Published in final edited form as:
Community Dent Oral Epidemiol. 2014 April ; 42(2): 170–177. doi:10.1111/cdoe.12069.

Associations between measures of central adiposity and periodontitis among older adults

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Abstract

Objective—To evaluate the association between measures of adiposity and periodontitis among older Puerto Rican adults.

Methods—A cross-sectional study was conducted among 147 representative adults ≥70 years living in the San Juan metropolitan area. Height, weight, waist (WC) and hip circumference were measured by trained personnel. Periodontal probing depth and attachment loss (AL) were measured by calibrated examiners. Periodontitis was classified according to the Center for Disease Control/American Academy of Periodontology (CDC-AAP) definitions, and using tertiles of mean AL and percent of sites with AL≥3mm. Multivariable polytomous logistic regression models adjusted for age, gender, smoking, education, diabetes status, physical activity and total fruit and vegetable intake were used to model associations between WC, waist-to-hip ratio (WHR), and periodontitis.

Results—High WC (men: ≥102cm vs. <102cm, women: ≥88cm vs. <88cm) compared to normal showed non-significant associations with severe (OR=2.56, 95%CI: 0.76-8.67), moderate periodontitis (OR=1.53, 95%CI: 0.65-3.60), and upper tertile of mean AL (OR=2.28, 95%CI: 0.83-6.23). Elevated WHR vs. normal (men: ≥0.95 vs. <0.95, women: ≥0.88 vs. <0.88) was associated with moderate periodontitis (OR=2.36, 95%CI: 1.01-5.52) and showed a borderline significant association with the upper tertile of mean AL (OR=2.52, 95%CI: 0.96-6.63, p=0.06).

Conclusion—Central adiposity was associated with a greater risk of periodontitis in this population of older adults, although analyses were underpowered. These results hold important public health implications given the high prevalence of adiposity and periodontitis among older adults.

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The authors have no conflicts of interest to disclose.

Introduction

Approximately 12% of the US population is comprised of older adults (≥ 65 years), and this percentage is estimated to increase up to 20% by 2030.(1) The prevalence of obesity and overweight among older adults has also increased dramatically over the past few decades.(2, 3) Using data from the National Health and Nutritional Examination Survey (NHANES) 2003-2004(3), approximately 71% of adults >60 years of age are overweight (body mass index-BMI ≥25 kg/m^2) and 30% are obese (BMI ≥30 kg/m^2).

The prevalence of periodontitis increases strongly with age. Estimates from NHANES III suggest a prevalence of moderate and severe periodontitis of approximately 14% among those 65-74 years of age and 21% among individuals 75+ years (CDC-AAP definition).(4) Among Puerto Rican elders (75+ years) the prevalence of moderate and severe periodontitis has been estimated at 45%.(5)

Untreated periodontitis ultimately leads to tooth loss which can have deleterious effects on masticatory ability and diet quality, which in turn may have important consequences on systemic diseases.(6) Furthermore, periodontitis has also been associated with increased risk of cardiovascular disease, coronary heart disease, pancreatic cancer and diabetes.(7, 8) Thus, associations between obesity and periodontitis would have important health implications.

A recent meta-analysis reported that BMI≥30 kg/m^2 was significantly associated with an increased odds of periodontitis (OR=1.35; 95% CI: 1.23-1.47);(9) however, data among older adults have been equivocal.(10-12) Few studies have addressed the limitations of BMI in older adult populations, or specifically evaluated central adiposity in this context. The validity of BMI as a measure of adiposity decreases with older age (≥60 years), due to changes in body composition;(2, 13) thus, other measures of body composition such as waist circumference (WC) and waist-to-hip ratio (WHR) may be more robust measures. Therefore, we evaluated the association between measures of central adiposity and oral health among a population of older Puerto Rican adults.

Materials and Methods

The study participants were enrolled in the cross-sectional study: the ‘Puerto Rican Elderly Dental Health Study’ (PREDHS). Subjects’ rights were protected by the UPR Medical Science Campus Institutional Review Boards and written informed consent was granted. PREDHS is a substudy of the Puerto Rico Elderly Health Conditions (PREHCO), a cohort study with a representative sample of Puerto Rican households with 1 or more adults aged ≥60 years in 2002. PREDHS was conducted to assess periodontal conditions among a representative sample of adults ≥70 years living in the San Juan metropolitan area in 2007. From the 1,364 individuals in PREHCO living in the San Juan Metropolitan area, we identified 943 non-institutionalized participants (Figure 1).

