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Original Article

Relationship of salivary adipocytokines, diet quality, physical activity, and nutrition status in adult *Emirati* females in United Arab Emirates

Amita Attlee [a, e, *], Hayder Hasan [b, e], Afra AlQattan [b], Nada Sarhan [b], Razan Alshammari [b], Shaikha Ali [b], Maryam Nabil [b], Alaa Alattrash [b], Veena Raigangar [c, e], Mohamed Madkour [d, e], Hema Unnikannan [e], Samir Awadallah [d, e]

[a] *Nutrition and Health Department, College of Food and Agriculture, University Arab Emirates University, Al Ain, United Arab Emirates*
[b] *Department of Clinical Nutrition and Dietetics, College of Health Sciences, University of Sharjah, Sharjah, United Arab Emirates*
[c] *Department of Physiotherapy, College of Health Sciences, University of Sharjah, Sharjah, United Arab Emirates*
[d] *Department of Medical Laboratory Sciences, College of Health Sciences, University of Sharjah, Sharjah, United Arab Emirates*
[e] *Sharjah Institute for Medical Research (SIMR), University of Sharjah, Sharjah, United Arab Emirates*

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ABSTRACT

Aims: The United Arab Emirates (UAE) ranks as the fifth most obese country with increasing cardio-metabolic risks. In this paper, relationships of salivary adipocytokines (markers of cardio-metabolic syndrome), diet quality and physical activity in 90 normal-weight, overweight and obese (30 subjects in each group) *Emirati* adult females were investigated.
Methods: A cross-sectional research design was adopted. Anthropometric measurements, diet quality and physical activity questionnaires were administered. Overnight fasting saliva was collected to determine levels of adiponectin, interleukin-10 (IL-10) and tumor necrosis factor-alpha (TNF-α).
Results: Salivary adiponectin was significantly lower, while TNF-α was higher in obese than normal-weight subjects. IL-10 displayed a lower trend in obese subjects. Though diet quality and physical activity did not exhibit significant differences among the three groups, better diet quality and higher physical activity level were reported among normal-weight subjects. Salivary TNF-α correlated positively with body mass index (BMI) ($r = 0.37$; $p < 0.001$) and waist circumference ($r = 0.31$; $p < 0.001$), while adiponectin correlated negatively with BMI ($r = -0.28$; $p < 0.05$). IL-10 showed negative trend in correlation with obesity measures. Correlations were not observed between diet quality and physical activity with salivary adipocytokines. Interestingly, a significant negative correlation emerged between diet quality and neck circumference ($r = -0.24$; $p < 0.05$).
Conclusion: Our findings demonstrate that salivary adipocytokines correlate with obesity measures and can serve as convenient adjunct method in predicting cardio-metabolic risks in the population.

1. Introduction

Obesity has become a major worldwide health problem that leads to high rates of mortality and morbidity. Recent definitions of obesity have highlighted it to be a low grade chronic inflammatory condition leading to the development of metabolic disorders including insulin resistance, type 2 diabetes, and cardiovascular disease [1].

Many lines of evidence indicate that adipose tissue is not only an energy storage tissue, but also an endocrine organ that secretes multiple bioactive mediators, collectively known as adipocytokines. These are closely involved in the regulation of many processes such as energy metabolism, inflammation, diabetes and atherosclerosis [2]. Anti-inflammatory and pro-inflammatory adipocytokines, such as adiponectin, leptin, tumor necrosis factor-alpha (TNF-α), interleukin-6 (IL-6), interleukin-10 (IL-10) and other chemokines are produced by adipose tissues and have been

* Corresponding author. Nutrition and Health Department, College of Food and Agriculture, University Arab Emirates University, PO Box 15551, Al Ain, United Arab Emirates.
E-mail addresses: amita.attlee@uaeu.ac.ae (A. Attlee), haidarah@sharjah.ac.ae (H. Hasan), U00036569@sharjah.ac.ae (A. AlQattan), U00033413@sharjah.ac.ae (N. Sarhan), U00025822@sharjah.ac.ae (R. Alshammari), U00025912@sharjah.ac.ae (S. Ali), U00032237@sharjah.ac.ae (M. Nabil), U00032283@sharjah.ac.ae (A. Alattrash), veena@sharjah.ac.ae (V. Raigangar), mmadkour@sharjah.ac.ae (M. Madkour), hunnikannan@sharjah.ac.ae (H. Unnikannan), sawadallah@sharjah.ac.ae (S. Awadallah).

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shown to be implicated in the pathogenesis of insulin resistance, adipogenesis and inflammation [3]. Dysregulation in the secretion of these adipocytokines, resulting from excessive adiposity and/or adipocyte dysfunction, plays a major role in the development and progression of various cardio-metabolic disorders [1,4]. For instance, decreased serum levels of adiponectin and IL-10, and increased levels of TNF-α, were found to be associated with various metabolic and inflammatory disorders including obesity and metabolic syndrome [4–6].

Over the past decade, many studies have demonstrated that saliva is a potential biological fluid for detection of biomarkers of metabolic and inflammatory conditions [7–10]. Being non-invasive, and easily collected and analyzed, saliva offers several advantages over blood and has proven to be an effective alternative to serum analysis, especially for screening purposes in pediatric and elderly subjects [11,12]. Studies conducted on healthy subjects as well as on subjects with diabetes, cardiovascular disease and metabolic syndrome, have reported close association between serum and salivary levels of many of these adipocytokines [10–14].

