Community Dental Health (2018) **35,** 148–152
Received 23 July 2017; Accepted 17 October 2017

doi:10.1922/CDH_4235Chari05

The relationships among consumption of fruits, tooth loss and obesity

Malini Chari[1] and Wael Sabbah[1]

[1]*Dental Institute, King's College London. London, United Kingdom.*

Objective: to explore whether consumption of fruits attenuates the relationship between tooth loss and obesity among adult Americans. ***Basic research design:*** data from the Behavioral Risk Factor Surveillance System 2012, a cross-sectional survey. ***Participants:*** 20,103 adults aged 18 and over who participated in the Behavioral Risk Factor Surveillance System 2012, a nationally representative survey of non-institutionalized adult American. ***Main outcome measures:*** Obesity (Body Mass Index ≥ 30 kg/m^2). Logistic regression analysis was used to assess the association between obesity and number of missing teeth adjusting for consumption of fruits socio-demographic factors, physical activity, diabetes and self-rated general health. ***Results:*** The prevalence of obesity was higher among adults with ≥ 6 missing teeth and among those with fruit intakes less than once a day. Individuals with ≥ 6 missing teeth were at higher risk of obesity with odds ratios 1.25 (95% CI: 1.04, 1.50), the relationship attenuated after adjusting for fruit consumption. ***Conclusions:*** Frequent consumption of fruits was inversely associated with each of obesity and number of missing teeth. The findings imply a mediating role of fruit consumption in the relationship between tooth loss and obesity.

Key words: *Adult, fruit, obesity, tooth loss*

Introduction

Obesity is a growing public health concern, with a continuously rising prevalence (World Health Organization 2016b), particularly in the United States (U.S.), with 69.6% adults overweight and 35% obese (Nguyen *et al*. 2010). Obesity has consistently showed a significant association with oral health, particularly periodontal disease among middle-aged and older populations with an inflammatory pathway implicated in this relationship (Nascimento *et al*. 2015). However, these findings were based on reviews of cross-sectional studies. Longitudinal studies have also reported higher incidence of periodontitis among obese individuals (Morita *et al*. 2011). The study suggested a bi-directional relationship between obesity and periodontal disease, but there is no evidence of causality (Morita *et al*. 2011). Diabetes, a well-known co-morbidity related to both obesity and periodontitis, could be another possible explanation for this relationship as obese individuals are at higher risk of diabetes and diabetes is a risk factor for periodontitis (Keller *et al*. 2015). Given that tooth loss is the ultimate consequence of periodontitis, it could therefore be associated with obesity. This potential relationship was suggested in a number of observational studies (Nascimento *et al*. 2015, Östberg *et al*. 2009). Several mechanisms have been postulated about the relationship between tooth loss and obesity. These include compromised diet because of inability to chew healthy food. The common risk factors for both obesity and tooth loss, such as poor dietary habits and lower socioeconomic status could be the underpinning mechanisms for the relationship (Nascimento *et al*. 2016).

The consumption of fruit, has been widely acknowledged for its health benefits and was highly recommended by the World Health Organization (WHO) to be incorporated into the daily diet (McGuire 2011). There is evidence suggesting that consumption of fruit could be beneficial in reducing the risk of hypertension, diabetes and cardiovascular disease, all of which are associated with obesity (Boeing *et al*. 2012). Studies have also shown that increasing fruit intakes, without significant alterations to overall diet, may protect against short-term weight gain, contributing to either maintenance or loss of body weight (Mytton *et al*. 2014).

Loss of teeth adversely affects mastication and chewing capacity, consequently affecting diet and nutrient intakes, as individuals with fewer teeth were found to have difficulty in chewing a range of fruits, such as apples, berries, peaches and oranges (Schwingshackl *et al*. 2015). The available evidence is therefore suggestive of a trend wherein, the presence or absence of teeth may influence food choices, adversely impacting on the consumption of fruit and fibre that play a major role in the management of body weight. Given the aforementioned evidence on the complex relationship between fruit consumption, obesity and tooth loss, it is plausible that inability to chew and consume fruits as a result of tooth loss potentially explain the known association between tooth loss and obesity (Nascimento *et al*. 2016). We set out to examine the relationship between tooth loss and obesity and to explore whether consumption of fruit attenuates this association. The findings of the analysis would demonstrate a hypothesis pertaining to the relationship among obesity, tooth loss and fruit consumption.

