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Obesity and periodontitis in 60–70-year-old men

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Abstract

Objective: The aim was to investigate whether there was an association between obesity and periodontitis in a homogeneous group of 60–70-year-old Western European men. The study also explored whether a high body mass index (BMI) in early life predicted poor periodontal status in later life.

Methodology: A representative sample of the male population of UK, who were enrolled in a cohort study of cardiovascular disease, was examined between 2001 and 2003. A total of 1362 men with six or more teeth completed a questionnaire, had a clinical periodontal examination and had their weight and height recorded. Multivariable analysis was carried out using logistic regression with adjustment for possible confounders. Models were constructed with low- and high- threshold periodontitis as dependent variables and with BMI as a categorical predictor variable. Low-threshold periodontitis was identified when at least two teeth had $\geqslant$6 mm loss of attachment and at least one site had a pocket of $\geqslant$5 mm. High-threshold periodontitis was identified when $\geqslant$15% of sites had $\geqslant$6 mm loss of attachment and there was deep pocketing ($\geqslant$6 mm). Modelling was repeated for other predictor variables including BMI at 21 years of age and change in weight since 21 years of age.

Results: Two hundred and ninety-eight (21.9%) of the men studied, who had a BMI of >30 kg/m^2, were classified as obese. Obesity was associated with low-threshold periodontitis, odds ratio (OR) = 1.77 ($p = 0.004$) after adjustment for confounders. The BMI at 21 years of age did not predict periodontitis in the men investigated. Participants who had experienced a large (>30%) increase in weight during adulthood had an increased risk of poor periodontal condition; however, this was attenuated and no longer significant after adjustment for confounders.

Conclusions: It is concluded that obesity was associated with periodontitis in the homogeneous group of 60–70-year-old European men investigated. High BMI levels in early life did not predict periodontitis in later life in the men studied.

Key words: BMI; obesity; periodontitis; pocketing

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The global obesity epidemic has been described by the World Health Organisation (2000) as one of the most blatantly visible, yet most neglected, public health problems that threatens to overwhelm both more- and less-developed countries. Trends in obesity show that after remaining relatively stable in the 1960s and 1970s, the prevalence among adults has increased markedly since 1980 in many developed countries (Olshansky et al. 2005). The most recent data from the United States indicated that 32% of adults were obese in 2004 (Ogden et al. 2006). In the United Kingdom, the prevalence of obesity among adults almost tripled between 1980 and 2002 (Rennie & Jebb 2005).

There is concern for public health as excess bodyweight is now the sixth most important risk factor contributing to disease worldwide and increased levels of obesity may result in a decline in life expectancy in the future (Olshansky et al. 2005). Obesity is a multisystem condition associated with an elevated risk of cardiovascular disease, type 2 diabetes and some cancers (Haslam & James 2005). An association between obesity and chronic periodontitis was identified in Japanese subjects (Saito et al. 1998) and a follow-up study concluded that increased abdominal adiposity was a key factor (Saito et al. 2001). Further studies from Japan (Nishida et al. 2005, Saito et al. 2005) and Brazil (Dalla Vecchia et al. 2005) also found that obesity was associated with an increased risk of periodontitis. Investigations from the United States, using the large NHANES III dataset, supported

Conflict of interest and source of funding statement

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associations between measures of body fat and periodontal disease (Al-Zahrani et al. 2003, Wood et al. 2003, Genco et al. 2005).

There are no published studies of obesity as a risk indicator for periodontitis in European populations. Some questions were also raised by previous studies, which found that the associations were not uniform throughout the populations studied, with Al-Zaharani et al. (2003) reporting a relationship for younger subjects but not for those who were middle aged or older and Dalla Vecchia et al. (2005) finding an association in women but not in men. The aim of the current study was to investigate whether there were associations between obesity and periodontal status in a homogeneous group of Western European men aged 60–70 years. There is considerable interest in the possible influence of adiposity in early life on the development of chronic disease in later life. The study therefore also explored whether high body mass index (BMI) in early life predicted poor periodontal status in later life.