We excluded 551 participants who met the following criteria: did not pass a mini-mental exam to ensure proper consent and participant’s ability to answer questions during the interview (n=123, 13%), those previously identified for participation in another clinical study (n=158, 16.8%) in order to minimize participant burden, were edentulous (n=134, 14%), and <70 years of age (n=136; 14%), resulting in a sample of 392 individuals eligible for screening and recruitment. The PREDHS sample consisted of 183 individuals after recruitment and screening exclusion of those (47%) who indicated medical conditions that contraindicated periodontal probing without prophylactic antibiotic therapy (n=60, 15%), were sick, hospitalized or had died since the last PREHCO interview (n=19, 5%), could not be reached (n=23, 6%), or refused participation (n=107, 27%). For the present analyses several additional exclusions were made: 8 participants with BMI <18.5 kg/m^2, 3 who

suffered stroke, 5 with prior myocardial infarction, 4 with cancer (to minimize potential bias due to drastic weight loss), 6 with missing data on WC or WHR, 3 with missing data on diabetes status or education level, and 7 with missing data on fruit and vegetables intake resulting an analytic sample of 147 participants.

Assessment of central adiposity

Height, weight, WC and hip circumference (HC) were measured in participants' homes by trained research assistants. Details regarding the protocol for each assessment have been previously published.(14) Height was measured with participants standing against a wall and using a stadiometer. Participants' weight was measured on a balance, without shoes or thick socks. A measuring tape was used to determine WC and HC, over one layer of clothing while standing straight. The WC measurement was taken around the waist right above the iliac crest, assuring that the tape was unfolded and at the same height around the waist. The HC measurement was made at the mid-point between the iliac crest and the greater trochanter, ensuring that the tape was unfolded and straight. Waist-to-hip ratio was calculated by dividing WC by HC. Waist circumference and WHR were categorized per standard guidelines for both men and women (men: elevated WC ≥40 inches (102 cm), WHR ≥0.95 and women: elevated WC ≥35 inches (88 cm), WHR ≥0.88); there are no separate well accepted standards for Latino or Latino sub-groups.(15, 16)

Assessment of oral health outcomes

In-home dental exams were conducted using the same clinical criteria and instrumentation used by the NHANES dental examinations.(17) Dental examiners were trained and standardized by the NHANES reference dental examiner and then completed a calibration session before the beginning of the study. The percent agreements between each of the trained examiners and the reference examiner ranged from 87% to 94%, and the Kappa values ranged between 0.75-0.87.(18) Probing depth (PD) and attachment loss (AL) measurements were assessed at several sites (mesio-buccal, mid-buccal, disto-buccal, as well as the disto-lingual and the deepest site, if one could be found that was greater than the first three sites) on all teeth excluding 3rd molars. The deepest pocket and the disto-lingual sites were included to avoid underestimation of disease severity.(19) We utilized two composite case definitions based on the CDC-AAP classifications of periodontitis.(20) Severe periodontitis was defined as having ≥2 teeth with AL≥6mm and ≥1 tooth with PD≥5mm in the interproximal sites. Subjects were classified with moderate periodontitis if they had ≥2 teeth with AL≥4mm or ≥2 teeth with PD≥5mm in the interproximal sites, but did not have severe periodontitis.(21) We also classified participants by tertiles of mean AL and percent of sites with AL≥3mm. The number of existing natural teeth, as a measure of oral health history (periodontitis, caries, trauma, or orthodontic treatment), was summarized in 3 categories: 1-9, 10-19, and 20-32 teeth.

Assessment of additional covariates

Data on age (years), smoking status (never, former and current), highest level of education (≤ 9^{th} grade, some high school or high school graduate, or some college or technical studies), and diabetes status (yes/no) were collected from the PREHCO interviewer administered questionnaire. Physical activity (any structured physical activity; yes/no) and total fruit and vegetable intake (tertiles of servings/week) were collected from an interviewer administered questionnaire during the PREDHS in-home study visit.

