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Poor oral hygiene and gingivitis are associated with obesity and overweight status in paediatric subjects

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Abstract

Aim: The association between obesity and periodontitis has been extensively investigated in adults but not in young people. Our aim is to evaluate whether overweight/obese paediatric patients have a greater chance of being affected by gingivitis than those of normal weight.

Subjects and Methods: Ninety-eight subjects ranging between 10 and 17 years of age were classified as obese/overweight or normal weight on the basis of body mass index. Auxological data, blood pressure, insulin resistance, psychological profile, oral hygiene habits, plaque and gingival indices were collected.

Results: Anthropometric measurements and blood pressure were significantly higher in overweight/obese subjects than in the normal-weight subjects ($p < 0001$). The overweight/obese subjects showed a worse attitude towards oral hygiene. Two-way ANOVA revealed a significant effect of obesity status ($p < 0001$) on the gingival index. Logistic and linear regression analyses identified gingivitis as dependent on insulin resistance and bad oral hygiene rather than on the overweight/obese status simply defined. Negative psychological features related to physical and academic self-concept were also risk factors for gingivitis probably because they were related to a generic poor self-awareness.

Conclusion: The gingivitis observed in overweight and obese young subjects is probably due to a combination of metabolic and inflammatory profiles and neglected attitude towards oral hygiene.

Key words: emotional impact; gingival index; gingivitis; Multi-Dimensional Self-Concept Scale; obesity; oral hygiene; paediatric patients; periodontal disease; plaque index

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Obesity, identified by body mass index (BMI) $> 30\,kg/m^2$, is common in many parts of the world. It can be defined as a chronic disease, with a multi-factorial aetiology: genetic, environmental, socio-economical and behavioural factors all appear to be significantly involved. The prevalence of obesity seems to be increasing among people of all ages, in both developed and developing countries, making this topic one of the most studied in the last few years (Seidell 1999, Wang & Lobstein 2006, Han et al. 2010).

Besides, it is widely accepted that obesity is not only a cosmetic issue but also a major medical problem. In fact, there is compelling evidence regarding the relationship of this condition with serious health problems such as type 2 diabetes, hypertension, dislipidaemia, coronary artery disease, stroke, osteoarthritis and certain forms of cancer (Wisse 2004, Lau et al. 2007). Recent studies have also suggested a relation between periodontal disease, gingivitis and periodontitis, and obesity in adults (Pischon et al. 2007, Ritchie 2007, D'Aiuto et al. 2008, Chaffee & Weston 2010).

Although the main aetiologic factor of both diseases is plaque accumulation, gingivitis is often documented in the paediatric population, whereas the

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diagnosis of periodontitis is much less frequent in this age group (Coventry et al. 2000, Pihlstrom et al. 2005).

Several hypotheses for biological interactions between obesity and periodontal diseases have been proposed: impaired glucose tolerance, perturbations in lipid profiles, alterations in host immunity, increasing activation of macrophages, impaired microvascular function, physiological responses to psychosocial stress and secretion of pro-inflammatory substances from adipose tissue including TNF-α, IL-6 and C-reactive protein (Mohamed-Ali et al. 1998, Pischon et al. 2007, Ritchie 2007, D'Aiuto et al. 2008, Chaffee & Weston 2010).

On the other hand, some authors (Saito & Shimazaki 2007, Ylöstalo et al. 2008) underlined that the evidence till now available supporting the presence of a common biological mechanism at the basis of body overweight and periodontal infection is not fully convincing and they supposed a bias related to the low oral health awareness included in the generally unhealthy lifestyles of obese subjects.

As in the adult population, childhood obesity is globally epidemic and its prevalence shows an increasing trend throughout the world (Kosti & Panagiotakos 2006, Wang & Lobstein 2006, Eaton et al. 2010, Fazio et al. 2010, Han et al. 2010, Pigeot et al. 2010). However, the understanding of this medical problem in children is far from being achieved due to the lack of comparable representative data from different countries and varying criteria for defining obesity (Wang & Lobstein 2006).