Correspondence to: Wael Sabbah, Dental Institute, King's College London. London, United Kingdom , Bessemer Road, Denmark Hill, London, SE5 9RW, UK. Telephone 020 3299 3272; Email: wael.sabbah@kcl.ac.uk

Methods

Data for this cross-sectional study are from the Behavioral Risk Factor Surveillance System (BRFSS) 2012 collected by Centers for Disease Control and Prevention (CDC). The BRFSS is a nationally representative survey of the U.S. population (Centers for Disease Control 2014). The data are self-reported and were collected using the BRFSS 2012 standardized questionnaire via computer-assisted telephone interviews (CATI) from non-institutionalized American adults aged 18 years or above, obtaining information on health related preventive practices, oral health status and risk behaviours associated with chronic conditions. The 2012 survey consisted of the core and optional modules covering 50 and 18 states, respectively, in a complex multistage cluster sample design to recruit landline and cellular phone users (Centers for Disease Control 2014).

The interviewers were trained as per the BRFSS protocol and confidentiality of participants was maintained by ensuring their anonymity to the interviewers. A total of 477,285 interview calls were made, with the weighted response rate varying from a minimum of 27.7% to a maximum of 60.4% across the states (Centers for Disease Control 2014).

The main outcome variable was obesity, which was represented by BMI calculated from the self-reported height and weight of the participants. Pregnant women were excluded from the study. BMI was categorized into a dichotomous variable of (obese $\geq$ 30 kg/m^2; non-obese < 30 kg/m^2) (World Health Organization 2016a).

Information on tooth loss was obtained from the core component of the questionnaire. Participants were asked to report the number of permanent teeth that were removed as a result of tooth decay or gum disease, excluding those that were missing due to orthodontics or injury. This variable was categorized into 4 groups, (1) no missing teeth, (2) 1-5 teeth missing, (3) $\geq$ 6 teeth missing and (4) all teeth missing.

Data on frequency of fruit consumption were also drawn from the optional module. Participants were asked how often they consumed fruits such as apples, oranges, grapes, berries, watermelon, pomegranates etc. including dried raisins and fruit salads, in the last 30 days. It included consumption of fruit in all meals and snacks. For the purpose of this study, we converted the monthly and weekly consumption of fruit into frequency of daily fruit intakes and categorized this variable into the following 2 groups, consumption of fruits $\geq$1 per day and < 1 per day

The confounding variables included were age (18-24, 25-34, 35-44, 45-54, 55-64 & 65+), gender and ethnicity (White, Black, Hispanic, Multiracial and Others). Annual household income included 5 groups: <15,000; 15,000-<25,000; 25,000-<35,000; 35,000-<50,000 and 50,000+ US dollar. Education included 4 groups: (1) did not graduate high school, (2) graduated high school, (3) attended college for1-3 years and (4) college graduate. Leisure-time physical activity, diabetes and self-rated general health were also included in the analysis.

Secondary analysis used the complex sampling procedures in STATA/SE version 12.1. (STATA Corp, Texas, USA). Statements for stratification, clustering and sample weight were used to account for the complex sampling design for the combined landline telephone and cellular phone data. Only cases with complete data were included.

The distribution of all variables, namely age, gender, ethnicity, income, education, number of missing teeth, diabetes, self-rated general health, physical activity and consumption fruits was examined for the whole population and within the obese and normal weight groups. Chi Square was used to assess the relationship between obesity and each included variable.

Sequential logistic regression models were assessed the relationship between obesity (outcome) and tooth loss adjusting for all demographic variables. The second model was further adjusted for consumption of fruit, income and education. The final model was additionally adjusted for physical activity, diabetes and self-rated general health.

To demonstrate that low fruit consumption might-explain the relationship between tooth loss and obesity, we tested the relationship between fruit consumption as an independent variable and tooth loss. Logistic regression models were also constructed to assess the relationship between tooth loss and consumption of fruit (outcome variable), adjusting for demographic and socioeconomic variables.

Results

The final sample included in the analysis was 20,103 participants with complete data. The distribution of demographic, socioeconomic, oral and general clinical characteristics, along with physical activity and consumption of fruit are presented in Table 1. The prevalence of obesity was 29.7 %, equally distributed among men and women with approximately 30% adults reporting 1-5 missing teeth and 50.3% adults reported consuming fruits less than once a day. Obesity was most pronounced among adults with >6 teeth missing at 36.7%. However, it declined marginally among edentulous individuals and was notably higher among those with fruit intakes less than once a day (31.5%), than among those who consumed fruit more than once a day (27.7%).