Statistical Analysis

Descriptive analyses were conducted for the whole sample and separately by categories of WC and WHR. Polytomous logistic regressions, which simultaneously model predicted probabilities of multiple diagnostic outcome categories were estimated to evaluate the association between WC and WHR, and moderate and severe periodontitis (CDC-AAP definitions), tertiles of mean attachment loss, tertiles of percent of sites with AL≥ 3 mm, and categories of number of teeth.(22) We evaluated 2 multivariable models. Multivariable model 1 adjusted for age and gender. Multivariable model 2 additionally adjusted for smoking, education, diabetes status, physical activity and total fruit and vegetable intake. A similar multivariable model excluding participants with diabetes was calculated but results were similar to the main effects obtained from a multivariable model including diabetics and adjusted for diabetes status (Model 2), therefore diabetes status was maintained as a covariate (results not shown).

In sensitivity analyses we additionally adjusted multivariable model 2 for number of teeth as a confounder; since the estimates did not change appreciably, we decided to maintain the original multivariable model in primary analyses. To asses misclassification in extremely obese participants we evaluated models excluding those with BMI ≥40 kg/m^2; however, the results were materially unchanged; therefore, results are presented for all participants.

To further explore the associations between central adiposity and periodontitis, we conducted several *a priori* stratified analyses by age (> 77 vs. ≤ 77 years), gender, smoking status (ever vs. never), and diabetes; we also stratified by number of teeth (1-9, 10-19 and 20-32) for models with periodontitis as the outcome, and by periodontitis (moderate or severe vs. no periodontitis) for models with number of teeth as the outcome. Effect estimates from strata defined by binary variables were compared by employing a Wald-type statistical test where the squared difference of the log relative risks from the two strata was divided by the sum of their variances, and compared against a χ^2 statistic with 1 degree of freedom. However, many of the stratified models were unstable due to limited power, and are therefore not reported. We used a complete case analysis approach as less than 7% of observations were missing data on any one particular covariate. The final sample for the analysis included 147 participants. All p-values were two-sided. Analyses were conducted using SAS statistical software (version 9.1.3; SAS Institute, Cary, NC).

Results

The characteristics of participants according to WC and WHR are provided in Table 1. The final sample of 147 participants consisted of 99 women and 48 men, with a mean age of 77.7 years (SD: 5.7 years, range: 70-96). Sixty-five percent of participants exhibited high WC and 63% a high WHR. High WC and WHR were more prevalent among women than men (high WC: 72% of women vs. 52% men. p-value=0.02; high WHR: 65% women vs. 58% men, p-value=0.45). Twenty-one percent of participants exhibited severe periodontitis while 39% exhibited the moderate type. The mean AL was 2.68 (SD 1.46) and the percent of sites with AL≥3 mm was 39.4 (SD 25.8). Approximately 4% of participants were current smokers, while 20% reported past smoking. Participants with a high WHR were slightly older (p-value=0.01); and participants with a high WC were more likely to be diabetic (p-value=0.03) and somewhat older (p-value=0.08).

Table 2 shows the multivariable adjusted associations between measures of central adiposity (WC and WHR) and periodontitis. Participants with a high WC exhibited a greater odds of severe periodontitis compared to those with a normal WC when adjusted for covariates in Model 2, although the association was not statistically significant. High WC was associated

with an increased albeit non-significant odds of being in the upper tertile of mean AL compared to normal WC. Participants with high WC exhibited nearly two-fold odds of having 10-19 teeth vs. 20-32 teeth compared to those with normal WC.

High WHR (men: ≥0.95 vs. <0.95, women: ≥0.88 vs. <0.88) was significantly associated with a greater odds of moderate periodontitis compared to normal WHR in the fully adjusted analysis. When adjusted for covariates in model 1, high WHR showed a significantly greater than two-fold odds of being in the upper tertile of mean AL compared to normal WHR, and a non-significant moderately greater odds of being in the in the upper tertile of percent of sites with AL≥ 3 mm.

To further explore the associations between central adiposity and periodontitis, we conducted several *a priori* stratified analyses by age, gender, smoking status and diabetes. Due to the small sample size, estimates were unstable and many of the models failed to converge. We did not find evidence of significant variation of the association between central adiposity and periodontitis across any of the risk factors (results not shown). Among participants ≤77 years, high WHR was associated with a greater than two-fold increase in the odds of moderate periodontitis compared to those with normal WHR (OR=2.66, 95% CI: 1.00-7.06; events=19), compared to a null association among those >77 (OR=1.30; 95% CI: 0.44-3.82; events=27), when adjusted for covariates in Model 1.

Discussion

Our results suggest that central adiposity may be associated with periodontitis among older adults, although analyses were underpowered. These associations were generally consistent across various definitions of periodontitis. Furthermore, there was a suggestion that the association between WHR and moderate periodontitis varied by age.