The relationship between periodontitis and obesity in young people has not been extensively investigated in the literature. Reeves et al. (2006) analysed this possible connection in US adolescents from 13 to 21 years, underlining how periodontitis could be associated with weight and waist circumference in those aged between 17 and 21 years. In particular, in this subgroup, each 1 kg increase was associated with a 6% increase in the risk of periodontal disease; similarly, each 1 cm increase in waist circumference was linked to a 5% increase in the risk of periodontitis. In contrast, there was no relationship between these parameters in the younger children aged between 13 and 16 years.

Modéer et al. (2010) have recently investigated paediatric obesity as a risk indicator for periodontal disease, in a group of 52 obese children and adolescents ranging between 11 and 17.9 years of age matched with a group of 52 normal-weight subjects. The paper documented a worse hygiene attitude in obese subjects, a significantly higher frequency of pathological periodontal pockets (>4 mm) and of sites positive to bleeding on probing (BOP%) with respect to the controls. The BMI adjusted for gender and sex (BMI-SDS) was discovered to be a serious risk factor [odds ratio (OR) = 1.87] for periodontal diseases including the presence of pathological periodontal pockets.

In the present study, we too hypothesized that obesity may have a negative impact on periodontal health in young people, in particular regarding gingival inflammation. Consequently, the study aimed to verify the presence of gingival inflammation, plaque accumulation and oral hygiene attitude in obese and normal-weight subjects.

Moreover, while the physical and financial consequences of childhood overweight and obesity are well documented, little research is available on the emotional effect of these on children and adolescents (Cornette 2008, Griffiths et al. 2010). We believe that the emotional effects may have some influence on oral health attitudes because in general, the attitude towards self-care is demonstrated to be strongly influenced by the psychological profile (Swallen et al. 2005, Cornette 2008, Dorri et al. 2010, Griffiths et al. 2010). For these reasons, we also hypothesized that in overweight and obese young subjects, the self-concept may be altered even if we are unable to aprioristically hypothesize whether this may be a cause or a consequence of the body unfitness.

Subjects and Methods

Approval of the study was obtained from the local Ethical Committee and informed written consent was obtained from all patients and their parents.

The study was designed as an observational comparative survey of oral hygiene and gingival health in overweight and obese children *versus* normal-weight ones. Statistical power was calculated using means and variances obtained from a previous pilot study. Calculation revealed that the recruitment of 98 subjects ensured a power more than 95% with a 95% confidence interval.

Subject recruitment and assessment of auxological data

The experimental group consisted of overweight and obese Caucasian children, ranging between 10 and 17 years of age, consecutively recruited between February 2009 and July 2009, at the Endocrinology and Auxology Department of the University Hospital. The control group included normal-weight children referred to the University Pediatric Division of the same University Hospital for a routine check-up. Subjects affected by chromosomal pathologies or major medical conditions such as diabetes, Cushing syndrome, GH deficiency or any kind of diagnosed immunological syndrome or those who consumed medications that could increase gingival volumes were not included in the study. Subjects with any diagnosed cognitive syndrome or those who did not speak the native language were also excluded.

The groups were formed on the basis of BMI values. Cole's rule based on BMI percentiles for each age to define overweight children and obesity limits was used (Cole et al. 2000). BMI percentiles corresponding to a BMI adult value of 25 kg/m^2 were used as a cut-off for overweight. BMI percentiles corresponding to a BMI adult value of 30 kg/m^2 were used as a cut-off for obesity.

Auxological records, blood pressure evaluation and homoeostasis model assessment of the insulin resistance index (HOMA-IR)

The following auxological data were collected by a sole investigator skilled in paediatrics:

- age: the chronological age was obtained considering the date of birth and the clinical examination day, through the subtraction of, respectively, the days, months and finally years;
- weight (kg) of the patient undressed on fasting and with an empty bladder at 0.1 kg; and
- height (cm) of the patient using a Harpenden statimeter with the Cameron measurement technique (Cameron 1984).