In logistic regression, adjusting for demographic variables (Table 2), tooth loss was associated with obesity, wherein individuals with more than 6 missing teeth were more likely to be obese (Odds Ratio (OR) = 1.57, 95%CI: 1.32-1.87). After adjusting for consumption of fruit and socioeconomic factors, the relationship was attenuated by 22% (OR: 1.25, 95% CI: 1.04-1.5). However, the significance was lost after adjusting for diabetes, general health and physical activity in the fully adjusted model (Table 2). The consumption of fruits also demonstrated an inverse association with obesity, (OR: 0.84, 95% CI: 0.75-0.95), which remained significant in the fully adjusted model (OR: 0.86, 95% CI: 0.77-0.97).

The relationship between tooth loss and consumption of fruits is presented in Table 3. An inverse association was found between tooth loss and fruit consumption, which remained significant when adjusting for demographic and socioeconomic variables (Table 3).

Table 1. Distribution of demographic, dental and health data among overall sample and those who were obese (n = 20,103)

Variable		*Overall* % (95% CI)	*Obese* % (95% CI)	*p (Chi sq.)*
Gender	Males	49.2 (47.6, 50.4)	29.5 (27.8, 31.2)	NS
	Females	50.8 (49.5, 52.0)	29.8 (28.3, 31.3)	
Age	18-24	11.5 (10.5, 12.5)	12.4 (9.7, 15.8)	<0.001
	25-34	17.0 (15.9, 17.9)	30.3 (27.0, 33.8)	
	35-44	18.8 (17.8, 19.8)	34.0 (31.2, 37.0)	
	45-54	20.1 (19.2, 21.1)	34.6 (32.1, 37.1)	
	55-64	16.4 (15.6, 17.2)	34.0 (31.6, 36.2)	
	65+	16.1 (15.4, 16.8)	25.6 (23.7, 27.6)	
Education	< High School	15.6 (14.6, 16.7)	37.0 (33.3, 40.7)	<0.001
	High School	25.5 (24.4, 26.6)	32.8 (30.6, 35.0)	
	Attended College	30.8 (29.6, 32.0)	31.5 (29.3, 33.7)	
	College Graduate	27.9 (27.0, 28.9)	20.6 (19.2, 22.1)	
Income	< 15000 per annum	13.8 (12.9, 14.7)	35.8 (32.3, 39.6)	<0.001
	15000 per annum	16.9 (16.0, 17.9)	35.2 (32.4, 38.0)	
	25000 per annum	10.3 (9.6, 11.1)	33.8 (30.3, 37.4)	
	35000 per annum	13.3 (12.5, 14.2)	28.5 (25.6, 31.5)	
	50000 per annum	45.5 (44.2, 46.7)	25.1 (23.6, 26.7)	
Ethnicity	White	56.7 (55.4, 57.9)	26.9 (25.7, 28.1)	<0.001
	Black	17.0 (16.1, 17.9)	38.6 (35.8, 41.4)	
	Hispanic	17.5 (16.4, 18.7)	36.6 (33.0, 40.4)	
	Other Race	7.0 (6.2, 7.9)	13.2 (9.6, 17.8)	
	Multiracial	1.6 (1.3, 1.9)	27.6 (20.7, 35.7)	
Number of missing teeth	None	54.5 (53.3, 55.8)	25.5 (24.0, 27.1)	<0.001
	1-5 teeth missing	29.9 (28.8, 31.1)	33.8 (31.7, 36.0)	
	≥ 6 missing teeth	10.7 (10.0, 11.4)	36.7 (33.6, 40.0)	
	All teeth missing	4.7 (4.3, 5.1)	34.6 (30.7, 38.7)	
Fruit consumption	≥once a day	49.6 (48.3, 50.8)	27.7 (26.1, 29.3)	<0.001
	<once a day	50.3 (49.1, 51.6)	31.5 (30.0, 33.1)	
Diabetes	Present	12.8 (12.0, 13.5)	52.2 (49.0, 55.4)	<0.001
	Absent	87.2 (86.4, 87.9)	26.3 (25.1, 27.5)	
Physical Activity	Yes	79.9 (79.0, 80.8)	27.5 (26.2, 28.8)	<0.001
	No	20.0 (19.1, 21.0)	38.0 (35.6, 40.5)	
Self- rated general health	Excellent	52.6 (51.3, 53.8)	20.4 (19.0, 21,8)	<0.001
	Good	30.5 (29.4, 31.7)	36.7 (34.6, 38.9)	
	Fair/poor	16.8 (15.9, 17.7)	29.6 (28.5, 30.8)	

