CLINICAL RESEARCH STUDY

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Chocolate Consumption and Indicators of Adiposity in US Adults

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ABSTRACT

PURPOSE: The purpose of this research is to investigate the association between consumption of chocolate and measures of adiposity in a large, representative sample of US adults.

METHODS: Cross-sectional data from 13,626 nondiabetic adults (≥20 years) participating in the National Health and Nutrition Examination Survey study were aggregated using 5 study cycles from 2005-2006 through 2013-2014. Chocolate consumption was determined based on 2 24-hour dietary recalls. Body mass index (BMI) and waist circumference were objectively measured. We used multivariable linear regression to test associations of 1) any chocolate consumption (yes/no), and 2) the total amount of chocolate consumption (grams/day, in quartiles) with BMI and waist circumference. Models controlled for sociodemographic, lifestyle, health-related, and dietary covariates.

RESULTS: Overall, 11.1% of the population self-reported any chocolate consumption in either of their 2 24-hour dietary recalls. Adjusted linear regression models showed that individuals who reported any chocolate consumption had 0.92 kg/m^2 (95% confidence interval, 0.53-1.32) lower BMI, and 2.07 cm (95% confidence intervals, 1.22-2.92) lower waist circumference than those who reported no chocolate consumption. In models examining the association of amount of chocolate consumption and weight status, compared with those who did not consume chocolate, lower BMI (*P* for trend = .003) and waist circumference (*P* for trend = .001) were observed in the first, second, and third quartiles of total chocolate consumption.

CONCLUSIONS: In this representative sample of US adults, chocolate consumption was associated with lower markers of adiposity. Further research using a longitudinal or experimental design is needed to establish the direction of causation.

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INTRODUCTION

In 2015/2016, approximately 7.3 million tons of retail chocolate confectionery were consumed worldwide.[1] This figure is expected to reach approximately 7.7 million tons by 2018/2019.[1] In the United States, the average person consumes 4.4 kg of chocolate per year.[2] With chocolate consumed in such substantial volumes, it is important to understand its impact on human health. In a recent umbrella review[3] with integrated meta-analyses, which included 10 systematic reviews (8 meta-analyses) and a total of 84 studies, chocolate consumption was found to be associated with reduced risk of cardiovascular disease death, acute myocardial infarction, stroke, and diabetes, although this was based on weak evidence of credibility. Intervention studies suggested chocolate consumption was related to improvements in flow-mediated dilatation (an indicator of blood vessel health) and markers of insulin resistance.[3]

CLINICAL SIGNIFICANCE

- People who reported any chocolate consumption had, on average, a 0.92-kg/m^2 lower body mass index, and 2.07-cm lower waist circumferences than those who did not report any chocolate consumption.
- A higher amount of chocolate consumption was associated with lower body mass index and waist circumference.
- Taken together, chocolate consumption was associated with lower markers of adiposity.

Such health benefits of chocolate consumption may be a result of flavonoids that are present in chocolate. Indeed, research has suggested that flavonoids may protect against cardiovascular disease, acting as antioxidant, antiplatelet, and anti-inflammatory agents.[4] Flavonoids in chocolate have also been shown to be protective against other potential risk factors for cardiovascular disease, such as hypercholesterolemia, hypertension, and improved endothelial function.[5] Flavonoids may also influence health via effects on adiposity, acting as a fat-reduction agent. For example, one study of 2734 healthy, female monozygotic twins aged 18-83 years found that higher habitual intake of a number of flavonoids was associated with lower fat mass, independent of shared genetic and common environmental factors.[6] Thus, it is plausible that benefits of chocolate consumption on health are driven by lower levels of adiposity among chocolate consumers.

The existing literature on the association between chocolate consumption and adiposity is mixed. For example, a recent meta-analysis showed that higher confectionary intake was inversely associated with overweight and obesity.[7] However, a prospective study of 12,830 participants showed that chocolate consumption was associated with long-term weight gain, in a dose–response manner.[8] A key limitation of previous studies is that they have not accounted for the amount of dark and nondark chocolate consumed. Dark chocolate contains a higher volume of flavonoids than other chocolate types, so it is important to take this into account when investigating the association between chocolate consumption and measures of adiposity.