Both weight and height were measured twice and the averages were used for calculation. BMI was computed as follows: [weight (kg)/height^2 (m^2)].

In addition, waist circumferences and hip measurements using the greater trochanter as an anatomical reference were recorded with an inelastic millimetre tape.

All these data were collected at an assessment visit and if they met the inclusion criteria, the subjects were invited to take part in the study. The patients were then scheduled for a second appointment for blood pressure measurements, psychological profile assessment and oral examination.

Blood pressure values were collected according to the procedures suggested by the British Hypertension Society (National High Blood Pressure Education Program Working Group 2004). Systolic and diastolic blood pressure values were recorded by a single skilled investigator different from the one who had collected the auxological data.

Insulin resistance was evaluated by the HOMA-IR index for insulin resistance defined as fasting insulin (mIU/l) multiplied by fasting glucose (mmol/l) and divided by 22.5 (Matthews et al. 1985). The cut-off for insulin resistance was considered when the HOMA-IR index was >3.16 (Conwell et al. 2004, Keskin et al. 2005, Sen et al. 2008). Categories for patients with a normal and a pathological HOMA-IR index were considered for the analysis.

Psychological profile assessment and questionnaire

To appraise the psychological profile, the Multidimensional Self-Concept Scale (MSCS) according to Bracken (1992) and validated for the Italian language was applied (Bracken 1998).

The questionnaire evaluates the global self-concept and six specific domains of self-concept: Social, Competence, Affect, Academic, Family and Physical domains. Each domain consists of 25 items. Each item is scored from 1 (strongly agree) to 4 (strongly disagree). Negatively worded items were reverse scored. The rough global and domain scores were calculated as sums of all items or of domain-specific items. The domains scores were standardized using the standard score conversions available in the user manual, which indicates the normal range of psychological profile for every specific class of population. A score higher or lower than the limit indicated for a normal profile suggests a very positive self-concept or alternative negative attitudes. The questionnaire was self-filled by the children in the presence of a nurse available throughout the session to answer questions. No time restraint was imposed for questionnaire compilation.

The distributions of normo, negative or positive self-concept related to each domain were considered for statistical analysis.

Preventive attitude, oral hygiene and gingival health status

All the subjects answered a short questionnaire that covered topics on oral hygiene habits and preventive attitude.

The oral hygiene and health or inflammation oral status of each patient was evaluated by a dental hygienist through the recording of the plaque index (PI) and the gingival index (GI) (Loe & Silness 1963, Silness & Loe 1964). Intra-examiner variability for PI and GI was assessed previously using a replicate examination of five young patients (aged between 10 and 14 years) and occurred 1 h after the first one. The dental hygienist was trained till reaching an intra-examiner calibration of more than 90% for both indexes.

To exclude the effect of different status of dental permutation on plaque presence and gingival features, the indices were collected only from the first upper and lower molars and central and lateral incisors present in all subjects belonging to both the experimental and the control group. Sites on deciduous or newly erupted teeth were not considered in order to exclude the effect of exfoliation or immature status of the gingival complex on both plaque accumulation and inflammatory responses.

Data were reported as the mean values of all measurements for each subject.

Statistical analysis

Statistical Package for Social Sciences (IBM-SPSS, Windows version 19.0, Chicago, IL, USA) was used.

Student's *t*-test was used to compare the age, waist circumference, blood pressure parameters, PI and GI, after checking the homogeneity of variance using Levene's test.

The χ^2 exact test was applied to compare the distribution of negative, normo or positive self-concept related to each of the six domains of the MSCS in the obese/overweight *versus* normoweight groups. Student's *t*-test and univariate two-way ANOVA, followed by Sheffè post-hoc test were used to analyse the effect of obese/overweight status and gender factors.