Table 1. Baseline characteristics for 1362 participants

	Mean (SD)	Range
Age (years)	64.2 (2.9)	58.7–72.3
Teeth	19.9 (5.6)	6–28
BMI (2001–2003)	27.5 (3.6)	18.6–48.8
BMI in (1991–1994)	26.1 (3.1)	18.4–47.6
BMI as 21 year old	22.4 (2.4)	14.7–33.0

BMI as 21 year old was calculated using participants' estimates of their weight at that age.
BMI, body mass index.

Table 2. Baseline characteristics among 1362 men in PRIME according to category of BMI as measured in 2001–2003

	Normal BMI <25 ($n=336$)	Overweight BMI $\geqslant 25$–$\leqslant 30$ ($n=728$)	Obese BMI >30 ($n=298$)	p
Age (years), mean (SD)	64.0 (2.9)	64.4 (2.9)	64.0 (2.9)	0.98
Teeth, mean (SD)	20.5 (5.4)	20.1 (5.5)	18.6 (5.7)	<0.0001
Periodontitis, low threshold, *n* (%)	72 (21.4)	180 (24.7)	97 (32.6)	0.002
Periodontitis, high threshold, *n* (%)	21 (6.3)	47 (6.5)	30 (10.1)	0.08
% sites with probing depth $\geqslant 5$ mm, mean (SD)	3.3 (6.6)	3.4 (6.8)	4.8 (8.7)	0.01
Smoking, *n* (%)				
Never	154 (45.8)	292 (40.2)	98 (32.9)	<0.0001
Past	111 (33.0)	327 (44.9)	155 (52.0)	
Current light	44 (13.1)	74 (10.2)	31 (10.4)	
Current heavy	27 (8.0)	33 (4.5)	14 (4.7)	
Diabetes, *n* (%)	10 (3.0)	38 (5.2)	30 (10.1)	0.0002

p values are for comparisons between obese and normal groups.
BMI, body mass index.

Material and Methods

Study population

The study subjects were participants in Prospective Epidemiological Study of Myocardial Infarction (PRIME), which is a cohort study of cardiovascular disease in men in Northern Ireland. The sampling frame was based on industry, the civil service and on general medical practices. Between 1991 and 1994, a sample of 2748 representing approximately 5% of 50–60-year-old men from the greater Belfast area was recruited to match broadly the social class structure of the population in Northern Ireland (Yarnell 1998). Between 2001 and 2003, the surviving men were contacted by post and invited to attend a review as part of their continuing involvement in the PRIME study. A total of 2010 men were reviewed and a clinical periodontal examination was completed for 1400 (69.7%) of the men. The remainder of the sample was made up of 363 (18.1%) men who did not have a dental examination because a specialist dental examiner was not available during their visit, 158 (7.9%) who were edentulous and 89 (4.4%) who refused or had a medical condition that precluded periodontal probing. Each subject completed a questionnaire, which gathered information on their demographic and socioeconomic background, level of education, occupational activity and tobacco consumption. Measurements of weight and height were also recorded. Approval for the project was obtained from the Research Ethics Committee of the Faculty of Medicine, Queen's University, Belfast. The aims of the investigation and the nature of the study were fully explained to the subjects, who gave their informed written consent before participation.

All the periodontal examinations were completed by one of four dental hygienists who was calibrated to a ''gold standard'' senior clinical researcher before the study. There were regular monthly meetings to ensure inter- and intra-examiner consistency and reproducibility throughout the study period. In the periodontal examination, clinical measurements were made at the mesial, distal, buccal and palatal/lingual aspects of all teeth excluding third molars. Probing depths were measured from the gingival margin to the base of the clinical pocket with the probe tip parallel to the long axis of the tooth and positioned interproximally as close as possible to the contact point. Measurements were made to the nearest millimetre and where any doubt existed the lower value was scored. Clinical attachment level was recorded as the distance from the cement–enamel junction (CEJ) to the base of the clinical pocket. This was calculated by measuring the distance from the CEJ to the gingival margin and subtracting this value from the probing depth measurement (recession was recorded as a negative value). All clinical measurements were recorded using Michigan O periodontal probes with Williams markings from a batch of probes purchased for the study.

