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Review Article

Obesity, Diabetes Mellitus and Oral Health: A Comprehensive Review with Emphasis on Geographical Area; Childhood Obesity and Prevention along with Role of Breast Feeding

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Abstract

Obesity along with dental caries, periodontal diseases have become a major worldwide public health problem related to development of diseases like type 2 diabetes mellitus, hyper lipidemia, hypertension and cancer. Hence we did a pubmed search with MeSH terms like obesity, oral health, periodontal disease, masticatory function in both obesity and T2DM. We found around 3400 articles correlating to obesity and oral health of which we selected 78 articles after ruling out duplicate studies, in this study special emphasis was given on the correlation of obesity and poor health in different geographical areas, effects on childhood obesity and dental health, role of breast feeding and importance of prevention of poor oral health, oral hygiene habits and how it could be tracked right from pregnancy to infancy to childhood to old age. Prevention remains the mainstay of avoiding it with avoidance of sweets, daily brushing twice and repeated dental visits, in the presence of obesity and T2DM were associated with double the incidence of periodontal diseases as compared to the presence of obesity and T2DM alone.

Keywords: *Obesity; T2DM; Periodontal Disease; Dental Caries; Childhood Obesity and Oral Health; Pregnancy, Geographical Regions*

Introduction

In our previous works on obesity we have reported on the various aetiopathogenetic factors related to obesity besides different ways of treating it [1-11]. Further we had reviewed in a lesser detail regarding correlation of obesity and oral health [12]. Here we review the same in a greater detail considering the geographical aspect and effect right from pregnancy and tracking it to childhood, adulthood along with old age.

Obesity and oral health in India

Periodontitis or pyorrhea, is an inflammatory infection which changes the tooth supporting structure causing an increased alveolar bone loss if untreated can ultimately advance to tooth loss. Chronic periodontal infection is an inflammatory state which is described by a deviation in the microbial environment and composition of subgingival plaque biofilms and accelerated destruction of tooth supporting architecture, which is host mediated [13]. It is considered as one of the externally prevalent global condition which is represented as a leading public health dilemma for both developing and developed countries. It ranks amongst the ten most common prevalent chronic infections.

Periodontal diseases are also influenced by different risk factors that include age, smoking, oral hygiene, socioeconomic status, genetics, race, gender, psychosocial stress, osteopenia, osteoporosis and different other systemic diseases like type 2 diabetes mellitus (T2DM) and cardiovascular diseases (CVD), that signifies that Periodontitis does not occur just as a result of plaque deposition but also is associated with different host factors that could change the consequence of the plaque on an individual person.

Obesity (OB) by definition is increased body fat as per lean body mass, which affects health [14]. It is linked to low grade systemic inflammation which cause development of various disorders like metabolic syndrome, T2DM, dyslipidemia, CVD [15]. With its increasing incidence it has become the 6th most dangerous factors causing worldwide diseases which have an impact on reducing life expectancy [16]. As per WHO, obesity has become a major predisposing cause which predisposes to chronic diseases ranging from CVD to cancer [13]. There are abundant energy dense foods, reduced physical activity. WHO recommends that body mass index (BMI) can be used to categorize 0besity for all age groups [2].

A positive affiliation has been reported between prevalent periodontal diseases and obesity by different workers. Linden., *et al.* did not find a correlation between obesity in early adulthood and severity of periodontitis at the age of 60 - 70 yrs, while Morita., *et al.* described a positive correlation between BMI and periodontal disease [16,17]. Suvan., *et al.* found a heterogeneity among various studies where higher odds of periodontitis was found among obese individuals but no studies were done in young adults in relation to periodontitis and obesity [18]. Hence Deshpande., *et al.* 2017 studied 100 participants who were randomly taken and divided into 2 groups having 50 people in each group. Those having a BMI > 30 Kg/m^2 were considered obese and those < 30 kg/m^2 nonobese. Waist circumference (WC) was also measured. Gingival index (GI), pocket probing depth (PPD), gingival recession (REC) and clinical attachment level (CAL) were measured by a single examiner. Independent t test was done for comparing GI, probing depth, gingival recession and CAL among obese and nonobese participants. The prevalence of periodontitis was significantly more in obese as compared to nonobese group ($p < 0.05$ for GI, $P < 0.05$ for PPD and $p < 0.03$ for CAL). Thus they concluded that a strong correlation existed between obesity and periodontitis. Obese people could be at a greater risk for developing periodontal disease [19].