Two binary logistic regression analyses, uncorrected with a constant, were used to model the relations between the gingival inflammation ($GI>1$), and other medical and auxological and psychological parameters. In detail, the first analysis included the PI, HOMA-IR index, age, gender and obesity–overweight status whereas the second included, in addition, the data regarding the MSCS (Social, Competence, Affect, Academic, Family and Physical domains). In both analyses, the maximum likelihood was used. Both binary logistic regression models were carried out without constant (») to avoid the effect of the different sizes of the test and control group.

Multiple linear regression analysis was applied to investigate the relations between the state of gingival inflammation ($GI>1$) and some parameters including obesity/overweight status, HOMA, gender, age and PI.

Results

Auxological records and blood pressure assessment

A total of 98 patients (48 males and 50 females) who were eligible and willing to fill in the MSCS questionnaire were included in the study.

According to the BMI classification, subjects were divided into two groups: those who were overweight or obese and those of normal weight. The group of overweight or obese subjects included 66 children, 32 male and 34 female, whose mean BMI was $28.85 \pm 4.33\,kg/m^2$. The children belonging to this group were aged 12.84 ± 2.4 years.

The control group included 32 children (16 male and 16 female) defined as normal weight according to the reference (mean BMI $18.79 \pm 2.52\,kg/m^2$). The mean age recorded was 13.64 ± 1.8 years old and did not differ significantly from those of the first group. In contrast, as expected, the two groups differed significantly ($p<0001$) in all the anthropometric measurements considered (Table 1). The mean obese/overweight waist circumference was 93.50 cm (± 11.81) compared with 67.84 cm (± 7.45) in the normal-weight group. In the obese/overweight group, 53 patients (28 male and 25 female) also

Table 1. Auxological data

	Overweight/obese subjects ($N = 66$)	Normal-weight subjects ($N = 32$)	p
BMI (kg/m^2), M ± SD	28.85 ± 4.33	18.79 ± 2.52	<0.001
Waist circumferences (cm), M ± SD	93.50 ± 11.81	67.84 ± 7.45	<0.001
Hip measurements (cm), M ± SD	101.68 ± 15.65	84.20 ± 10.66	<0.001

Student's *t*-test indicates that indexes chosen to select samples were different between the two groups.
BMI, body mass index; *M*, mean; SD, standard deviation.

