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The relationship between oral hygiene status and obesity among preschool children in Hong Kong

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Abstract: *Objectives:* To explore the association between oral hygiene status and obesity among preschool children in Hong Kong. *Methods:* Three hundred and twenty-four 5-year-old children in Hong Kong were recruited. Their oral hygiene status was recorded using visible plaque index (VPI). Body height, body weight, waist circumference (WC), hip circumference and triceps skinfold thickness (TRSKF) were measured to assess general adiposity (weight/height ratio, W/H; body mass index, BMI), central adiposity (WC; waist/hip ratio, WHR) and peripheral adiposity (TRSKF). The relationships between VPI and W/H, BMI, WC, WHR and TRSKF were examined in bivariate and regression analyses. *Results:* Fifty-six per cent of the children were considered to have high VPI (VPI $\geq$ 65.0%). Logistic regression analyses identified that W/H *z*-score (OR = 1.28, 95% CI = 1.01–1.61) and WC *z*-score (OR = 1.25, 95% CI = 1.00–1.58) were associated with high VPI. No association was found after adjusted for socio-demographic status ($P > 0.05$). *Conclusion:* Oral hygiene status was not associated with obesity among 5-year-old children in Hong Kong after controlling for socio-demographic factors.

Key words: body mass index; obesity; oral hygiene; triceps skinfold thickness; waist circumference; waist/hip ratio; weight/height ratio

Introduction

Periodontal disease is the most common chronic disease globally (1, 2). The public health concern with respect to periodontal disease is not simply its high prevalence but because of its recognized association and, now acknowledged causation, with several systemic health problems such as cardiovascular disease, diabetes mellitus and low term birth weight (3–5). It is accepted that periodontal disease has its origin in gingivitis and that dental plaque is of key aetiological concern (6). Moreover, it is now recognized through life-course epidemiological studies that gingivitis and associated plaque accumulation in childhood and adolescence were associated with the development of established periodontal disease and tooth loss in later life (7, 8). Thus, the issue of periodontal health and oral hygiene is of key concern in childhood.

Obesity is emerging (and some suggest established) as a global public health concern (9). There is growing interest in the relationship between obesity and oral health because both are significant public health problems. Several studies have reported on the association between dental caries and obesity among elderly and children (10–15). Two recent systematic reviews have also identified positive associations between periodontal disease (or surrogate markers of) and obesity among adults

(16, 17). However, there is a dearth of information on the relationship between obesity and periodontal health, or surrogate markers of dental plaque among children (18).

For the most part, assessment of obesity within dental research has focused on one aspect, general obesity, and on one index of assessing it, namely body mass index (BMI). Increasingly, it is recognized that it is not only 'general obesity' that is important as a marker of disease(s), but also central and peripheral obesity (19). Furthermore, it is acknowledged that there are several different indices of general, central and peripheral obesity, which in themselves may have different abilities to identify associations with health problems (19). No studies have explored a possible association between VPI and BMI among preschool children, but studies among adolescents have identified an association (20, 21). Thus, it is evident that limited exploration of the associations between different types of obesity, different indices of obesity and markers of periodontal health has been undertaken, particularly among children.

Therefore, this study aimed to investigate the association between oral hygiene status and general, central and peripheral obesity in a community sample of preschool children in Hong Kong SAR, China.

Study population and methodology

Study population

The study population was 5-year-old Chinese preschool children. The sampling frame was all registered local kindergartens on Hong Kong Island, which is one of the three broad districts (Hong Kong Island, Kowloon and New Territories) in Hong Kong SAR. A random sample of 10 local kindergartens from four districts in Hong Kong Island was selected. Within each kindergarten, all K3 children (5 years old) were invited to participate in the study. Parents/primary caregivers provided their written consent and children provided their assent. Sample size was estimated based on the assumption that children with higher BMI z-score have higher visible plaque index (VPI). Based on an assumption that the odds ratio (OR) of having a high VPI would be ~1.40 with an increase of 1 unit in BMI z-score and a prevalence of high VPI in the population of ~50%, a sample size of 278 was calculated to have 80% statistical power with the level of statistical significance (alpha) set at 0.05. Considering the potential of a non-response of approximately 20%, it was proposed to invite approximately 350 subjects. The study protocol was approved by the Institution Review Board of the University of Hong Kong/Hospital Authority Hong Kong West Cluster (UW 11–385).