Therefore, the aim of the present study was to investigate the association between consumption of dark and nondark chocolate and measures of adiposity in a large, representative sample of US adults.

MATERIALS AND METHODS

Study Population

The National Health and Nutrition Examination Survey (NHANES), described in detail elsewhere,[9,10] was designed to provide cross-sectional estimates of the prevalence of health, nutrition, and potential risk factors among the civilian noninstitutionalized US population. Since 1999, NHANES has surveyed a nationally representative, complex, stratified, multistage probability sample of the US population continuously in 2-year cycles, with different participants included in each wave. The assessment methods include a household interview and a physical examination in a mobile examination center. For the present analyses, we included nondiabetic adult participants over 5 study cycles (2005-2006; 2007-2008; 2009-2010; 2011-2012; 2013-2014) with available data on chocolate consumption from 2 24-hour dietary recalls.

Measures

Exposure: chocolate consumption. A key component of NHANES is dietary assessment. In brief, NHANES participants are asked to complete 2 24-hour recalls of dietary intake using the US Department of Agriculture's Automated Multiple-Pass method.[11] For the cycles used in the present analyses, the first 24-hour recall was administered in person by a trained dietary interviewer using a standardized protocol during the physical examination in a mobile examination center. The second 24-hour recall was administered via telephone between 3 and 10 days after the first recall. Nutrient intakes were calculated based on food intake using a revised nutrient database that converts intakes of food items to nutrients for each individual. Daily chocolate consumption (overall and dark chocolate [≥45% cocoa solids], specifically) was calculated in grams using the average of the 2 24-hour recalls, with implausibly high intakes excluded by removing observations above the 99th percentile. The present analyses focus on 2 variables derived from this measure of chocolate consumption. The first was a 3-level categorical measure of chocolate consumption (none, chocolate but no dark chocolate, any dark chocolate). The second was a 5-level measure of the amount of chocolate consumed (any type) in grams/day. Individuals who reported no chocolate consumption were coded 0, and those who reported any chocolate consumption were grouped into quartiles, coded 1 through 4 from the lowest to highest chocolate consumption.

Outcome: weight status. Anthropometric measures including weight, height, and waist circumference were used to define weight status. Weight and height were measured during the physical examination in a mobile examination center or in the participant's home, following standard procedures. Body mass index (BMI) was calculated as weight in kilograms divided by the square of height in meters and categorized as underweight (<18.5 kg/m^2), normal weight (18.5-24.9 kg/m^2), overweight (25.0-29.9 kg/m^2), or obese (≥30 kg/m^2). For analytic purposes, we excluded those with an underweight BMI (n = 380) due to potential underlying health conditions. Waist circumference was measured during the physical examination using a tape measure at the uppermost lateral border of the hip crest (ilium).[12]

Covariates. Total energy intake and total sugar intake were derived from the mean of the 2 24-hour dietary recalls, and categorized into quartiles. Alcohol intake was derived from 2 24-hour recalls and dichotomized to no (zero intake) and yes (any intake).

Self-reported sociodemographic characteristics included age, marital status (collapsed to living alone [widowed, divorced, separated, never married] and living with someone [married, living with partner]), sex (men and women), race (non-Hispanic white, non-Hispanic black, Hispanic, other [other than non-Hispanic white, non-Hispanic black, Hispanic, including multiracial]), education (collapsed to below high school [<9th grade, 9-11th grade], high school [high school graduate/general education diploma or equivalent], above high school [some college or associates degree, college graduate or above]), and annual household income (15 categories of annual household income levels collapsed to <$25,000, $25,000-$74,999, and ≥$75,000).