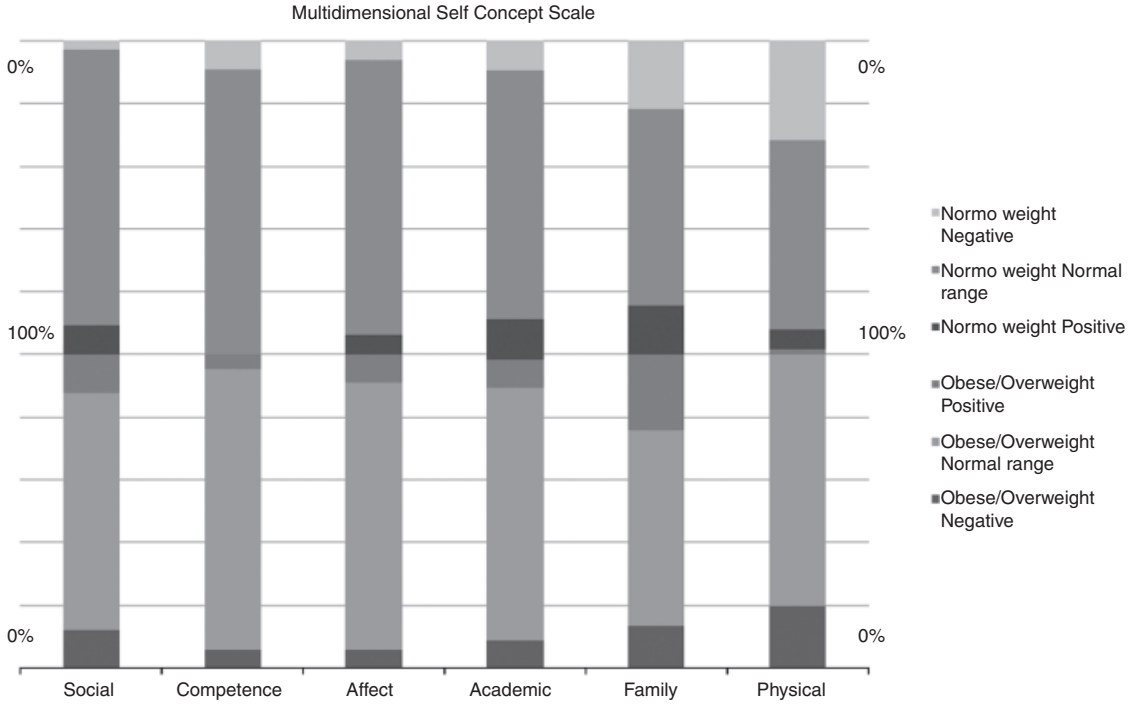

Fig. 1. Results deriving from the psychological profile assessment through Multidimensional Self Concept Scale (MSCS).

had abdominal obesity (mean waist circumference 96.76 cm). The hip measurements differed significantly between the two groups and were, respectively, 101.68 (± 15.65) cm in the overweight/obese group and 84.20 (± 10.66) cm in normal-weight subjects.

In overweight/obese subjects, the mean systolic blood pressure value was 129.37 ± 19.96 mm Hg while diastolic pressure was 84.89 ± 14.66 mm Hg. Both measurements were significantly higher ($p < 0.001$) than those in normal-weight subjects (systolic 109.33 ± 13.84 mm Hg, diastolic 71.78 ± 8.95 mm Hg). Significantly higher values of both systolic ($p < 0.001$) and diastolic arterial pressure ($p < 0.001$) suggested that adipose tissue accumulation is a condition associated with one of the major risk factors for the metabolic syndrome.

Psychological profile assessment

The global and specific self-concept domain did not differ between the obese/overweight and normal-weight subjects recruited for this study. Most of the subjects in both groups obtained self-concept global scores ranging between the limits reported for the general population. Only 4.5% and 6% of the subjects belonging, respectively, to obese/overweight and normal-weight subjects recorded negative global self-concept scores, while 1.5% and 3% were more positive than those of the 90th percentile of the normal population. Even when data were analysed for a single domain, only a few negative attitudes were recorded in both groups (Fig. 1).

The hypothesis that obesity can affect self-concept and in particular the Social and Physical domains was not verified. Only Family self-concept was observed to differ between the two groups, with significance near to the level ($p = 0.058$). The obese/overweight group seemed to be weakly characterized by a more positive and less negative Family self-concept in comparison with the control.

Preventive attitude and oral hygiene and gingival health status

Most of the subjects of both groups reported brushing their teeth more than three times a day (81% and 75%, respectively, for obese/overweight and normal) with both oscillatory and rotator movements, mostly using a manual toothbrush. Most subjects in both groups had visited a dentist recently for a dental check-up examination (51% and 59%, respectively, for obese/overweight and normal groups). Despite these results, the knowledge of certain aspects of oral self-preventive behaviour is poor in both groups and worse in normal-weight subjects compared with obese. In fact, 40% of obese and only 25% of normal-weight subjects were able to recognize all cariogenic foods from a list. Moreover, the overweight/obese subjects showed a worse attitude towards oral hygiene with respect to normal-weight subjects, which helps explain the more evident inflammation