Obesity and masticatory function

In the past couple of decades, the association between obesity and masticatory function has been noticed because, masticatory function affects nutritional intake [20,21], masticatory function means the objective capacity of a person to tear solid foods into pieces or subjective response of a person to questions concerning chewing food [22]. Objective masticatory function is defined as a masticatory performance, that assesses the particle size distribution of food when chewed for a given number of strokes [23], and hence its impact on obesity is of great concern. However due to difficulty and variety of objective measurements for mastication, scarce information is available on the association between masticatory function and obesity. Objective masticatory function has been strongly associated with factors like remaining teeth, number of missing teeth and use of prosthesis [24-30]. These factors affecting masticatory function have been studied in association with obesity. Thus Tada 2018, reviewed studies for associations objective between masticatory function and between obesity and between factors affecting masticatory function (FAM) and obesity were considered for providing extensive assessment of impact of mastication on obesity. Thus Tada 2018 studied four electronic databases namely Pubmed, EMBASE, Cochrane Library and Web of Science to search publications that assessed association, between mastication and obesity among populations >= 18 yrs. The publications included were analysed based on the study design, main conclusions and strength of evidence identified by 2 authors who screened all abstracts and full text articles and abstracted data and performed quality assessment by using a critical tool, the Critical Appraisal Skills Programme Cohort Study Characteristics. A total of 18 articles (16 cross-sectional, 1 cohort studies and RCT met our inclusion criteria and were evaluated. Poorer mastication was associated with obesity in 12/16 cross-sectional studies. One cohort study showed that the obesity group displayed higher tooth loss than the normal weight group. Case RCT showed that chewing intervention x8 weeks significantly reduced waist circumference. Thus they concluded that most studies showed a positive association between mastication and obesity in adults. But since most of them are cross-sectional studies, they are insufficient for drawing a causal relation. More RCT's especially an intervention of improvement of mastication and obesity is needed to confirm the association [31].

South Korea

Similarly Park., *et al.* studied the relation between oral behaviors and nutrition status in South Korean adults. Data from the Korea national Health and Nutritional Examination survey between 2008 to 2010 was used for assessing this. A total of 15,666 participants got included for analysis. Oral behaviours including the time of day, and rate of tooth brushing, usage of secondary oral products were considered in this analysis. Obesity was defined using these 3 methods namely BMI, WC and percentage of body fat (PBF). Hierarchical multivariable logistic regression analysis were performed to determine the alteration of oral health behaviour with obesity after adjusting for possible confounding variables. The frequency of daily tooth brushing and usage of secondary oral products was lower in individuals having obesity, irrespective of the method used to define obesity. Reversely, the risk of general obesity, abdominal obesity and high PBF was higher in individuals with a lower daily frequency of tooth brushing and usage of secondary oral products [32].

Europe

Nihtila., *et al.* studied associations between oral behaviors, lifestyle factors and being overweight among young European adults, 2011 - 2012. The subjects constituted a representative Sample of adult population aged 18 - 35 yrs from 8 European countries who participated in the Escarcel study. The participants completed a self-administered questionnaire on dietary habits, oral health, behavior, smoking, exercise, height and weight. Overweight was defined as BMI >= 25 kg/m^2 using the World Health Organization (WHO) criteria. Mean BMI was 23.2 (SD3.48) and 24.3% of the study population were Overweight. Those who were overweight drank more soft drinks (p = 0.05) and energy drinks (p = 0.006) compared with those who were not overweight. Brushing once a day (OR 1.6; 95% CI 1.3 - 1.9), emergency treatment for last dental visit OR 1.6; 95% CI 1.3 - 2.0), and having 7 or more eating or drinking occasions daily (OR 1.4; 95% CI 1.1 - 1.7), were statistically significant associated with overweight. Associations were found between oral health behavior, lifestyle and overweight. A greater awareness of the detrimental lifestyle factors including oral hygiene habits among overweight young adults is important for all health care providers including oral health care professionals [33].