Discussion

To the best of our knowledge, this is the first study to examine the relationships among consumption of fruit, tooth loss and obesity using a nationally representative sample. Overall, this study demonstrated an association between tooth loss (> 6 teeth) and obesity in a sample of adults aged 18 years or above. The relationship ceased to be significant after accounting for general health and clinical conditions. Fruit consumption appeared to attenuate this relationship, wherein individuals with more missing teeth were less likely to consume fruit, and those with daily fruit intakes were less likely to be obese, portraying a trend of less fruit intakes with number of missing teeth. These findings were consistent with previous studies exploring the effects of tooth loss on fruit consumption (Brennan *et al*. 2010) and the role of fruit consumption in weight management (Boeing *et al*. 2012, Schwingshackl *et al*. 2015), respectively.

Here, the association between tooth loss and obesity remained significant even after accounting for sociodemographic variables, in contrast to previous studies (Nascimento *et al*. 2015, Östberg *et al*. 2009), where the association was eliminated, with the incorporation of these factors.

Obesity is a growing public health problem in the US and other parts of the world. Increasing consumption of fruit is seen as a potential intervention to tackle this epidemic. Earlier studies have shown a risk reduction of 17% of abdominal obesity as a result of increased fruit intakes, as well as an average reduction in body weight with regular consumption (Mytton *et al*. 2014, Schwingshackl *et al*. 2015). On the other hand, tooth loss hinders individuals' ability to consume fruit (Brennan *et al*. 2010). Previous studies have shown that consumption of fruit varied from 90% among dentate adults to 78% among denture users (Gilbert *et al*. 2004, Bradbury *et al*. 2008). The findings of the current analysis, highlighting the potential impact of tooth loss on fruit consumption and on obesity, could be beneficial for health promotion policies to reduce obesity.

Table 2. Logistic regression analysis for predictor s of obesity among 20,103 adult Americans

Variable		*Model 1*	*Model 2*	*Model 3*
Gender	(female)	1.01 (0.90, 1.12)	1.00 (0.89, 1.12)	1.00 (0.89, 1.12)
Age (reference group 18-24)	25-34	2.89* (2.09, 3.99)	3.31* (2.38, 4.60)	3.23* (2.32, 4.49)
	35-44	3.48 (2.55, 4.74)	4.30* (3.13, 5.92)	3.75* (2.72, 5.16)
	45-54	3.54* (2.60, 4.80)	4.40* (3.21, 6.01)	3.39* (2.47, 4.65)
	55-64	3.29* (2.42, 4.46)	4.21* (3.07, 5.77)	2.93* (2.13, 4.04)
	65+	2.14* (1.57, 2.93)	2.69* (1.94, 3.71)	1.79* (1.28, 2.49)
Number of Missing Teeth	1-5 missing teeth	1.31* (1.15, 1.49)	1.17* (1.02, 1.34)	1.25* (1.04, 1.51)
(reference group no teeth missing)	≥ 6 missing teeth	1.57* (1.32, 1.87)	1.25* (1.04, 1.51)	1.06 (0.84, 1.33)
	All teeth missing	1.52* (1.23, 1.87)	1.12 (0.89, 1.41)	0.85 (0.63, 1.15)
Ethnicity (reference group White)	Black	1.65* (1.43, 1.89)	1.54* (1.34, 1.78)	1.50* (1.30, 1.73)
	Hispanic	1.69* (1.41, 2.02)	1.50* (1.24, 1.82)	1.40* (1.15, 1.71)
	Other Race	0.41* (0.28, 0.60)	0.49* (0.33, 0.71)	0.45* (0.31, 0.66)
	Multiracial/ Non Hispanic	1.15 (0,79, 1.68)	1.15 (0.78, 1.70)	1.08 (0.71, 1.64)
Income	15000 to < 25000		0.93 (0.76, 1.14)	0.99 (0.80, 1.22)
(reference group < 15000)	25000 to < 35000		0.88 (0.70, 1.11)	0.99 (0.78, 1.26)
	35000 to < 50000		0.76* (0.61, 0.96)	0.91 (0.72, 1.16)
	> 50000		0.71* (0.58, 0.87)	0.94 (0.77, 1.16)
Education	High School		1.06 (0.87, 1.30)	1.20 (0.97, 1.48)
(reference: < high school)	Attended college		1.08 (0.88, 1.34)	1.29* (1.03, 1.60)
	Graduated from college		0.66* (0.52, 0.82)	0.83 (0.66, 1.04)
Fruit Consumption: ≥once a day			0.84* (0.75, 0.95)	0.86* (0.77, 0.97)
Diabetes	Non-diabetic			0.40* (0.34, 0.47)
Lack of Physical activity				1.16* (1.01, 1.33)
General health	Good			1.94* (1.70, 2.21)
(reference: excellent)	Poor			2.28* (1.90, 2.73)