Lifestyle characteristics included leisure-time physical activity and smoking status. Participants reported the number of days and minutes spent in moderate and vigorous recreational activities in a typical week. We summarized the total number of minutes for both activities and classified participants as inactive (zero moderate-to-vigorous physical activity) or active (any moderate-to-vigorous physical activity) based on physical activity guidelines.[13] Smoking status was classified into: never smokers (have never smoked 100 cigarettes and do not smoke now), former smokers (have smoked 100 cigarettes in lifetime and do not smoke now), and current smokers (have smoked 100 cigarettes in lifetime and smoke now).

Information on chronic conditions that were considered suspected correlates were extracted, including self-reported doctors' diagnoses (by answering the question "Has a doctor or other health professional ever told you that you had . . ." for each condition) of cardiovascular disease, arthritis, and cancer. Participants who reported diabetes mellitus were excluded from the analyses due to potential confounding by increased prevalence of obesity[14] and likelihood of dietary restrictions that prohibit chocolate consumption.

Statistical Analyses

All statistical analyses were performed using STATA version 14.0 (STATA Corp., College Station, Texas). Survey analysis procedures were used to account for the sample weights, stratification, and clustering of the complex sampling design to ensure nationally representative estimates.[9] Descriptive characteristics were analyzed by summarizing weighted means and standard errors and one-way analysis of variance for continuous variables and weighted proportions and chi-squared tests for categorical variables by BMI category.

For each outcome of BMI and waist circumference, 2 multivariable linear regression models were constructed to evaluate the association of chocolate consumption with weight status. First, we estimated the association of overall chocolate consumption (yes/no) with BMI and waist circumference, respectively. Secondly, we examined whether the amount of chocolate consumption (zero for nonchocolate consumers, and in quartiles among chocolate consumers) was independently associated with weight status, with and without adjustment for dark chocolate consumption (yes/no). It was not possible to analyze the association with the amount of dark chocolate consumption specifically due to the small number of participants reporting any dark chocolate consumption. All models were adjusted for sociodemographic factors (age, sex, marital status, education level, annual household income), lifestyle factors (leisure-time physical activity, smoking status, alcohol intake), total energy intake, and chronic conditions. We considered *P* values < .05 to be statistically significant.

RESULTS

A total of 20,125 men and women aged ≥20 years provided data on chocolate consumption, BMI, and waist circumference. We excluded those who were underweight (n = 304), and those with diabetes (n = 2518). A further 3677 participants were excluded due to missing data on covariates, leaving a total of 13,626 people in the final analyses (mean age 46.5 years, 47.8% male). The individuals we excluded had lower BMI compared with the analyzed sample (28.6 kg/m^2 vs 29.8 kg/m^2, $P < .001$), yet there were more chocolate consumers in the analyzed sample (11.1% vs 7.0%, $P < .001$).

Of our analyzed sample, 1332 (11.1%) adults reported any chocolate consumption in their 2 24-hour dietary recalls, of whom 148 (12.1%) reported any dark chocolate consumption. Sample characteristics in relation to BMI category are summarized in Table 1. There were significant differences among sociodemographic and lifestyle characteristics across weight status. Those with a BMI ≥30 kg/m^2 were more likely to be non-Hispanic black or Hispanic, and have a lower household income and level of education, and

Table 1 Sociodemographic Characteristics of US Adults Aged 20-80 Years in the NHANES (2005-2014), By Weight Status (Body Mass Index, kg/m^2)*