Sweden

General Health and oral health share similar causal and behavioral mechanisms [34], and the self-perceived oral health of an individual has been related to general health [35]. For example dental attendance patterns are correlated with other health habits [36]. Irregular dental care was found to be associated with dental anxiety [37]. Number of possible confounders should be considered in studies of oral health and obesity. Among these are socioeconomic and lifestyle factors that are associated with body weight [38] and oral health [34]. Thus Ostberg collected random sample from 1992 data collection in the Prospective Population study of Women of Gotherberg, Sweden (n = 999, 38 ->= 78 yrs). The study comprised a clinical and radiographic examination together with a self-administered questionnaire. Obesity was defined as BMI >= 30 kg/m^2, waist hip ratio (WHR) >= 0.80m. Associations were estimated using logistic regression including adjustments of possible confounders. The mean BMI Value was 25.96 kg/m^2 and mean WHR 0.83, and the mean WC 0.83m. The number of teeth, the number of restored teeth, xerostomia, dental visting habits and self-perceived health were significant associations between a small number of teeth (< 20) and obesity BMI (OR 1.95, 95%CI 1.40 - 2.73), WHR (1.67; 1.28 - 2.19) and WC (1.94; 1.47 - 2.55), respectively. The number of carious lesions and masticatory function showed no association with obesity. The obesity measure was of significance particularly with regard to behavior, such as irregular dental visits with a greater risk of associated with BMI (1.83; 1.23 - 2.71) and WC (1.96; 1.39 - 2.75,) but not with WHR (1.29; 0.90 - 1.85). Thus they concluded that associations were found between oral health and obesity. The choice of obesity measures in oral health studies should be carefully considered [39].

In Hawaii

The US Healthy people 2020 includes objective OH4: reduce the proportion of adults who have ever had a permanent tooth extraction because of dental caries [40]. Healthy people 2020 also sets age specific goals for adults aged 45 - 64 years (OH-4.1 reduce the proportion of adults aged 45 - 64 yrs adults who have ever had a permanent tooth extraction because of dental caries or periodontal disease)and for adults aged 45 - 64 years (OH 4.2, reduce the proportion of adults aged 45 - 64 yrs who have lost all their natural teeth). The overall prevalence of tooth loss and edentulism has been on the decline in the US from 1972 to 2008, and it has begun to improve [41-43]. Yet the improvement in dental health has not been shared equally across the US, with substantial differences among racial/ethnic populations at

highest risk [42,44]. Tooth loss is a sensitive indicator of overall dental health and access to dental care [45], and oral health in general is correlated with overall health status. Oral health is also associated with other disproportionally poor health outcomes in minority populations, such as DM [46-49], and is often affected by other sociodemographic factors like unemployment [50]. Therefore understanding the relationship of excess tooth loss in the context of other tooth factors is critical in reversing poor dental health among high risk minority populations.

Although there have been studies which had documented associations between tooth loss and demographic status [41,51,52], dental care access [48,53,54] and DM [55-58]. Few studies had looked into these factors together and by racial/ethnic groups, specially among native Hawaiians and other Pacific islanders. First step in improving oral health in native Hawaiians and other Pacific islanders is the identification of racial/ethnic tooth loss prevalence and its relationship to systemic diseases. Thus the study carried out by Deguchi., *et al.* 2017 fills this oral health international gap. They examined differences in the occurrences of tooth loss among whites, Filipinos, Japanese and Native Hawaiians. They used data from the Hawai'i Behavioral Risk Factor Surveillance System collected from 2011 to 2014. Participant responses were included if they self-identified as Native Hawaiian, white, Japanese or Filipino. Differences in excess tooth loss (6 or more teeth) and known risk factors (demographics, DM and dental visits] were analyzed using univariate analyses and adjusted stepwise, logistic regression models. They found an inequity among oral health in the 4 ethnic groups. Among the groups, native Hawaiians had the largest proportion of excess tooth loss. The univariate analyses found differences in the strength of these associations among the 4 racial/ethnic groups. The stepwise analyses found that the associations of excess tooth loss and race/ethnicity were not significant after adjusting for demographic, DM and dental visits. Thus they concluded that there is need for programs and policies which improve oral healthcare in Hawai'i for those with low levels of income and education and those with DM [59].