Data collection

Oral health examination

The oral health examination included a dental plaque assessment employing the VPI according to the methods and criteria recommended by Ainamo and Bay (22). The proportion of surfaces with visible dental plaque was calculated as the number of surfaces with visible dental plaque divided by the total number of surfaces examined. The oral health examinations were performed using an intra-oral disposable mouth mirror with a built-in LED light source. All children were examined on a portable dental chair by one examiner who had been trained and calibrated prior to study initiation. Repeat assessments, by the same examiner, were made among 10% of randomly selected participants, with at least 10 other children examined between duplicate examinations for each selected child, to test intra-examiner reliability.

Anthropometric measurements

Anthropometric measurements, including body height, body weight, waist circumference (WC), hip circumference (HC) and triceps skinfold thickness (TRSKF), were taken by a calibrated and trained examiner using standardized methods in anthropometry (23). Body height was measured to the nearest 0.001 metre with a stadiometer. Body weight was recorded in kilograms to the second decimal place using a self-zeroing digital scale (Tanita, Japan). The WC and HC were recorded to the nearest 0.1 cm with an inelastic tape. A skinfold calliper (Harpenden, UK) was used to assess TRSKF to the nearest 0.1 mm. The W/H was calculated as weight in kilograms divided by the height in metres. The WHR was computed as WC in centimetres divided by HC in metres. Furthermore, BMI was calculated as weight in kilograms divided by the square of height in metres. Repeat assessments were made by the same trained and calibrated examiner among 10% of participants to ensure intra-examiner reliability.

Family socio-economic status

A questionnaire completed by the parents was used to obtain information on family characteristics including socio-economic status assessed according to the parental educational attainment and family monthly income.

Statistical analysis

Correlation between VPI and the adiposity indices was examined. The children were categorized into two groups based on their VPI: high VPI ($\geq$median VPI) and low VPI (<median VPI) (24). VPI (high/low) was the dependent variable in the bivariate and multivariate analyses. Associations between VPI, adiposity indices (W/H, BMI, WC, WHR and TRSKF) and socio-demographic status were investigated using chi-squared test, two-sample t-tests or one-way ANOVA. Evidence of multicollinearity between adiposity indices was examined prior to the regression analyses. Logistic regression analyses (unadjusted and adjusted) were performed to assess the relative importance of the association between adiposity indices and VPI [via odds ratio (OR) values].

Results

Of the 324 children who were recruited in the survey, 322 (99.4%) had visible plaque on their primary teeth. The mean VPI (SD) was 63.8% (20.3%), while the median VPI (IQR) was 65.0% (50.0%, 80.0%). High VPI was defined as VPI score greater than or equal to median value (65.0%), while low VPI was less than 65.0%. One hundred and eighty children (56%) were categorized as having high VPI. Mean (SD) of W/H, BMI, WC, WHR and TRSKF were 17.9 (2.3), 15.7 (1.7), 52.0 (4.9), 0.87 (0.05) and 10.4 (3.1), respectively. Sixty-seven (20.6%) children were considered to be overweight or exhibited obesity according to the WHO BMI-for-age criteria (25); forty-four (13.6%) children were considered to be obese according to their W/H based on the Hong Kong Growth Survey criteria (26). The intraclass correlation coefficient (ICC) for VPI, body height, body weight, waist circumference, hip circumference and TRSKF for initial and repeat assessments was 0.99, 0.91, 0.99, 0.90, 0.93 and 0.93, respectively.

Bivariate analyses identified variations in VPI and adiposity status with respect to participants' socio-demographics (Table 1). The boys had higher mean W/H, WC and WHR than the girls ($P < 0.05$). Parental educational attainment was associated with mean VPI, W/H, BMI, WC and TRSKF ($P < 0.05$). Furthermore, the family income level was associated with mean WHR and TRSKF ($P < 0.05$).

There were no significant correlations between VPI and all five of the adiposity indices: W/H ($r = 0.08$, $P = 0.14$), BMI ($r = 0.05$, $P = 0.38$), WC ($r = 0.05$, $P = 0.33$), WHR ($r = 0.02$, $P = 0.74$) and TRSKF ($r = 0.07$, $P = 0.21$).