		Body Mass Index (kg/m^2)			
		18.5-24.9 (n = 3996)	25.0-29.9 (n = 4744)	≥30 (n = 4886)	*P* Value
Age (years)	Mean (SE)	44.3 (0.5)	48.1 (0.3)	46.9 (0.4)	< .001
Sex (men)	%	41.2	55.0	46.2	< .001
Marital status (living with a partner)	%	60.7	68.4	64.7	< .001
Race					< .001
Non-Hispanic white	%	73.6	73.4	69.2	
Non-Hispanic black	%	7.6	8.3	13.7	
Hispanic	%	9.5	13.2	14.6	
Other	%	9.3	5.1	3.5	
Household income					< .001
≤$20,000	%	19.6	19.0	21.4	
$20,000-74,999	%	37.5	40.9	46.1	
≥$75000	%	42.9	40.1	32.5	
Education					< .001
Less than High school	%	12.5	15.3	16.0	
High school	%	19.6	21.5	24.3	
Some college and above	%	67.9	63.2	59.7	
Smoking					< .001
Never smoker	%	56.7	55.0	57.2	
Former smoker	%	20.2	26.6	25.2	
Current smoker	%	23.1	28.4	17.6	
Alcohol drinking (yes)	%	41.2	39.3	29.9	< .001
Chronic conditions (yes)†	%	26.8	35.6	48.2	< .0001
Total energy intake (kcal, day)	Mean (SE)	2133.7 (20.7)	2145.7 (15.5)	2103.9 (16.2)	.262
Total sugar intake (gram, day)	Mean (SE)	118.2 (1.5)	113.7 (1.1)	112.6 (1.4)	.004
Total chocolate intake (gram, day)	Mean (SE)	94.3 (4.2)	87.4 (3.1)	86.4 (3.7)	.141

*All estimates are weighted to be nationally representative.
†Chronic conditions include cardiovascular disease, arthritis, and cancer.

were less likely to smoke or drink alcohol. Average daily intakes of sugar were higher among adults who had BMI below the obese range.

After adjustment for covariates, we observed significant associations of chocolate consumption with BMI and waist circumference. In the fully adjusted linear regression model, individuals who reported any chocolate consumption had a 0.92-kg/m^2 (95% confidence interval [CI], 0.53-1.32) lower BMI, and 2.07-cm (95% CI, 1.22-2.92) lower waist circumference than those who did not report any chocolate consumption (Tables 2 and 3). In models examining the association of amount of chocolate consumption and weight status, significantly lower BMI (*P* for trend = .003) and waist circumference (*P* for trend = .001) were observed in the first, second, and third quartile of total chocolate consumption (Tables 2 and 3). The estimated beta-coefficients in the top quartile of total chocolate consumption did not reach statistical significances, yet both were suggesting lower adiposity (BMI −0.71; 95% CI, −1.69-0.28; waist circumference −1.50; 95% CI, −3.54-0.55).

DISCUSSION

In this large, representative sample of US adults, people who reported any chocolate consumption had, on average, a 0.92-kg/m^2 lower BMI, and 2.07-cm lower waist circumferences than those who did not report any chocolate consumption. Moreover, a higher amount of chocolate consumption was found to be associated with lower BMI and waist circumference. Importantly, these associations were observed independent of the proportion of dark/non-dark chocolate consumed and other potentially important confounding variables such as total caloric intake.

Findings from the present study support those of some, but not all, previous literature.[7] Three mechanisms may explain the association between chocolate consumption and lower measures of adiposity. Firstly, those who consume a greater amount of chocolate may consume less fat,[15] and sugar (abundant in chocolate) contains fewer kilojoules than fat.[15] Second, literature has shown that consumption of sugar may lead to increased satiety that may result in lower caloric intake;[16] however, this variable was controlled for in the present analyses. Third, it may be that the flavonoids in the chocolate are responsible for the lower levels of BMI and waist circumference observed in this study.[6] Interestingly, adjustment for consumption of dark chocolate (rich in flavonoids) in models examining chocolate consumption and adiposity outcomes made no substantial difference to the findings. Future experimental research is needed to confirm or refute these findings and further

Table 2 Associations of Chocolate Consumption with Body Mass Index (kg/m^2) Among Adults Aged 20-80 Years (n = 13,626) in NHANES (2005-2014)