In Vietnam

Vu Pham 2018 examined the relationship between OB, T2DM and periodontal disease in Vietnamese patients 712 patients >=18 yr, visiting the Institute of traditional Medicine, ho chi Minh City. All participants completed a questionnaire along with undergoing anthropometric index measures for obesity (height, weight, WC, hip circumference) and had their body fat percentage measured. A full periodontal examination was performed after a fasting glycaemic levels were determined. Occurrence and risk of periodontal outcomes were compared across 3 different measurements of obesity (BMI, WHR and body fat percentage (BF% age), or the prevalence of periodontitis in obese group (37.0%, 36.4% and 24.6% by BMI, WHR and BF% age respectively or T2DM group (50.7%) was significantly higher than those without these conditions ($p < 0.05$). Subjects with obesity or T2DM had significantly > PD and CAL loss than those who were not obese or diabetic ($p < 0.01$). Multivariate logistic regression, adjusted for cofounding variables showed that the likelihood (odds ratio, OR) for periodontitis was highest in the obese and T2DM group (OR = 4.24, CIP [2.29, 7.86]; OR = 4.06, CI [2.24, 7.36]; and OR = 5.44, CI [2.94, 10.03]), followed by the obese and nondiabetic (OR = 2.28, CI [1.05, 4.95], OR = 202, CI [1.34, 3.56] and then the nonobese T2DM group (OR = 2.20, CI [1.21, 3.98]; OR = 1.99, CI [0.93, 4.24] and OR = 5.22, CI [2.76, 9.84]) when obesity was defined by BMI, WHR and BF% age respectively ($p < 0.05$). Thus they concluded a significant association between OB, T2DM or those with both systemic conditions and periodontitis was found in Vietnamese patients [60].

Obesity, oral health and inflammatory markers

Elangovan., *et al.* tried to examine the relationship between measures of body fat like BMI,WC and total body fat percent and markers of inflammation around dental implants in stable periodontal maintenance patients. 73 Patients got enrolled in this cross-sectional assessment. The study visit consisted of a physical examination which included anthropologic measurements of body composition i.e. BMI, WC, body fat %: intraoral assessments were performed (full mouth plaque index, periodontal and peri-implant comprehensive examinations) and peri-implant sulcular fluid (PISF) was collected on the study implants. Levels of interleukin (IL)-1α, IL1β, IL-6, IL-8, IL-10, IL-12, 1L-17, tumor necrosis factor- α,C reactive protein, osteoprotegrin, leptin and adiponectin in PISF were measured using multiplex proteomic immunoassays. Correlation analysis with body fat measures was then performed using appropriate statistical methods. After adjustments

for covariates, regression analysis revealed statistically significant correlation between IL-1β in PISF and WC (R = 0.33'0 = 0.0047). Thus they concluded that in this study periodontal maintenance patients, a modest but statistically significant positive correlation was observed between the levels of IL-1β, a major proinflammatory cytokine in PISF and WC, a reliable measure of central obesity [61].