An emerging body of literature has suggested that both overall and central obesity are associated with a greater risk of periodontitis.(23, 24) Few studies have evaluated the association specifically among older adults, and the results are conflicting.(10, 12, 25-27) This may be partly explained by the use of potentially inappropriate measures of adiposity among older participants, such as BMI (11, 25, 28) and the control of intermediates (e.g. diabetes) on the causal pathway.(10, 25)

Utilizing data from NHANES III, Al-Zahrani et al. examined the association between WC and periodontitis among adults ≥18 years. (25) In multivariable analyses, elevated WC (>102cm men/ >88 cm women) was associated with a significantly greater odds of periodontitis among adults 18-34 years (OR=2.27; 95% CI: 1.48-3.49), but not among adults 60-90 years (OR=1.14; 95% CI: 0.86-1.50). In contrast, in the Hisayama study, a population of Japanese women aged 40-79 years, investigators reported that high WC and WHR were similarly associated with a significantly greater odds of mean PD. WC >88 cm compared to <88 cm was significantly associated with mean PD ≥2.0 mm (OR=1.8; 95% CI: 1.2-2.8); however, there were no observed associations between either measure of central adiposity and AL. (29) In the present analyses, our results for mean AL and composite periodontal disease measures were comparable.

Most studies evaluating the association between obesity and periodontitis have utilized BMI as the primary measure of adiposity. A recent meta-analysis(9) reported BMI ≥30 kg/m^2 was significantly associated with a greater odds of periodontitis (OR=1.35; 95% CI: 1.23-1.47). However, it is unclear whether the association is limited to younger adults since several studies have reported null associations among older age groups.(10, 11, 25, 28)

The null associations observed between adiposity and periodontitis among older populations may potentially be explained by the use of BMI as the primary measure of body composition, which may miss key changes in body composition with aging.(30) Such changes include decreases in fat free mass and decreased height with an increase in fat mass leading to a decrease in the validity of BMI in older individuals.(30, 31) BMI does not provide information on the distribution of fat which is of particular relevance among older adults due to fat redistribution and increases in intra-abdominal fat.(2, 13) Thus, other measures of body composition such as WC and WHR may be more robust measures of adiposity among older adult populations. Waist circumference, an excellent measure of both abdominal visceral fat and total abdominal fat as shown by dual energy x-ray absorptiometry,(32) has been associated with increased risk of insulin resistance, dyslipidemia and cardiovascular disease.(30) However, WHR can be influenced by changes in lean body mass as the hip measurement reflects one of the largest lean muscles in the body.(33)

Diabetes may potentially be on the causal pathway between obesity and periodontitis, therefore statistical adjustment may attenuate any observed association. However, our estimates were virtually unchanged by adjustment for diabetes status. Although we observed a stronger association between WHR and moderate periodontitis among those ≤77 years, estimates were unstable and confidence intervals were wide, as this study was not designed to detect sub-group interactions; hence analyses were underpowered and should be interpreted with caution.

Obesity may lead to periodontitis by inducing a state of low grade systemic inflammation and pro-inflammatory environment conducive to a hyper-inflammatory response by gingival tissues in the presence of periodontal pathogens.(23, 34) The adipose tissue of overweight and obese individuals has been shown to secrete pro-inflammatory cytokines such as TNF-α and IL1-β.(35, 36) Moreover, evidence suggests abdominal obesity (both visceral and subcutaneous) contributes to increased systemic free fatty acids due to “spill over” from adipose tissue to the liver as a result of an inability of the adipose tissue to adequately retain free fatty acids.(30) The resulting increased free fatty acid concentration may lead to β-cell apoptosis thereby inducing insulin resistance. Hence, abdominal obesity has been implicated as a key contributing component to the metabolic syndrome and is consistently associated with insulin resistance.(30) Furthermore, insulin resistance may have an important role in the pathogenesis of periodontitis by inducing vascular abnormalities such as basement membrane thickening in gingival tissues.(37) These vascular alterations may lead to impairment of the delivery of leukocytes and nutrients into the gingival and periodontal tissues and movement of metabolic waste of periodontal pathogens out of the tissue leading to decreased wound healing capacity and increased severity of periodontitis.(23, 37) Although the cross-sectional design of this study precludes the assessment of the temporal sequence, it is unlikely that periodontitis would play a key role in the development of obesity which is generally caused by excess calories and lack of physical activity. Our small sample size limited our ability to examine variation in the underlying association across sub-groups (e.g. age, gender, diabetes, smoking status). While these results may not be directly generalizable to other populations of older adults, given the particular ethnic and demographic characteristics of this population, it is unlikely that the underlying biologic association would vary substantially across populations. Further research is needed among older adult populations to confirm these findings in diverse populations.