Table 2. Plaque and gingival index according to Löe and Silness

	Obese/overweight total subjects	Obese/overweight males	Obese/overweight females	Normal-weight total subjects	Normal-weight males	Normal-weight females
N subjects	66	32	34	32	18	14
Gingival index	1.20 ± 0.42	1.22 ± 0.42	1.18 ± 0.43	0.76 ± 0.50	0.86 ± 0.55	0.62 ± 0.44
Plaque index	1.42 ± 0.61	1.50 ± 0.62	1.34 ± 0.59	0.77 ± 0.49	0.96 ± 0.52	0.52 ± 0.31

Table 3. Binary logistic regression analysis

	β-coefficient	df	p
Plaque index	1.856	1	0.001
Gender	− 1.231	1	0.001

Age, overweight/obesity status and HOMA-IR not significant.
Relationships between gingival inflammation and gender, age, plaque index, overweight/obesity status, HOMA-IR.
df, degree of freedom; HOMA-IR, homoeostasis model assessment of the insulin resistance index.

Table 4. Binary logistic regression analysis

	β-coefficient	df	p
Plaque index	2.674	1	0.001
Academic domain	− 1.369	1	0.001

Gender, age, obesity/overweight status, HOMA-IR, Social, Competence, Affect, Family, and Physical domains not significant.
Relationships between gingival inflammation and gender, age, plaque index, overweight/obesity status, HOMA-IR and MSCS domains.
df, degree of freedom; HOMA-IR, homoeostasis model assessment of the insulin resistance index; MSCS, Multidimensional Self-Concept Scale.

of the gums in the overweight/obese group This was evident from the significantly higher amount of biofilm deposition on the dental surfaces clinically measurable with the PI ($p<0.001$) and the increased GI observed in the overweight/obese group in comparison with the normal group ($p<0.001$) (Table 2). This difference was also confirmed by the analysis of frequencies. Most of the subjects in the normal group were in fact free from any gingival inflammation (GI < 1:65.6%), whereas only 28.8% of the overweight/obese group showed healthy gums.

When the PI data were evaluated using univariate two-way ANOVA considering gender and weight and their interaction, significant differences were observed for gender ($p<0.01$) and obesity status ($p<0.001$) but not for the combination of both. In particular, less plaque was observed in normal-weight females with respect to the males of the corresponding group ($p<0.01$). In contrast, the GI was significantly positively higher in overweight/obese subjects ($p<0.001$) but the ''gender'' factor failed to show any differences (Table 2).

Table 5. Linear regression relationship between gingival inflammation (expressed as gingival index) and overweight/obesity status, insulin resistance, age, gender and plaque index

	β-coefficient	t	p
Plaque index	0.607	8.730	0.000
Age	0.326	4.909	0.000
HOMA-IR	0.093	2.119	0.038

Overweight/obesity status and gender not significant.
df, degree of freedom; HOMA-IR, homoeostasis model assessment of the insulin resistance index.

The first binary logistic regression analyses are reported in Table 3. Gingival inflammation, defined as GI > 1, shows a strong positive correlation with the PI and male gender. The other variables considered in the model (i.e. overweight/obesity status, HOMA index and age) were not predictive of gingival inflammation.

When variables related to the psychological profile were considered with PI, gender, age, overweight/obesity status and HOMA-IR (Table 4) to build the logistic model, the academic domain was seen to have a significant role as a predictor of gingival inflammation, as well as the PI, indicating that subjects with a poor academic profile also risked having gingival inflammation and vice versa.

In addition, to improve analysis by excluding an arbitrary cut off for gingival inflammation definition, we further analysed the data using a continuous form of GI in linear regression analysis (Table 5) to test the relation with the following descriptors: overweight/obesity status, insulin resistance (HOMA index < or > 3.16), age, gender and PI. As expected, the latter was strongly, conversely related to the GI (β-coefficient = 0.607, $p<0.001$) but also age (β-coefficient = 0.326, $p<0.001$) and insulin resistance (β-coefficient = 0.093, $p=0.038$) are strongly related to an increased risk of gingival inflammation.