Model 1: Adjusted for age, gender and ethnicity.
Model 2: Model 1 + income, education and consumption of fruits.
Model 3: Model 2 + diabetes, physical activity and self-rated general health.
*$p<0.05$

Table 3. Logistic regression analysis for tooth loss as a predictor of fruit consumption (n=20,103)

Variable		*Model 1*	*Model 2*
Gender (female)		1.71* (1.54, 1.89)	1.74* (1.57, 1.93)
Age (reference: 18-24)	25-34	1.60* (1.25, 2.06)	1.47* (1.14, 1.90)
	35-44	1.63* (1.28, 2.08)	1.43* (1.12, 1.83)
	45-54	1.72* (1.36, 2.18)	1.50* (1.18, 1.92)
	55-64	2.04* (1.61, 2.59)	1.75* (1.37, 2.24)
	65+	2.54* (2.00, 3.24)	2.25* (1.77, 2.88)
Number of Missing Teeth	1-5 teeth	0.79* (0.70, 0.89)	0.85* (0.75, 0.97)
(ref: no teeth missing)	≥ 6 missing teeth	0.68* (0.57, 0.80)	0.79* (0.66, 0.94)
	All teeth	0.49* (0.40, 0.59)	0.59* (0.48, 0.73)
Ethnicity (reference: White)	Black	0.86* (0.75, 0.98)	0.90 (0.78, 1.03)
	Hispanic	1.73* (1.46, 2.05)	1.91* (1.59, 2.30)
	Other Race	1.40* (1.08, 1.83)	1.25 (0.96, 1.64)
	Multiracial/ Non Hispanic	1.12 (0.80, 1.59)	1.13 (0.80, 1.60)
Income	15000 to < 25000		0.92 (0.75, 1.11)
(reference: < 15000)	25000 to < 35000		0.84 (0.67, 1.05)
	35000 to < 50000		1.07 (0.87, 1.32)
	More than 50000		1.12 (0.93, 1.36)
Education	High School		0.89 (0.73, 1.08)
(reference: < high school)	Attended college		0.92 (0.75, 1.13)
	Graduated from college		1.34* (1.09, 1.65)

Model 1: Adjusted for age, gender and ethnicity
Model 2: Model 1 + for income and education
*$p<0.05$

There are some limitations in this study. Firstly, its cross-sectional nature does not support conclusions on causality. Reliance on self-reported data may lead to over or under reporting of a condition, incorporating recall or social desirability bias. However, the validity of self-reports in BRFSS was found to be moderate in relation to physical measures, with minimal differences against other national surveys (Pierannunzi *et al*. 2013). Self-reported tooth loss has been validated by high agreement with clinical assessments, affirming that self-reported oral health conditions reflect actual clinical status (Gilbert *et al*. 1997). Finally, data on fruit consumption were based on 30-day rather than 24-hour recall, which may have led to under/ over reporting of consumption.

The findings of the study demonstrated that fruit consumption may have a mediating role in the relationship between tooth loss and obesity, which could be confirmed by research using different study designs. It also highlights the importance of tooth loss as a potential risk factor for obesity, which operates through an inability to eat fruits and fibres.

Given the cross-sectional design, further longitudinal research, with physical BMI measures, detailed dental examination and dietary and behavioural patterns is warranted to affirm the role of fruit consumption in the relationship between tooth loss and obesity. It is also worth noting that both obesity and tooth loss are complex health outcomes with multiple determinants. While the current analysis did not fully explore all the complex risk factors for both conditions, some of the common determinants such as diabetes and lower socioeconomic position were included in the current analysis, and explained part of the relationship. Furthermore, fruit consumption could also be a surrogate for other health behaviours related to both obesity and tooth loss.

Conclusions

This study provides an insight into the pathway linking tooth loss with obesity. As this is the first study exploring whether fruit consumption attenuates this relationship, it may serve as a platform to initiate further research into the subject, to better understand the complex pathway between tooth loss and obesity.