Conclusions

Multivariable analysis on the measures of central adiposity and periodontitis among older adults suggested a possible association between these two conditions. Our findings warrant

further investigation in larger longitudinal studies, with repeated dental and weight measures to assess the temporal sequence and to allow for the adjustment of potential unintentional weight loss among sub-clinically diseased individuals. The observed association between obesity and periodontitis among older adults is of substantial importance given the growing population of older adults and the high prevalence of obesity and periodontitis among this vulnerable population.

Acknowledgments

Funding: This work was supported by the National Institutes of Health (G12RR03051, K24DE016884 and S21 MD001830).

The authors acknowledge the PREDHS team's help with the study: Dr. Mauricio Montero, Dr. Enrique Santiago, Dr. Maria L. Aguilar, Dr Sona Tumanyan, Dr Ana L. Dávila, Dr Alberto García, Ms Sasha Martínez, Ms Yarí Valle, Ms Vanesza Robles, Mr Michael Brunelle, Ms Mildred Rivera, Ms Jennifer Torres, Ms Jennifer Guadalupe, Dr Monik Jimenez and Dr Maribel Campos.

References

1. Greenberg, S. A Profile of Older Americans: 2010: Administration on Aging. US Department of Health and Human Services; 2010.
2. Villareal DT, Apovian CM, Kushner RF, Klein S. Obesity in older adults: technical review and position statement of the American Society for Nutrition and NAASO, The Obesity Society. Obes Res. 2005; 13(11):1849–63. [PubMed: 16339115]
3. Ogden CL, Carroll MD, Curtin LR, McDowell MA, Tabak CJ, Flegal KM. Prevalence of overweight and obesity in the United States, 1999-2004. Jama. 2006; 295(13):1549–55. [PubMed: 16595758]
4. Dye BA, Tan S, Smith V, et al. Trends in oral health status: United States, 1988-1994 and 1999-2004. Vital Health Stat. 2007; 11(248):1–92.
5. Montero M, Elías A, Cuadrado L, Toro-Vizcarrondo C, Joshipura K. Periodontal Status of Older Adults in San Juan. J Dent Res Issue. 2007; 86(Spec Iss A):0647. www.dentalresearch.org.
6. Joshipura KJ, Willett WC, Douglass CW. The impact of edentulousness on food and nutrient intake. J Am Dent Assoc. 1996; 127(4):459–67. [PubMed: 8655866]
7. Burt, BA.; Eklund, SA. Dentistry, Dental Practice, and the Community. Elsevier Saunders; St. Louis, Missouri: 2005.
8. Michaud DS, Joshipura K, Giovannucci E, Fuchs CS. A prospective study of periodontal disease and pancreatic cancer in US male health professionals. J Natl Cancer Inst. 2007; 99(2):171–5. [PubMed: 17228001]
9. Chaffee BW, Weston SJ. Association between chronic periodontal disease and obesity: a systematic review and meta-analysis. J Periodontol. 2010; 81(12):1708–24. [PubMed: 20722533]
10. Borges-Yanez SA, Irigoyen-Camacho ME, Maupome G. Risk factors and prevalence of periodontitis in community-dwelling elders in Mexico. J Clin Periodontol. 2006; 33(3):184–94. [PubMed: 16489944]
11. Weyant RJ, Newman AB, Kritchevsky SB, et al. Periodontal disease and weight loss in older adults. J Am Geriatr Soc. 2004; 52(4):547–53. [PubMed: 15066069]
12. Linden G, Patterson C, Evans A, Kee F. Obesity and periodontitis in 60-70-year-old men. J Clin Periodontol. 2007; 34(6):461–6. [PubMed: 17403015]
13. Fukagawa NK, Bandini LG, Young JB. Effect of age on body composition and resting metabolic rate. Am J Physiol. 1990; 259(2 Pt 1):E233–8. [PubMed: 2382714]
14. Palloni, A.; Sánchez-Ayéndez, M.; Dávila, A. PREHCO: Puerto Rican Elderly Health Conditions. University of Puerto Rico, University of Wisconsin-Madison; San Juan, Puerto Rico: 2003.
15. ADA timely statement on Nutrition and Your Health: Dietary Guidelines for Americans. J Am Diet Assoc. 1990; 90(12):1720. [PubMed: 2131341]