Childhood and adolescent obesity and oral health

Childhood and Adolescent obesity has become increasingly seen in young people [62], which has reached epidemic proportions, becoming a major public health problem. 1 in 3 children 5 - 9 yrs old are above the weight recommendations given by WHO, and 23.2% adolescents are overweight [63]. Overweight children and Adolescents might present with chronic diseases traditionally dependent on age increasingly earlier [64]. Obesity has been identified as risk factor for CVD [6], hypertension [13], T2DM [65], hyperlipidemia [66]. A systemic inflammatory condition and high levels of CRP can be associated [67], thus it is a potential risk for periodontal disease, mainly so in young individuals [68]. Periodontal disease is a chronic inflammatory oral disease, being infectious and having high prevalence [68,69], which if left untreated can cause destruction of the supporting tissues of teeth [64]. In overweight/obese people production of inflammatory cytokines by adipose tissue aggravates the systemic inflammatory condition that predisposes to either the establishment/worsening of inflammatory diseases liken periodontitis [67]. Few studies have investigated this association in Childhood and adolescents [62,64,70-72]. Thus Cavalcanti., *et al.* tried to evaluate this association in Brazilian children. A cross-sectional study which used a probability cluster sampling, and the sample was defined by statistical criteria, consisting of 559 students aged 15 - 19 yrs enrolled in public schools of adolescents of Campina Grande, PB, Brazil in 2012. Socioeconomic characteristics were analyzed, as well as self-reported general and oral health and topometric data and deep pocket periodontal condition (CPI and OHI-S). Descriptive and analytic analysis from bivariate and multivariate Poisson regression analysis with 5% significance levels was performed. Of the 559 adolescents, 18.6% were overweight and 98.4%had some form of periodontal changes like bleeding (34.3%), shallow pocket (22%) and deep pocket (2.3%). There was association between presence of periodontal changes and obesity status in adolescents was indicated by the presence of periodontal changes with obesity ($P < 0.05$; CI 95%: 0.99-[0.98 - 0.99]. Thus they concluded that an association between presence of periodontal changes and obesity status in adolescents is indicated [73].

Microbiota in oral biofilm

Zeigler CC., *et al.* tested the hypothesis if microbiota in oral biofilm is linked with obesity in adolescents by designing a cross-sectional study. Obese adolescents (n = 29) with mean age of 14.7 yrs and normal weight subjects (n = 58) matched by age and gender were examined in respect to visible plaque index (VPI%) and gingival inflammation (bleeding on probing (BOP%)). Stimulated saliva was collected. They answered a questionnaire concerning medical history, medication, oral hygiene habits, smoking habits, and socioeconomic background. Microbiological samples taken from the gingival crevice was analyzed by checkboard DNA-DNA hybridization technique. The sum of bacterial cells in subgingival biofilm was significantly associated with obesity ($p < 0.001$). The link between sum of bacterial cells and obesity was not confounded by any of the study variables (chronic diseases, medication, VPI%, BOP%, flow rate of saliva, or meal frequency). Totally 23 bacterial species were present in approximately 3 folds higher amounts, on average in obese subjects compared with normal weight controls. Of the *Proteobacterium* phylum, *Campylobacter rectus* and *Neisseria mucosa* were present in 6 fold higher amounts among obese subjects. The association between obesity and sum of bacterial cells in oral subgingival biofilms indicates a possible link between oral microbiota and obesity in adolescents was their conclusion [74].

Obesity and oral Health in Hongkong in children

Lifshitz., *et al.* studied oral health in children with Obesity and DM, by addressing periodontal Disease (PD) and dental caries (DC), since these are the 2 most common chronic diseases affecting obesity and DM patients. OB plays a possible role in the development of PD. Both overall OB and central adiposity are associated with increased risk of gingivitis and its progression to PD. The inflammatory changes of PD might not be limited to the oral cavity, they might also trigger systemic sequences. Patients with type 1and type 2 DM (T1DM, T2DM)

present an increased prevalence of gingivitis and PD. In diabetics PD develops at a younger age than in healthy population, besides it worsened with the prolongation of DM. Progression to PD has been correlated with metabolic control of disease and is more prevalent and more severe in patients having increased hemoglobin A1c (Hb A1c) levels. PD negatively affects glycaemic control and other DM related complications and there is a general belief that treatment of PD can positively influence these negative effects. In addition DC is a multifactorial oral disease which is frequently detected in those having OB and DM, though its prevalence in systemic reviews is inconclusive. Associations between gingivitis, PD, and DC share similar behavior i.e. inadequate oral hygiene habits and unhealthy dietary intake. Insufficient tooth brushing and intake of sugary foods may result in greater detrimental oral effects. Maintaining oral health will prevent oral chronic diseases and ameliorate the consequences of chronic inflammatory processes. Thus they concluded that, the care of obese and DM patients requires a multidisciplinary team with medical and dental health professionals [75].