References

Boeing, H., Bechthold, A., Bub, A., Ellinger, S., Haller, D., Kroke, A., Leschik-Bonnet, E., Müller, M.J., Oberritter, H. and Schulze, M. (2012): Critical review: vegetables and fruit in the prevention of chronic diseases. *European Journal of Nutrition* **51**, 637-663.

Bradbury, J., Thomason, J., Jepson, N., Walls, A., Mulvaney, C., Allen, P. and Moynihan, P. (2008): Perceived chewing ability and intake of fruit and vegetables. *Journal of Dental Research* **87**, 720-725.

Brennan, D., Singh, K., Liu, P. and Spencer, A. (2010): Fruit and vegetable consumption among older adults by tooth loss and socio-economic status. *Australian Dental Journal* **55**, 143-149.

Centers for Disease Control. (2014): Behavioral Risk Factor Surveillance System (BRFSS) Available from: http://www.cdc.gov/brfss/about/index.htm.

Gilbert, G.H., Duncan, R.P. and Kulley, A.M. (1997): Validity of Self-reported Tooth Counts During a Telephone Screening Interview. *Journal of Public Health Dentistry* **57**, 176-180.

Gilbert, G.H., Meng, X., Duncan, R.P. and Shelton, B.J. (2004): Incidence of tooth loss and prosthodontic dental care: effect on chewing difficulty onset, a component of oral health–related quality of life. *Journal of the American Geriatrics Society* **52**, 880-885.

Keller, A., Rohde, J.F., Raymond, K. and Heitmann, B.L. (2015). Association between periodontal disease and overweight and obesity: a systematic review. *Journal of Periodontology* **86**, 766-776.

Mcguire, S. (2011): U.S. Department of Agriculture and U.S. Department of Health and Human Services, Dietary Guidelines for Americans, 2010. 7th Edition, Washington, DC: U.S. Government Printing Office, January 2011. Advances in Nutrition (Bethesda, Md.), 20110430, May, vol. 2, no. 3, pp. 293-294 ISSN 2156-5376; 2161-8313. DOI 10.3945/an.111.000430 [doi].

Morita, I., Okamoto, Y., Yoshii, S., Nakagaki, H., Mizuno, K., Sheiham, A. and Sabbah, W. (2011): Five-year incidence of periodontal disease is related to body mass index. *Journal of Dental Research*, **90**, 199-202.

Mytton, O.T., Nnoaham, K., Eyles, H., Scarborough, P. and Mhurchu, C.N. (2014): Systematic review and meta-analysis of the effect of increased vegetable and fruit consumption on body weight and energy intake. *BMC Public Health* **14**, 886.

Nascimento, G., Leite, F., Conceição, D., Ferrúa, C., Singh, A. and Demarco, F. (2016): Is there a relationship between obesity and tooth loss and edentulism? A systematic review and meta-analysis. *Obesity Reviews* **17**, 587-598.

Nascimento, G.G., Leite, F.R., Do, L.G., Peres, K.G., Correa, M.B., Demarco, F.F. and Peres, M.A. (2015): Is weight gain associated with the incidence of periodontitis? A systematic review and meta-analysis. *Journal of Clinical Periodontology* **42**, 495-505.

Nguyen, D.M. and El-Serag, H.B. (2010): The epidemiology of obesity. *Gastroenterology Clinics of North America* **39**, 1-7.

Östberg, A., Nyholm, M., Gullberg, B., Råstam, L. and Lindblad, U. (2009). Tooth loss and obesity in a defined Swedish population. *Scandinavian Journal of Social Medicine* **37**, 427-433.

Pierannunzi, C., Hu, S.S. and Balluz, L. (2013): A systematic review of publications assessing reliability and validity of the Behavioral Risk Factor Surveillance System (BRFSS), 2004–2011. *BMC Medical Research Methodology* **13**, 49.

Schwingshackl, L., Hoffmann, G., Kalle-Uhlmann, T., Arregui, M., Buijsse, B. and Boeing, H. (2015): Fruit and vegetable consumption and changes in anthropometric variables in adult populations: *a systematic review and meta-analysis of prospective cohort studies*. PloS One 10, e0140846.

World Health Organization. (2016a): BMI Classification 2016. Available from: http://apps.who.int/bmi/index.jsp?introPage=intro_3.html.

World Health Organization. (2016b): Obesity and overweight 2016 Available from: http://www.who.int/mediacentre/factsheets/fs311/en/.