Discussion

While the relationship between periodontal disease and obesity has been extensively studied in adulthood, this possible connection has not been adequately investigated in earlier life stages. In the present study, we examined two samples of children taken from a population attending our Pediatric Department. This target population theoretically introduced a possible bias with respect to the choice of a general population, limited by the fact that the objective of investigation was dentally focused and not paediatric. On the other hand, the hospital environment allowed access to medical information not easy available for a general population.

Therefore, within the above-mentioned limitation, the present study aimed to verify an association between obesity/overweight status and periodontal disease in young people, limiting this assessment to gingivitis and plaque. The evaluation of periodontal infrabony defects, rare but not completely absent in young people, was not considered on account of the difficulty in correctly evaluating the presence of infra-bony pockets during the eruption.

Our results highlighted that the strongest predictor of gingival inflammation is plaque accumulation. The PI was in fact always strongly and significantly related to GIs in all analyses performed. However, in our study, the ANOVA two-way analysis demonstrated that increased body fat is associated with both plaque formation and gingival inflammation in young patients as suggested for adults in other papers (Pischon et al. 2007, Ritchie 2007, D'Aiuto et al. 2008, Chaffee & Weston 2010, Saxlin et al. 2011).

Our results far from clarify the primitive role of the adipose tissue and whether it may represent a reservoir for inflammatory cytokines and hormones, which would make an active host

inflammatory response typical of periodontal disease more likely, as other authors have suggested (Genco et al. 2005, Modéer et al. 2010). This issue has recently been widely debated. Saxlin et al. (2011) have shown, in a large survey, that obesity is associated with periodontal disease but that obesity was not a risk for the development of periodontal infection for the 396 obese subjects included in a sub-group and followed up for 4 years (Saxlin et al. 2010). In contrast, in a longitudinal study carried out on 3590 adult Japanese subjects, a dose–response relationship between BMI and the development of periodontal disease in a population was shown (Morita et al. 2011).

Another large survey conducted on 4246 adult Korean subjects revealed that obese people with BMI $\geqslant$ 25 had an adjusted OR of 0.991 (0.806–1.220) for having periodontitis but in contrast abdominal fat obesity was significantly correlated with periodontitis (Kim et al. 2010), suggesting that metabolic syndrome more than obesity itself plays some role in gum inflammation, as other studies also suggest (Andriankaja et al. 2010, Benguigui et al. 2010, Timonen et al. 2010). However, the cytokine profile in people affected by metabolic syndrome and the effect on periodontal disease are far from being fully understood. IL-1B and IL-8 were demonstrated to be more highly concentrated in the crevicular fluids of obese subjects, while adiponectin was not (Modéer et al. 2010). Obesity was also reported to differently affect the immunologic response to *Porphyromonas gingivalis* in terms of TNF-α and IL-6 expression (Amar et al. 2007) and a concentration of pro-inflammatory cytokines such as IL-1β, IL-8, and PGE^2 in crevicular fluids was observed (Zhong et al. 2007, Modéer et al. 2010).

In our study, we considered the HOMA-IR because it is suggested as being more reliable than the fasting glucose/insulin ratio and quantitative insulin sensitivity check index for assessing insulin resistance among obese children and adolescents (Sen et al. 2008). Unfortunately, no validated cut-off is available for the paediatric age to date because only a few studies, with a small number of adolescent patients, have been published (Conwell et al. 2004, Keskin et al. 2005, Lee et al. 2006). In contrast, some authors have identified a value of 3.16 (Conwell et al. 2004, Keskin et al. 2005, Sen et al. 2008) as a cut-off for the adult population, derived from models validated with the euglycaemic hyperinsulinaemic clamp. For these reasons, we adopted the arbitrary cut-off level of 3.16 similar to that considered for adulthood. Regarding our study, it should not be overlooked that we also found 20 patients with abdominal obesity and hypertension and 45 showed insulin resistance, measured by the HOMA-IR index, over the cut-off (3.16) considered indicative for metabolic syndrome. These are criteria relevant for the diagnosis of metabolic syndrome, which is claimed to be a very serious health condition in youth as well as in adulthood and suggested to be involved in periodontal disease development in a strong (Andriankaja et al. 2010, Benguigui et al. 2010) or weak manner (Timonen et al. 2010). The latter observation seems to be in accordance with those observed in our sample of young subjects where the HOMA index was significantly related, in linear regression models, to the presence of a positive GI (β-coefficient = 0.093, $p = 0.038$). These results suggest that the increased body fat alone is not sufficient to contribute to the development of gum inflammation but other medical implications frequently associated with obesity might be considered to explain the nature of the interaction between obesity and gingivitis.