Periodontal status

Low-threshold periodontitis was identified by the presence of at least two teeth with non-contiguous inter-proximal sites with $\geqslant 6$ mm loss of attachment and with at least one pocket of $\geqslant 5$ mm. High-threshold periodontitis was identified when $\geqslant 15\%$ of all sites measured had loss of attachment $\geqslant 6$ mm and there was at least one site with deep pocketing ($\geqslant 6$ mm).

Table 3. Multivariable analysis. Relationships between BMI present and past and changes in weight with low-and high-threshold periodontitis

	Low-threshold periodontitis		High-threshold periodontitis	
	1 OR 95% CI	2 OR 95% CI	1 OR 95% CI	2 OR 95% CI
BMI				
Normal	1.00 r	1.00 r	1.00 r	1.00 r
Overweight	1.20	1.23	1.04	1.07
	0.88–1.64	0.88–1.71	0.61–1.76	0.61–1.88
Obese	1.77**	1.77**	1.68	1.55
	1.24–2.53	1.20–2.63	0.94–3.00	0.82–2.93
BMI 21				
Low	1.00 r	1.00 r	1.00 r	1.00 r
Middle	0.94	1.02	1.04	1.04
	0.70–1.27	0.74–1.41	0.63–1.72	0.60–1.78
High	0.99	1.10	1.04	1.00
	0.74–1.33	0.80–1.51	0.63–1.73	0.58–1.72
Change weight since 21				
Low	1.00 r	1.00 r	1.00 r	1.00 r
Middle	1.03	0.99	0.84	0.88
	0.76–1.39	0.72–1.36	0.49–1.46	0.49–1.55
High	1.52**	1.33	1.79*	1.65
	1.12–2.06	0.95–1.86	1.08–2.95	0.95–2.87

Model 1, unadjusted; Model 2, adjusted for age, smoking, diabetes, years in education, socioeconomic status, dental attendance and toothbrushing frequency.
*$p<0.05$, **$p<0.01$.
OR, odds ratio; r, reference categories; BMI, body mass index.

Potential predictors of poor periodontal status

BMI was calculated as the body weight/height^2 (kg/m^2). The BMI measured between 2001 and 2003 was categorised using the World Health Organization (2000) classification: normal weight equated to BMI <25 kg/m^2, overweight $\geqslant 25$ to $\leqslant 30$ kg/m^2 and obese >30 kg/m^2. When the cohort was recruited between 1991 and 1994 and subsequently at the dental examinations between 2001 and 2003, each man was asked to estimate his weight when he was 21 years of age. The average of these reported weights was used to calculate the BMI at age 21 years, using the height recorded at the initial examination of the cohort between 1991 and 1994. This was to allow for the height shrinkage that occurs from middle age. Because so few men were obese when young, the BMI at age 21 years was divided into tertiles for use in further analyses. The percentage change in weight between the value as a 21 year old and that measured at the examination in 2001–2003 was calculated. The men were divided into those with a stable weight, classified as those who lost or gained $<15\%$, those with a medium gain in weight ($\geqslant 15$–$\leqslant 30\%$) and those with a large gain (>30%). There were five men who lost >15% of their weight and they were excluded from the categorisation.

Smokers were divided into current heavy ($\geqslant 20$ cigarettes/day), current light (<20 cigarettes/day), past or never. Diabetes was categorised by self report of the condition. The number of years spent in full-time education was recorded. Socioeconomic status (SES) was categorised as manual or non-manual from the occupation of the men according to the coding system of the United Kingdom Registrar General (1980). Dental attendance pattern was divided on the basis of self reporting as ''only when in trouble'', occasional or regular and toothbrushing frequency was noted.

Statistical analysis

One-way analysis of variance or χ^2 analysis was used to compare the subgroups of the men with the level of significance set at $p<0.05$. Unadjusted odds ratios (OR) and confidence intervals were calculated using standard methods. Multivariable analysis was carried out using logistic regression to obtain OR adjusted for possible confounders. Models were constructed with the measures of periodontal status as dependent variables and with BMI as a categorical predictor variable. Confounders included in the analysis were age, smoking, diabetes, education, SES, pattern of dental attendance and toothbrushing frequency. This modelling was repeated for other predictor variables including BMI at 21 years of age and change in weight since 21 years of age. Statistical analysis was completed using SPSS version 14 (SPSS Inc., Chicago, IL, USA).

