 1.1)
Soda during other seasons*	0 (-0.5 to 0.4)	-0.3 (-0.8 to 0.3)	0.1 (-0.5 to 0.7)	-0.2 (-0.7 to 0.4)	-0.6 (-1.3 to 0.2)	0.1 (-0.6 to 0.7)
Beer during summer*	0.2 (-0.6 to 1.1)	0.3 (-0.8 to 1.4)	-0.5 (-2 to 0.9)	0.3 (-0.7 to 1.2)	0.4 (-0.9 to 1.7)	-0.5 (-2.6 to 1.6)
Beer during other seasons*	-0.8 (-1.6 to -0.1)	-0.8 (-1.6 to 0.1)	-0.2 (-1.6 to 1.2)	-0.7 (-1.5 to 0.1)	-0.7 (-1.6 to 0.3)	0.1 (-1.9 to 2.1)

Wine*	-0.8 (-2.4 to 0.8)	0.2 (-1.7 to 2)	-1.9 (-3 to -0.8)	-0.8 (-2.5 to 0.9)	0.1 (-2.3 to 2.6)	-1.9 (-3.4 to -0.4)
Liquor*	-0.8 (-2.3 to 0.7)	-0.4 (-2.9 to 2)	-0.9 (-2.4 to 0.7)	-0.2 (-1.7 to 1.3)	0.2 (-2.8 to 3.2)	-0.2 (-1.7 to 1.3)
Intension to lose weight						
No	0 [Reference]	0 [Reference]	0 [Reference]	0 [Reference]	0 [Reference]	0 [Reference]
Yes	2.4 (1.8 to 3)	2.3 (1.5 to 3.1)	2.3 (1.6 to 2.9)	3.1 (2.4 to 3.8)	2.9 (1.9 to 3.9)	2.9 (2.1 to 3.7)
Intension to not gain weight						
No	0 [Reference]	0 [Reference]	0 [Reference]	0 [Reference]	0 [Reference]	0 [Reference]
Yes	0.6 (0 to 1.3)	1 (-0.1 to 2)	0.3 (-0.3 to 1)	0.9 (0.1 to 1.6)	1.3 (0.1 to 2.5)	0.4 (-0.4 to 1.2)
HEI-2010	0 (-0.1 to 0)	0 (-0.1 to 0)	0 (-0.1 to 0)	0 (-0.1 to 0)	0 (-0.1 to 0)	-0.1 (-0.1 to 0)
Coffee drink*	-0.4 (-0.6 to -0.2)	-0.4 (-0.8 to 0)	-0.4 (-0.7 to -0.1)	-0.6 (-0.8 to -0.4)	-0.6 (-1.1 to -0.1)	-0.7 (-1 to -0.3)
Iced tea drink*	0.3 (0.1 to 0.6)	0.4 (0 to 0.7)	0.3 (0.1 to 0.6)	0.4 (0.1 to 0.7)	0.6 (0.1 to 1)	0.3 (0 to 0.6)
EGCG use						
No	0 [Reference]	0 [Reference]	0 [Reference]	0 [Reference]	0 [Reference]	0 [Reference]
Yes	0.9 (-0.4 to 2.1)	1.3 (-0.5 to 3)	0 (-1.8 to 1.7)	1.2 (-0.6 to 3)	1.4 (-1.1 to 3.8)	0.5 (-1.7 to 2.6)

* These variables based on the frequency of intake