Peng., *et al.* studied the association between oral hygiene status and obesity status among preschool hongkong children. 345 five year old children in Hong Kong were recruited. Their oral hygiene was recorded using visible plaque index (VPI). Body height, weight, WC, hip circumference and triceps fold thickness (TRSKF) were measured to assess general adiposity (weight/height ratio, W/H, BMI) central obesity (WC, waist/hip ratio, WHR) and peripheral adiposity (TRSKF). Relationships between VPI and W/H, BMI, WC, WHR and TRSKF were examined in bivariate and regression analysis. 56% of the children were considered to have high VPI (VPI >= 65%). Logistic regression analyses identified with W/H z scores (OR = 1.25, 95%CI = 1.00 - 1.58) were associated with high VPI. No Association was found after adjusted for sociodemographic status ($p > 0.05$). Thus concluding that oral hygiene status was not associated with obesity among 5year old children In Hong Kong after controlling or socio demographic factors [76].

Obesity and oral Health and breast feeding

Salone., *et al.* provided an update on benefits of breast feeding in relation to oral health. They examined literature regarding general health protections which breast feeding confers to infants and mothers and explored Associations between breast feeding, occlusion in the primary dentition and early childhood caries. For this systematic reviews when available, were supplemented with comparative studies and with statements of reports from major governmental and non-governmental organizations. On comparing health outcomes among formula-fed children, the health advantages found with breast feeding included a lower risk of acute otitis media, gastroenteritis and diarrhea, severe lower respiratory infections, asthma, sudden infant death syndrome, obesity and other childhood conditions. Also breast fed children developed a more favourable occlusion in primary dentition. Regarding dental caries these studies were inconclusive. Thus concluding that the American Academy of pediatric Dentistry, Chicago suggests that parents gently clean infants', gums and teeth after breast feeding. American Academy of pediatrics. Elk Grove Village, III, recommends that breast feeding should be exclusive for about the first 6 months of life and should continue with the introduction of appropriate complementary foods to atleast 12 months or beyond, as desired by the mother and child. Dentists and staff members can take steps to ensure that they are familiar with the evidence and guidelines pertaining to breast feeding and to oral health. They should follow the surgeons recommendations for promoting the same [77].

Obesity and oral Health during pregnancy

Kruger., *et al.* evaluated periodontal health and pregnant women and investigated association of periodontal disease status with demographic and socioeconomic characteristics along with medical and dental history. 311 pregnant women were interviewed to obtain sociodemographic data along with medical and dental histories. Clinical examination were performed to record the presence of visible plaque, gingival bleeding and caries activity. The periodontal condition was evaluated by Community Periodontal index of treatment needs (CPITN) in one tooth of each sextant (16, 11, 26, 36, 31 and 46). After the adjustment Analyses the presence of visible plaques remained the main determinant of (OR = 2.91, CI = 1.91 - 4.48) gingival bleeding (OR = 2.91, CI = 1.91 - 4.48). First trimester pregnancy status was also a predictor, with lower prevalence of gingival bleeding observed in the second (OR = 0.87, CI = 0.77-0.99) and third (OR = 0.82, CI = 0.73 - 0.93) trimesters. Thus concluding that pregnant women having dental plaque and first trimester pregnancy status were the main implicated factors predicting gingival bleeding [78].

Conclusions

Thus we have tried to summarize the correlation between obesity and oral health and touched on the different aspects like dental caries, periodontitis, masticatory function, GT, PPD, GR, CAL, alteration in microbiota in subgingival films, alteration in cytokines in PISF, dental anxiety and correlation of poor oral health with obesity development in various geographical areas of the world starting from pre-pregnancy, to childhood to adulthood. Importance of breast feeding in prevention is also emphasized along with avoidance of sweets, cold drinks brushing teeth twice daily. Thus overall attention has to be given for prevention and keeping good oral health for prevention of obesity development, avoidance of tooth loss, better maintenance of dentures once applied and avoidance of repeated antibiotics for the same.

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