Standardization of the adiposity indices (W/H, BMI, WC, WHR, TRSKF) into *z*-scores was performed prior to the logistic regression analyses so as to make the unit of different adiposity indices identical. Unadjusted regression models identified that two of the adiposity status were associated with high VPI: W/H *z*-score (OR = 1.28, 95% CI = 1.01–1.61, $P = 0.04$) and WC *z*-score (OR = 1.25, 95% CI = 1.00–1.58, $P = 0.05$; Table 2). Except for two pairs of adiposity indices [W/H and WHR ($r = 0.04$, $P = 0.51$), WHR and TRSKF ($r = 0.02$, $P = 0.74$)], a significant correlation was found for the other eight pairs of adiposity indices [0.92 for W/H and BMI, 0.80 for W/H and WC, 0.61 for W/H and TRSKF, 0.75 for BMI and WC, 0.12 for BMI and WHR, 0.66 for BMI and TRSKF, 0.44 for WC and WHR and 0.55 for WC and TRSKF ($P < 0.01$)] (Table 3). Thus, the adiposity indices showed evidence of multicollinearity, and thus, separate multivariate logistic regression analyses were conducted. When the combined effect of socio-demographic factors (parents' education attainment, household monthly income and gender) was explored in the regression analyses, none of the adiposity index was associated with high VPI ($P > 0.05$), see Table 2.

Discussion

There is growing interest in the relationship between oral health and obesity among children. For the most part, studies

Table 1. Socio-demographic variations in VPI and adiposity status among preschool children

Variable	VPI					W/H		BMI		WC		WHR		TRSKF	
	Low%	High%	*P*-value***	Mean (SD)	*P*-value****	Mean (SD)	*P*-value****	Mean (SD)	*P*-value****	Mean (SD)	*P*-value****	Mean (SD)	*P*-value****	Mean (SD)	*P*-value****
Gender															
Male	42.4	57.6	0.142	65.1 (18.4)	0.271	18.3 (2.40)	0.001**	15.9 (1.82)	0.075	53.0 (4.60)	0.001**	0.88 (0.04)	0.049*	10.1 (3.09)	0.068
Female	50.6	49.4		62.6 (21.8)		17.5 (2.15)		15.6 (1.55)		51.1 (4.95)		0.87 (0.06)		10.7 (3.03)	
Parents' education attainment															
Primary school graduate or below	5.8	8.3	0.066	66.7 (22.4)	0.033*	18.1 (2.40)	0.002**	15.9 (1.54)	0.012*	52.1 (4.27)	<0.001**	0.87 (0.04)	0.304	10.1 (2.65)	0.003**
Secondary school	39.4	50.3		66.4 (18.6)		18.3 (2.51)		16.0 (1.90)		53.0 (4.80)		0.88 (0.04)		11.1 (3.44)	
Post-secondary or above	54.7	41.4		60.3 (21.5)		17.3 (1.97)		15.4 (1.39)		50.7 (4.79)		0.87 (0.07)		9.9 (2.56)	
Household monthly income															
Less than $ 10 000	13.8	18.6	0.140	66.2 (20.3)	0.120	18.0 (2.53)	0.249	15.7 (1.76)	0.822	52.7 (4.81)	0.052	0.89 (0.04)	0.027*	9.7 (3.17)	0.022*
10 000–40 000	43.1	49.1		65.0 (20.2)		18.0 (2.32)		15.7 (1.73)		52.2 (4.39)		0.87 (0.04)		10.9 (3.25)	
Over $ 40 000	43.1	32.3		60.4 (20.7)		17.5 (2.14)		15.6 (1.54)		51.0 (5.37)		0.87 (0.07)		10.1 (2.64)	

VPI, visible plaque index; W/H, weight/height ratio; BMI, body mass index; WC, waist circumference; WHR, waist/hip ratio; TRSKF, triceps skinfold thickness.
Low VPI: VPI < 65%; High VPI: VPI ≥ 65%.
**P*-value < 0.05, ***P*-value < 0.01.
****P*-value: chi-squared test; *****P*-value: two-sample *t*-test/one-way ANOVA.