Results

In total 1558 men who participated in the Belfast PRIME study had a dental examination between 2001 and 2003. The 158 edentulous men and 38 with fewer than six teeth were excluded from further study. The remaining 1362 dentate men, who had a periodontal examination, formed the basis of this investigation (Table 1). There had been an increase of 1.4 kg/m^2 in BMI in the 10-year period since the previous physical examination of the cohort, which took place between 1991 and 1994 (Table 1). The number of men who were obese more than doubled from 139 (10.2%) in 1991–1994 to 298 (21.9%) in 2001–2003. A very small number of the men 17 (1.2%) had been obese as 21 year olds.

There was no significant difference in the age of the men in the three BMI categories (Table 2). For all the variables measured, there was virtually no difference between the normal and the overweight BMI groups. Those who were obese had fewer teeth, higher levels of low- and high-threshold periodontitis, a higher proportion of sites with probing depth $\geqslant 5$ mm, were more likely to have smoked and to suffer from diabetes than those in the lower BMI categories (Table 2). Men who were obese were more likely to be manual workers ($p<0.0001$), had spent fewer years in full-time education ($p<0.0001$), brushed their teeth less frequently ($p<0.0001$) and were less likely to be regular dental attenders than men with a lower BMI ($p<0.0001$).

Current BMI

In comparison with normal BMI, there were no significant associations between being overweight and either measure of

Table 4. Men who were obese as 60–70 year-olds: low or middle BMI third compared with the high BMI third at 21 years of age

	Low/middle third at 21 ($n = 149$)	High third at 21 ($n = 149$)	p
BMI at 21 years of age, mean (SD)	21.3 (1.4)	25.5 (2.1)	<0.0001
BMI as 60–70 year old, mean (SD)	32.4 (2.1)	32.9 (2.7)	0.09
% increase in BMI, mean (SD)	52.8 (15.5)	29.5 (12.1)	<0.0001
Age (years), mean (SD)	64.1 (3.1)	64.0 (2.8)	0.76
Teeth, mean (SD)	18.4 (5.9)	18.7 (5.5)	0.61
Periodontitis, low threshold, *n* (%)	45 (30.2)	52 (34.9)	0.39
Periodontitis, high threshold, *n* (%)	15 (10.1)	15 (10.1)	1.00
% sites with probing depth $\geqslant 5$ mm, mean (SD)	4.9 (9.1)	4.6 (8.4)	0.75
Smoking, *n* (%)			
Never	43 (28.9)	55 (36.9)	0.30
Past	83 (55.7)	72 (48.3)	
Current light	14 (9.4)	17 (11.4)	
Current heavy	9 (6.0)	5 (3.4)	
Diabetes, *n* (%)	15 (10.1)	15 (10.1)	1.00

BMI, body mass index.

periodontal status (Table 3). Relative to normal BMI, there was a significant association between obesity and low-threshold periodontitis. In the fully adjusted model, this association between obesity and low-threshold periodontitis remained significant ($p = 0.004$) with an OR of 1.77.

In the fully adjusted statistical models, the strongest associations were between smoking and the various measures of periodontal status. For current BMI and low-threshold periodontitis; there was a graded response related to heavy current smoking (OR = 4.83, 95% CI = 2.82–8.26, $p<0.0001$), light current smoking (OR = 2.60, 95% CI 1.71–3.97, $p<0.0001$) and past smoking (OR = 1.46, 95% CI = 1.08–1.97, $p = 0.013$). For current BMI and high-threshold periodontitis, both current heavy smoking (OR = 4.21, 95% CI = 2.04–8.72, $p<0.0001$) and current light smoking (OR = 3.22, 95% CI = 1.76–5.88, $p<0.0001$) had strong associations. This was typical of all the analyses completed and no other risk factor had an effect that was as strong as current smoking.

BMI at 21

There were no significant associations between BMI at 21 years of age and the measures of periodontal status (Table 3).

Change in weight since age 21

With reference to stable weight, there were significant associations between large gains in weight (>30% increase) and both low- and high-threshold periodontitis. However, these associations were not statistically significant after adjustment for confounders (Table 3).