Our results do not resolve the dilemma regarding whether the periodontal health status observed in the two weight classes is the outcome of healthy lifestyle awareness.

Correlations between oral self-care and general health lifestyles can make it challenging to determine what causes oral diseases. An example is the role of dental floss, related to many general lifestyle indexes, such as BMI, which may confound associations (Toneatto & Binik 1990). A study by Hujoel et al. (2006) showed how the absence of daily flossing strongly correlates to obesity among periodontal patients, in a dose-dependent fashion. However, daily flossing may be no more than a marker of positive general health awareness, underlining how complicated oral epidemiology can be.

In this light, we considered that psychological factors may differently affect obese and normal-weight subjects (Brownell 1984, Fiseković 2005, Cornette 2008, Griffiths et al. 2010) as the psychological profile is reported to affect the individual's propensity to carry out health-promoting behaviours such as toothbrushing (Macgregor et al. 1997, Koerber et al. 2006, Dorri et al. 2010). However, in the present paper, the self-concept evaluation and its domains, measured using the MSCS according to Bracken (1992), failed to show any differences between obese/overweight and normal-weight subjects, confirming the fact that factors that are claimed as pivotal in adulthood may not be verified in children and adolescents. For instance, the associations between physical activity, unhealthy dietary habits, cigarette smoking, blood pressure, overweight and obesity are well established in adults (Lobos et al. 2008). In contrast, a paradoxical association between healthy dietary habits and obesity has been observed in children (Fasting et al. 2008), and in our study too, the awareness of cariogenic foods is more evident in obese than in normal-weight children.

On the other hand, we observed a relationship between negative scores of some psychological domains and GI such as academic self-concept, which may indicate a psychological stress condition with a potential influence on duty habits including oral hygiene.

Also, smokers had higher odds of being overweight and obese status (Xu et al. 2007). This risk factor was not considered in our study due to the unreliability of the answers of our patients relating to this habit because of the presence of relatives during examination. However, we are aware that it could represent a confounding aspect, given its known role in the pathogenesis of periodontal disease and its association with low compliance with oral hygiene procedures in adolescents (Honkala et al. 2011).

In conclusion, our results underline the negative effect of overweight and obesity status on the health of the gingival tissue of young subjects probably due to a combination of metabolic and inflammatory profiles and the consequence of a generally neglected attitude towards oral disease prevention including self-hygiene procedures, diet information and compliance towards periodical oral prevention recalls. These considerations suggest the need to investigate more in depth the relation between severe obesity and periodontal health and, from a clinical point of view, to strengthen the collaboration between paediatricians and oral practitioners.

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Clinical Relevance

Scientific rationale for the study: The potential role of overweight/obesity status in the development of periodontal pathologies in paediatric subjects is not clear.

Principal findings: Overweight/obesity status, in particular when at risk of metabolic syndrome, negatively affects the periodontal health of young people supposedly through both biological and behavioural factors.

Practical implications: Young overweight/obese subjects need to be carefully monitored for the incidence of periodontal pathologies and should be encouraged to adopt healthy lifestyles.