	Unadjusted Beta-Coefficient (95% CI)		Multivariable-Adjusted* Beta-Coefficient (95% CI)		Multivariable-Adjusted† Beta-Coefficient (95% CI)	
Overall chocolate						
No	Reference		Reference			
Yes	−1.19	(−1.63 to −0.74)	−0.94	(−1.34 to −0.53)	−0.92	(−1.32 to −0.53)
Daily chocolate consumption						
None	Reference		Reference		Reference	
1st quartile (1.7-30.0 g)	−0.93	(−1.63 to −0.23)	−0.79	(−1.44 to −0.14)	−0.80	(−1.44 to −0.14)
2nd quartile (30.4-95.1 g)	−1.42	(−0.19 to −0.65)	−1.07	(−1.84 to −0.31)	−1.07	(−1.81 to −0.32)
3rd quartile (100-100 g)	−1.34	(−2.19 to −0.48)	−1.08	(−1.90 to −0.27)	−1.08	(−1.89 to −0.27)
4th quartile (102.6-453.6 g)	−0.97	(−2.00-0.07)	−0.71	(−1.70- 0.28)	−0.71	(−1.69-0.28)
P for trend‡	< .001		.002		.003	

CI = confidence interval.

*Adjusted for age, sex, race (non-Hispanic white, non-Hispanic black, Hispanic, other), education (below high school, high school, high school and higher), household annual income (<$20,000, $20,000-74,999, $75,000 and higher), physical activity (inactive, any activity), smoking status (never smoker, former smoker, current smoker), energy intake in quartiles, sugar intake (gram, day), alcohol consumption (yes/no), chronic conditions including cardiovascular disease, arthritis and cancer (yes/no).

†Additionally adjusted for dark chocolate consumption (yes/no).

‡*P* for trend was calculated by modeling the median value of chocolate consumption in each quartile as a continuous variable.

understand the role flavonoids play, if any, in influencing levels of adiposity. It should be noted that despite these plausible mechanisms, owing to the cross-sectional nature of the present study, another plausible explanation of the findings is that of reverse causation. For example, those who are overweight and obese may reduce their chocolate consumption if they believe that this is contributing to their weight problem. Given that a previous study using a prospective design showed chocolate intake was associated with weight gain over time,[8] this is a plausible explanation. A further explanation may be owing to reporting bias where those who are overweight and obese (but not of normal weight) may report lower chocolate consumption than true owing to the fear of being judged. Future studies now need to investigate the observed association using an objective measure of chocolate consumption and a longitudinal or experimental research design, controlling for important dietary variables.

Strengths of the present study include the large, representative sample of US adults and adjustment for important dietary variables (dark chocolate/nondark chocolate, total energy intake) in statistical models. However, the present findings must be interpreted in light of its limitations, including the cross-sectional study design and the possibility of reporting bias. Finally, the chocolate consumption variable was based on only 2 days' recall, therefore, it may not reflect consumption over a longer period.

In conclusion, in this large, representative sample of US adults, chocolate consumption was associated with lower

Table 3 Associations of Chocolate Consumption with Waist Circumference (cm) Among Adults Aged 20-80 Years (n = 13,626) in NHANES (2005-2014)

	Unadjusted Beta-Coefficient (95% CI)		Multivariable-Adjusted* Beta-Coefficient (95% CI)		Multivariable-Adjusted† Beta-Coefficient (95% CI)	
Overall chocolate						
No	Reference		Reference			
Yes	−2.64	(−3.66 to −1.62)	−2.08	(−2.97 to −1.19)	−2.07	(−2.92 to −1.22)
Daily chocolate consumption						
None	Reference		Reference		Reference	
1st quartile (1.7-30.0 g)	−1.49	(−3.09-0.10)	−1.27	(−2.77-0.23)	−1.27	(−2.77-0.23)
2nd quartile (30.4-95.1 g)	−2.70	(−4.62 to −0.78)	−2.11	(−4.02 to −0.20)	−2.11	(−4.00 to −0.22)
3rd quartile (100-100 g)	−3.67	(−5.82 to −1.52)	−3.00	(−4.90 to −1.09)	−3.00	(−4.87 to −1.12)
4th quartile (102.6-453.6 g)	−2.24	(−4.46 to −0.02)	−1.50	(−3.59-0.60)	−1.50	(−3.54-0.55)
P for trend‡	< .001		.001		.001	