16. National Institutes of Health. National Heart Lung and Blood Institute. North American Association for the Study of Obesity. The practical guide: identification, evaluation, and treament of overweight and obesity in adults. Bethesda, MD: 2000.
17. U.S. Department of Health and Human Services. Third National Health and Nutrition Examination Survey, 1988-1994, NHANES III Examination Data File (CD-ROM). Centers for Disease Control and Prevention; Hyattsville, MD: 1996.
18. Montero-Aguilar M, Muñoz-Torres F, Elías-Boneta AR, Dye B, Joshipura KJ. High levels of periodontal disease among the older adult population in San Juan, Puerto Rico. Community Dent Health. 2012; 29(3):224–8. [PubMed: 23038939]
19. Douglass CW, Jette AM, Fox CH, et al. Oral health status of the elderly in New England. J Gerontol. 1993; 48(2):M39–46. [PubMed: 8473693]
20. Page RC, Eke PI. Case definitions for use in population-based surveillance of periodontitis. J Periodontol. 2007; 78(7 Suppl):1387–99. [PubMed: 17608611]
21. Eke PI, Genco RJ. CDC Periodontal Disease Surveillance Project: background, objectives, and progress report. J Periodontol. 2007; 78(7 Suppl):1366–71. [PubMed: 17610396]
22. Biesheuvel CJ, Vergouwe Y, Steyerberg EW, Grobbee DE, Moons KG. Polytomous logistic regression analysis could be applied more often in diagnostic research. J Clin Epidemiol. 2008; 61(2):125–34. [PubMed: 18177785]
23. Pischon N, Heng N, Bernimoulin JP, Kleber BM, Willich SN, Pischon T. Obesity, inflammation, and periodontal disease. J Dent Res. 2007; 86(5):400–9. [PubMed: 17452558]
24. Ritchie CS. Obesity and periodontal disease. Periodontol. 2007; 44:154–63. 2000.
25. Al-Zahrani MS, Bissada NF, Borawskit EA. Obesity and periodontal disease in young, middle-aged, and older adults. J Periodontol. 2003; 74(5):610–5. [PubMed: 12816292]
26. Shimazaki Y, Saito T, Yonemoto K, Kiyohara Y, Iida M, Yamashita Y. Relationship of metabolic syndrome to periodontal disease in Japanese women: the Hisayama Study. J Dent Res. 2007; 86(3):271–5. [PubMed: 17314261]
27. Torrungruang K, Tamsailom S, Rojanasomsith K, et al. Risk indicators of periodontal disease in older Thai adults. J Periodontol. 2005; 76(4):558–65. [PubMed: 15857096]
28. Alabdulkarim M, Bissada N, Al-Zahrani M, Ficara A, Siegel B. Alveolar bone loss in obese subjects. J Int Acad Periodontol. 2005; 7(2):34–8. [PubMed: 15912922]
29. Saito T, Shimazaki Y, Kiyohara Y, et al. Relationship between obesity, glucose tolerance, and periodontal disease in Japanese women: the Hisayama study. J Periodontal Res. 2005; 40(4):346–53. [PubMed: 15966913]
30. Hu, FB. Obesity Epidemiology. Oxford University Press; New York: 2008. p. 149-95.
31. Willett WC, Dietz WH, Colditz GA. Guidelines for healthy weight. N Engl J Med. 1999; 341(6): 427–34. [PubMed: 10432328]
32. Clasey JL, Bouchard C, Teates CD, et al. The use of anthropometric and dual-energy X-ray absorptiometry (DXA) measures to estimate total abdominal and abdominal visceral fat in men and women. Obes Res. 1999; 7(3):256–64. [PubMed: 10348496]
33. Willett, W. Nutritional Epidemiology. Second Edition. Oxford University Press; New York: 1998.
34. Joshipura KJ, Wand HC, Merchant AT, Rimm EB. Periodontal disease and biomarkers related to cardiovascular disease. J Dent Res. 2004; 83(2):151–5. [PubMed: 14742654]
35. Das UN. Is obesity an inflammatory condition? Nutrition. 2001; 17(11-12):953–66. [PubMed: 11744348]
36. Tilg H, Moschen AR. Adipocytokines: mediators linking adipose tissue, inflammation and immunity. Nat Rev Immunol. 2006; 6(10):772–83. [PubMed: 16998510]
37. Beck JD, Offenbacher S. Oral health and systemic disease: periodontitis and cardiovascular disease. J Dent Educ. 1998; 62(10):859–70. [PubMed: 9847889]