The correlation between BMI at 21 years of age and at 60–70 years was low ($r = 0.33$, 95% CI 0.28–0.38). Half (50%) of those who were obese in later life came from the highest third of BMI at age 21. The remaining 50% of those who were obese were drawn from the low (22%) and middle (28%) thirds of BMI at 21 years of age. There was no difference in the prevalence of low- or high-threshold periodontitis, proportion of sites with probing depth $\geqslant 5$ mm, prevalence of diabetes or smoking behaviour in the obese men, which could be related to their BMI at 21 years of age (Table 4).

Discussion

The main finding of this study was that obesity in 60–70-year-old men in Northern Ireland was associated with a significantly increased prevalence of low-threshold periodontitis. The case definition of periodontitis was important and when periodontitis was assessed at two levels, as suggested by Tonetti & Claffey (2005), obesity was not significantly associated with high-threshold severe periodontitis.

The men studied were a representative sample of 60–70-year-old males in Northern Ireland and were almost exclusively of Western European origin. In general they were older than those examined in most other studies of obesity and periodontitis. Obesity increased the odds of having low-threshold periodontitis by 77%. This association survived adjustment for major confounders, including smoking and diabetes, likely to have affected the periodontal condition. This finding broadly agrees with those from North America (Wood et al. 2003, Genco et al. 2005) using data from NHANES III and studies of Japanese subjects (Saito et al. 1998, 2001, 2005; Nishida et al. 2005). In our study it seemed that only the highest levels of BMI were a factor as men who were overweight (BMI 25–29.9) did not have worse periodontal status than those who had a normal BMI. Other recent studies have reported little effect of overweight on other endpoints such as mortality (Flegal et al. 2005).

Variations in the strength of the association between obesity and periodontitis reported in studies of different populations may reflect a lack of uniformity in the case definitions used for periodontal disease. The cut offs used to identify periodontal disease in several previous studies of the effects of obesity included shallow pocketing of >3.5 mm (Saito et al. 1998, 2001, Nishida et al. 2005), which would have equated with very low levels of periodontal destruction. The use of low thresholds results in an increase in the proportion of subjects with disease, for example Saito et al. (2001) categorised over 50% of the their study group with periodontal disease. In our study, low-threshold periodontitis was relatively common affecting 26% of the men, which is broadly similar to previous work on the population of Northern Ireland (Mullally & Linden 1992). Severe periodontitis was identified in only 7% of the men examined and the association between obesity and high-threshold severe periodontitis failed to attain significance. However, the lower prevalence of severe periodontitis results in a reduced power to detect associations, and it is notable that the OR for high-threshold periodontitis among obese men although non-significant, were only slightly reduced compared with those for low-threshold periodontitis.

In the men with the highest levels of periodontitis, it may be that any effects of obesity were overshadowed by the harmful effects of smoking. In all multivariate models, smoking was the most

significant factor associated with the measures of periodontitis. There was a graded response with current heavy smoking emerging as a stronger factor than current light smoking, which in turn was stronger than past smoking. In general, men who were obese had a different risk factor profile from those who were overweight or had normal BMI. There was an increased prevalence and heaviness of smoking, more diabetes, lower SES, fewer years in education, less-regular dental attendance and less-frequent toothbrushing. All these factors have been associated with an increased risk of periodontitis (Borrell & Papapanou 2005). The association between obesity and low-threshold periodontitis survived adjustment for these factors; however, it is possible that there are other confounders that were not controlled for in the analysis.