*Adjusted for age, sex, race (non-Hispanic white, non-Hispanic black, Hispanic, other), education (below high school, high school, high school and higher), household annual income (<$20,000, $20,000-74,999, $75,000 and higher), physical activity (inactive, any activity), smoking status (never smoker, former smoker, current smoker), energy intake in quartiles, sugar intake (gram, day), alcohol consumption (yes/no), chronic conditions including cardiovascular disease, arthritis and cancer (yes/no).

†Additionally adjusted for dark chocolate consumption (yes/no).

‡*P* for trend was calculated by modeling the median value of chocolate consumption in each quartile as a continuous variable.

markers of adiposity. Further research using a longitudinal or experimental design and capturing average chocolate consumption over a prolonged period is needed to shed light on the potential causal role of chocolate on adiposity.

References

1. Statista. Consumption of chocolate worldwide from 2012/13-2018/19. 2019. Available at: https://www.statista.com/statistics/238849/global-chocolate-consumption/. Accessed January 11, 2020.
2. Statista. Statistics & facts on chocolate consumption and industry. Available at: https://www.statista.com/topics/1638/chocolate-industry/. Accessed January 11, 2020.
3. Veronese N, Demurtas J, Celotto S, et al. Is chocolate consumption associated with health outcomes? An umbrella review of systematic reviews and meta-analyses. *Clin Nutr* 2019;38(3):1101–8.
4. Corti R, Flammer AJ, Hollenberg NK, Lüscher TF. Cocoa and cardiovascular health. *Circulation.* 2009;119(10):1433–41.
5. Latham LS, Hensen ZK, Minor DS. Chocolate−guilty pleasure or healthy supplement? *J Clin Hypertens (Greenwich)* 2014;16(2):101–6.
6. Jennings A, MacGregor A, Spector T, Cassidy A. Higher dietary flavonoid intakes are associated with lower objectively measured body composition in women: evidence from discordant monozygotic twins12. *Am J Clin Nutr* 2017;105(3):626–34.
7. Gasser CE, Mensah FK, Russell M, Dunn SE, Wake M. Confectionery consumption and overweight, obesity, and related outcomes in children and adolescents: a systematic review and meta-analysis. *Am J Clin Nutr* 2016;103(5):1344–56.
8. Greenberg JA, Buijsse B. Habitual chocolate consumption may increase body weight in a dose-response manner. *PLoS One* 2013;8(8):e70271.
9. 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.
10. Curtin LR, Mohadjer LK, Dohrmann SM, et al. National Health and Nutrition Examination Survey: sample design, 2007-2010. *Vital Health Stat 2* 2013:(160):1–23.
11. Ahluwalia N, Dwyer J, Terry A, Moshfegh A, Johnson C. Update on NHANES dietary data: focus on collection, release, analytical considerations, and uses to inform public policy. *Adv Nutr* 2016;7(1):121–34.
12. M-A Cornier, J-P Després, N Davis, et al. Assessing adiposity. *Circulation* 2011;124(18):1996–2019.
13. U.S. Department of Health and Human Services. *Physical Activity Guidelines for Americans*. 2nd ed Washington, DC: U.S. Department of Health and Human Services; 2018.
14. Mokdad A, Ford E, Bowman B, et al. Prevalence of obesity, diabetes, and obesity-related health risk factors, 2001. *JAMA* 2003;289(1):76–9.
15. Janssen I, Katzmarzyk PT, Boyce WF, et al. Comparison of overweight and obesity prevalence in school-aged youth from 34 countries and their relationships with physical activity and dietary patterns. *Obes Rev* 2005;6(2):123–32.
16. Anderson GH, Woodend D. Consumption of sugars and the regulation of short-term satiety and food intake. *Am J Clin Nutr* 2003;78(4):843S–9S.