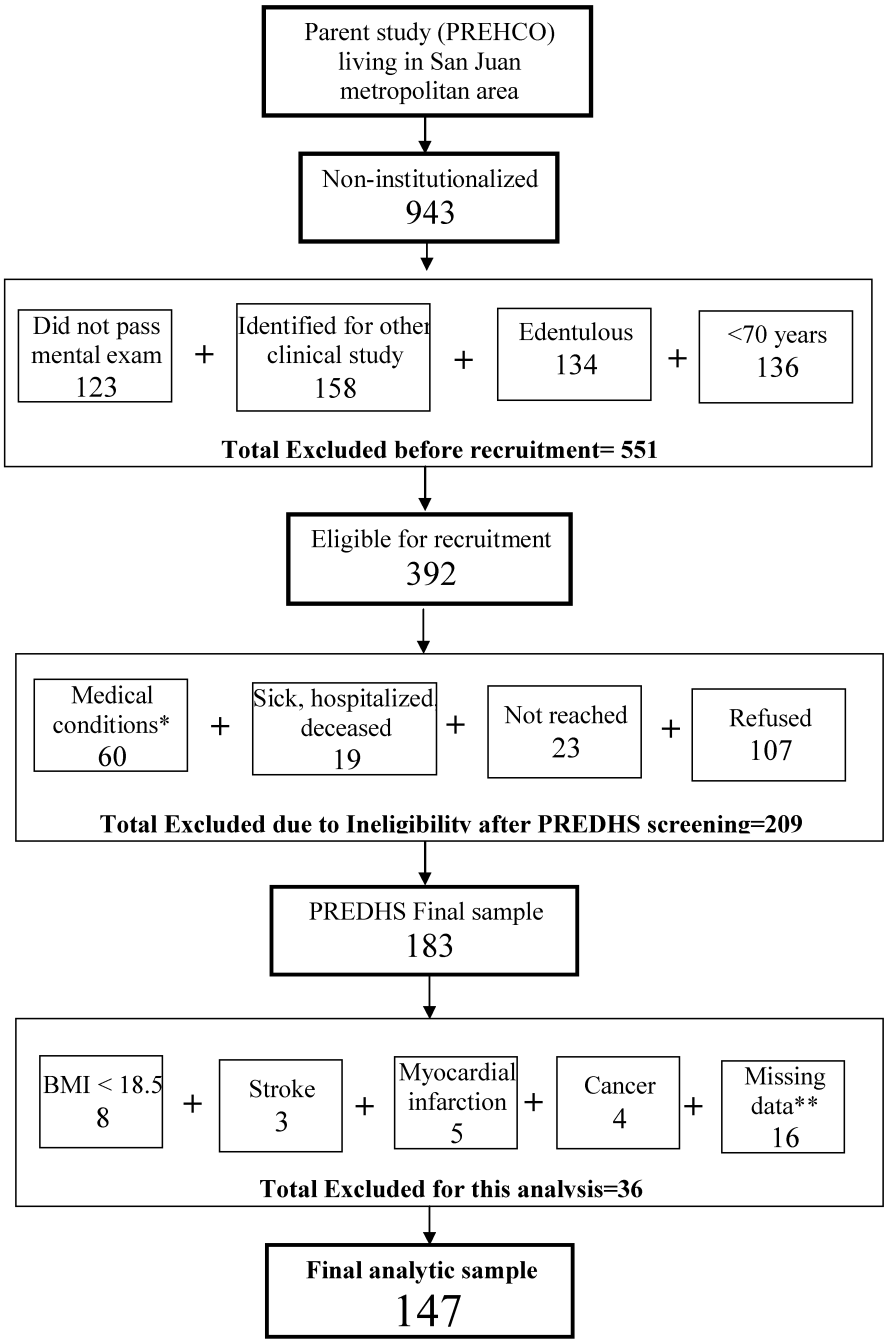

Figure1.