Table 2. **Logistic regression models of associations between VPI proportion and obesity (general, central and peripheral)**

	Unadjusted†			Adjusted‡		
High VPI (VPI ≥ 65%)	OR	95% CI	*P*-value	OR	95% CI	*P*-value
W/H *z*-score	1.28	1.01–1.61	0.04*	1.18	0.93–1.50	0.17
BMI *z*-score	1.18	0.94–1.48	0.15	1.11	0.87–1.40	0.40
WC *z*-score	1.25	1.00–1.58	0.05*	1.15	0.90–1.46	0.26
WHR *z*-score	1.10	0.88–1.38	0.38	1.09	0.86–1.37	0.48
TRSKF *z*-score	1.24	0.99–1.57	0.06	1.16	0.91–1.48	0.23

VPI, visible plaque index; W/H, weight/height ratio; BMI, body mass index; WC, waist circumference; WHR, waist/hip ratio; TRSKF, triceps skinfold thickness; CI, conference interval.
*P-value < 0.05.
†Unadjusted: separate logistic regression analyses.
‡Adjusted: adjusted for parents' education attainment (primary school graduate or below, secondary school, post-secondary or above), household monthly income (less than HK$10 000, $10 000–$40 000, over $40 000; USD1 = HK$7.8) and gender.

Table 3. **Correlation (Spearman's) between the five adiposity indices**

Adiposity indices	Adiposity indices				
	W/H	BMI	WC	WHR	TRSKF
W/H	–	0.92**	0.80**	0.04	0.61**
BMI	–	–	0.75**	0.12*	0.66**
WC	–	–	–	0.44**	0.55**
WHR	–	–	–	–	0.02
TRSKF	–	–	–	–	–

W/H, weight/height ratio; BMI, body mass index; WC, waist circumference; WHR, waist/hip ratio; TRSKF, triceps skinfold thickness; CI, conference interval.
*P-value < 0.05, **P-value < 0.01.

have focused on the relationship between dental caries and obesity owing to their similar aetiology, that is, diet. However, there is emerging interest in the relationship between periodontal health (or surrogate markers of dental plaque) and obesity (16–18). It should be borne in mind that exploration of associations between oral health (specifically periodontal health) and obesity is not simply a statistical exercise, because ultimately it is likely to have clinical and public health significance in that it can identify significant markers of their interrelationship and potentially similar aetiological factors that may share a common pathway. For example, dental plaque level is likely to reflect behaviour such as self-care that is related to other behaviours such as sedentary behaviour and dietary intake and therefore obesity. Ultimately, identifying such markers and pathways has implications for health promotion in the support of employing multisector common risk factor approach programmes.

Visible plaque index (VPI) assesses oral hygiene status and is a key surrogate measure of gingivitis (22). It represents the site prevalence of 'clearly visible dental plaque' at the gingival margin, and it is a simple and reliable index for epidemiological studies (22). In addition, the site prevalence provides a quantitative score overcoming the disadvantage of using the mean score (from ordinal scales) (22). Bivariate analyses identified significant socio-demographic variations in visible plaque, namely parental educational attainment, which concurs with a previous report (27). Socio-demographic variations in adiposity status were also evident, irrespective of the types of obesity (general, central and peripheral), adiposity indices and types of socio-demographic factor. This concurs with the widely accepted evidence that socio-demographic variations in obesity exist throughout the world (28).

In the categorization of VPI scores, various cut-off values have been proposed, but there is no single consensus as to what constitutes 'poor oral hygiene' (20, 24, 29, 30); in this study, the median value was used, that is, VPI ≥ 65.0% (24). In logistic regression analyses (unadjusted), general obesity as assessed by W/H was significantly associated with high VPI. Central obesity, as assessed by WC, had a borderline significant association with high VPI. Among adolescents, an association between VPI and obesity has recently been suggested (20, 21). To the best of our knowledge, no study has sought to investigate the possible relationship between VPI and obesity in preschool children; this precludes the possibility of comparing our findings with other published data. In our study, after controlling for socio-demographic factors, which are key predictors of VPI, no type of obesity or adiposity index remained associated with VPI.

In summary, bearing in mind the limitations of this cross-sectional study and the potential bias of this community sample, obesity was associated with VPI. However, after controlling for socio-demographic factors, an association between VPI and obesity failed to remain. Given the dearth of information on the relationship between VPI and obesity among preschool children, further studies are warranted to support or refute our claims.

Clinical relevance

Scientific rationale for study

Poor oral hygiene and obesity are highly prevalent among children, but little is known of their relationship.

Principal findings

The findings demonstrated an association between oral hygiene status and general obesity (as assessed by weight/height ratio) and central obesity (as assessed by waist circumference). However, no association was found after adjusted for socio-demographic factors.

Practical implications

This has clinical and public health implications for oral health promotion among preschool children.

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