The BMI at 21 years of age did not predict periodontitis in the older men investigated. We have no information on the periodontal condition of the men studied when they were young. It is difficult therefore to directly compare the current study to that of Al-Zahrani et al. (2003) who used the NHANES III dataset and reported an association between obesity and the prevalence of periodontal disease only in young adults. Another recent study using data from NHANES III has also reported an increased risk of chronic periodontitis in adolescents aged 17–21 years related to increased total body weight and waist circumference (Reeves et al. 2006). However, the men in the present study were born in the 1930s and in the early 1940s and would have been exposed to different influences during childhood and adolescence than those who participated in NHANES III. Almost all the men grew up in Northern Ireland and would have been subjected to dietary restrictions due to rationing both during and after the Second World War. The BMI at age 21 relied on self-reported weight and the average of the values recorded on two different occasions was used to reduce possible errors. Only 1.2% were obese in this study compared with 9.3% of 16–24 year olds in the United Kingdom in 2004 (NHS Health and Social Care Information Centre 2005) and 19% of the 18–34-year-old American subjects studied by Al-Zaharani et al. (2003). These differences probably reflect recent changes in eating patterns with an increased intake of food with high contents of fats and sugars, in larger portions and with increased availability (Haslam & James 2005), and the adoption of a sedentary lifestyle by children (Parsons et al. 2006). It may be that the outcomes reported by Al-Zaharani et al. (2003) and Reeves et al. (2006) reflect the changes in lifestyle in adolescence and early adulthood that have occurred in recent decades.

In this study, BMI at 21 years was poorly correlated with BMI in later life. Nevertheless, despite the low prevalence of obesity at 21 years of age, it should be noted that as 60–70 year olds, the prevalence of obesity (22%) in the men in this study was comparable with the level in the general population in the United Kingdom, which was 24% in 2004 (NHS Health and Social Care Information Centre 2005).

In the obese subjects studied, there was no difference in periodontal status between those who had been in the highest third of BMI at 21 years of age and those who had been in the low or middle thirds. It was the participants who had experienced a large ($\geqslant$30%) increase in weight during adulthood that had an increased risk of poor periodontal condition. However, this increased risk was attenuated and was no longer significant after adjustment for confounders. Changes associated with increasing BMI such as increased food intake and reduced physical activity resulting in obesity may have been accompanied by other changes in health-related behaviour resulting in poorer periodontal health. This has been highlighted recently by a study that reported a strong association between lack of flossing and being overweight or obese and concluded that this represented a link between oral and general health awareness (Hujoel et al. 2006).

If an independent association is to be postulated between obesity and low-threshold periodontitis then there should be a biologically plausible explanation. Genco et al. (2005) suggested that obesity was a significant predictor for periodontal disease and that insulin resistance mediated the association. Insulin resistance is induced by fat deposited intracellularly and by the secretory products of the expanded adipocyte mass, which is the body's most prolific endocrine organ (Haslam & James 2005). The production of TNF-α as adipocyte mass increases leads to a reflex suppression in the secretion of adiponectin, a powerful insulin sensitiser. The systemic concentration of the pro-inflammatory cytokine interleukin 6 (IL-6) increases with adiposity with as much as one third of circulating IL-6 originating from adipose tissue. IL-6 is a major regulator of the hepatic acute phase response by controlling synthesis of C-reactive protein (Visser et al. 1999) and therefore obesity can resemble a low-grade inflammatory state (Yudkin et al. 2000). The abnormal lipid metabolism prevalent in obesity as well as in insulin resistance may collectively result in the enhanced tissue breakdown associated with periodontitis.

It is concluded that obesity was associated with low-threshold periodontitis in the homogeneous group of 60–70-year-old men investigated. A weaker association was evident between obesity and severe periodontitis and this did not attain statistical significance. High BMI levels in early life did not predict periodontitis in later life but those who had the greatest proportional increases in weight during adult life had poorer periodontal status. Changes in behaviour resulting in the development of obesity may be associated with reduced awareness and practice of behaviours associated with maintaining long-term periodontal health. Obesity may, however, have an independent effect leading to the manifestation of signs of periodontitis.

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Clinical Relevance

Scientific rationale for the study: Several studies from Japan and the United States have reported an association between obesity and chronic periodontitis. There are no published studies of obesity as a possible risk indicator for periodontitis in European populations. It is not clear whether a high BMI in early life predicts increased expression of periodontitis in later life.

Principal findings: After adjustment for possible confounders, there was an association between obesity and low-threshold periodontitis in the 60–70-year-old European men studied. A high BMI in early life did not predict periodontitis in later life.

Practical implications: Dentists should be aware that obesity in later life may be associated with poor periodontal status. Increased food intake and reduced physical activity resulting in obesity may be accompanied by other changes in health-related behaviours resulting in poorer periodontal health. An increased focus on prevention in individuals at risk of developing obesity may benefit both general and dental health.