Explanation of final analytic sample

*Medical conditions that contraindicated periodontal probing without prophylactic antibiotic therapy

**6 missing WC and WHR, 3 missing diabetes status and education level, and 7 missing fruit and vegetables intake

Table1

Characteristics of the study population by waist circumference (WC) and waist-to-hip ratio (WHR)

	Waist Circumference			Waist-to-Hip Ratio		
	Normal WC	**High WC**	***P* value**	**Normal WHR**	**High WHR**	***P* value**
N (%)	51 (35%)	96 (65%)		55 (37%)	92 (63%)	
Age (yrs)	76.6 ± 5.0	78.3 ± 6.0	0.08	76.1 ± 4.8	78.7 ± 6.0	0.01
Male, %	45	26	0.02	36	30	0.46
Smoking status, %			0.56			0.89
Never	80	73		78	74	
Former	16	23		18	22	
Current	4	4		4	4	
Diabetes, %	12	27	0.03	16	25	0.22
Physical activity, %	35	38	0.80	29	41	
Education, %			0.55			0.14
≤9th grade	27	35		35	32	0.92
10-12th grade	26	20		22	22	
College or technical	47	45		44	47	
Fruits & vegetables	18.9 ± 13.2	18.6 ± 14.3	0.91	20.0 ± 14.0	18.0 ± 13.8	0.40
Number of natural teeth, %			0.29			0.39
1-9	18	19		18	18	
10-19	35	47		36	47	
20-32	47	34		46	35	
Severe periodontitis, %	20	22	0.80	25	18	0.07
Moderate periodontitis, %	37	41		27	47	
Mean attachment loss	2.70 ± 1.69	2.66 ± 1.33	0.87	2.57 ± 1.51	2.74 ± 1.43	0.49
% of sites with AL≥3mm	38.7 ± 25.1	39.7 ± 26.2	0.81	37.0 ± 26.9	40.8 ± 25.1	0.40
BMI	23.5 ± 2.8	29.8 ± 4.4	<0.0001	25.8 ± 4.6	28.7 ± 4.7	<0.001

Values are means ± SD or percentages as indicated

Table2

Multivariable Odds Ratios and 95% CI for periodontitis and number of teeth, according to Waist Circumference (WC) and Waist to Hip Ratio (WHR)

	High Waist Circumference*			High Waist to Hip Ratio**		
Oral health Outcomes	**Events exposed\ unexposed**	**Model 1†**	**Model 2‡**	**Events exposed\ unexposed**	**Model 1†**	**Model 2‡**
Periodontitis						
Severe	21\10	2.30 (0.80-6.63)	2.56 (0.76-8.67)	17\14	1.16 (0.44-3.05)	1.25 (0.43-3.66)
Moderate	39\19	1.43 (0.64-3.20)	1.53 (0.65-3.60)	43\15	2.30 (1.02-5.17)	2.36 (1.01-5.52)
No/mild (Ref.)	36\22	1.0	1.0	32\26	1.0	1.0
% of sites with AL≥3mm						
3rd tertile	31\15	1.19 (0.49-2.92)	1.12 (0.43-2.89)	31\15	1.56 (0.65-3.73)	1.52 (0.61-3.80)
2nd tertile	30\19	0.93 (0.39-2.20)	0.97 (0.39-2.40)	31\18	1.36 (0.59-3.16)	1.37 (0.57-3.26)
1st tertile (Ref.)	35\17	1.0	1.0	30\22	1.0	1.0
Mean AL (mm)						
3rd tertile	33\12	2.26 (0.88-5.79)	2.28 (0.83-6.23)	33\12	2.65 (1.06-6.64)	2.52 (0.96-6.63)
2nd tertile	34\20	1.43 (0.61-3.36)	1.43 (0.58-3.48)	34\20	1.72 (0.74-3.96)	1.62 (0.69-3.78)
1st tertile (Ref.)	29\19	1.0	1.0	25\23	1.0	1.0
Number of teeth						
1-9	18\9	1.39 (0.52-3.73)	1.33 (0.46-3.85)	17\10	1.19 (0.45-3.11)	1.16 (0.42-3.21)
10-19	45\18	1.78 (0.80-3.95)	1.85 (0.78-4.36)	43\20	1.44 (0.70-3.18)	1.42 (0.63-3.22)
20-32 (Ref.)	33\24	1.0	1.0	32\25	1.0	1.0

* High waist circumference, men: WC ≥40” (102cm), women WC ≥35” (88cm)

** High waist to hip ratio, men WHR ≥0.95, women WHR ≥0.88

† Model 1: Adjusted for age and gender

‡ Model 2: Model 1 + additionally adjusted for smoking, education, diabetes status, physical activity, total fruit and vegetable intake.