In the United Arab Emirates (UAE), obesity has become an important health concern among the native *Emirati* (UAE national) population. The UAE ranks as the fifth most obese country in the world with nearly 75% of the population being either overweight or obese [15]. Various lifestyle factors contribute to obesity and related cardio-metabolic risks. On the one hand, nutrition transition has witnessed the replacement of traditional *Emirati* food with energy-dense fast foods, sugar-sweetened beverages, frequent snacking and low fruits and vegetables consumption [16]. On the other hand, *Emiratis* blame their reduced physical activity on personal, social and environmental factors such as inactive occupations, rare participation in sports and sedentary leisure, hot weather, car-dependence, and restrictive nature of traditional clothing [16,17]. These lifestyle behaviors and conservative society norms are strongly associated with the development of obesity, particularly among females, in the UAE [16,17].

To the best of our knowledge, no studies on salivary adipocytokines and its association with dietary intake and physical activity in obese females from the UAE have been previously reported. Thus, the aim of this study was to investigate the association of selected salivary adipocytokines (adiponectin, TNF-α and IL-10) with diet quality and physical activity among healthy and obese young females from the UAE.

2. Materials and methods

2.1. Study design and setting

A cross-sectional study was conducted at the University of Sharjah (UOS), Sharjah, UAE between February–May 2016. All *Emirati* (UAE Nationals) females (staff and students) from the UOS were invited to participate in this study. A total of 90 subjects comprising 30 each of normal-weight, overweight and obese *Emirati* females aged 18–35 years were selected using the convenience sampling technique. The study protocol and consent forms were approved by the Research and Ethics Committee for the UOS (Ref. No. REC/16/01/13/S). Objectives of the study were explained and written informed consent obtained from the subjects before the data was collected.

2.2. Nutrition status

Physical measurements included stature (standing height) and body weight for assessment of body mass index (BMI), neck (NC) and waist circumferences (WC), and blood pressure. Stature was measured using a stadiometer (Seca Model No. 217) and weight using a weighing scale (Seca Medical Digital Column Model No.703) utilizing standardized techniques with minimum clothing and without the subjects' footwear [18]. BMI was calculated by dividing body weight in kilograms by the square of height in meters. The World Health Organization classification was used to determine the nutrition status. Accordingly, BMI values 18.5–24.9 kg/m^2 indicated a healthy weight (normal-weight), BMI≥25.0 to < 30.0 kg/m^2 was considered as overweight and BMI≥30.0 kg/m^2 as obesity [18].

Circumference measurements were taken using a measuring tape (Seca Model No. 203) and the mean of three readings was considered. Neck circumference was measured at mid-neck height, between mid-cervical spine and mid-anterior neck, to within 1 mm [19]. Waist circumference, a measure of central obesity, was assessed at the approximate midpoint between the lower margin of the last palpable rib and the top of the iliac crest [18]. Blood pressure was measured using a digital automated blood pressure monitor (OMRON®–BP742N, OMRON, Matsuzaka, Mie, Japan) on the right upper arm with the subjects in the sitting position [20].

2.3. Diet quality

A validated questionnaire- MEDFICTS (MF) Dietary Assessment Questionnaire was utilized to determine the diet quality of the subjects. MF is a brief instrument consisting of 8 food categories: meats, eggs, dairy, fried foods, fat in baked goods, convenience foods, fats added at the table, and snacks. The first column of the questionnaire addresses each of these food categories. Within each category, food items are assigned to either group 1 (desirable) or group 2 (undesirable) based upon total fat content. Numeric values are assigned to each food group, with weightings based upon weekly consumption and serving size. The questionnaire is scored using a totaling of the quality-adjusted intake quantity yielding a possible range of scores from 0 to 216 points. The National Cholesterol Education Program recommends MEDFICTS to assess adherence to the Adult Treatment Panel (ATP) III Therapeutic Lifestyle Changes (TLC) diet. Lower MF scores indicate diets containing less dietary fat. Thereby, a score of <40 points is consistent with a Step 2 diet (intake of <7% of energy from saturated fat, <30% of energy from total fat, and <200 mg dietary cholesterol/day), a score between 40 to 69 is consistent with a Step 1 diet, and a score of >70 is considered as high fat diet [21].

2.4. Physical activity

Physical activity was assessed in four domains using the eighth version of the International Physical Activity Questionnaire- IPAQ-long form (work, transportation, housework and leisure-time). A domain-specific activity score was calculated separately for each domain of physical activity (at work, transportation, housework and leisure). In addition, a total physical activity score was calculated as the sum of the number of minutes of total moderate activity for each subdomain (including walking), plus two times the number of minutes of vigorous activity for each subdomain. The domain-specific activity scores were calculated similarly to the total physical activity score. Accordingly, moderate activity was defined as activities performed for at least 10 min that produced an increase in respiration and heart rate, and caused sweating. Vigorous activities were defined as those activities that produced greater increases in respiration, heart rate and sweating. Insufficient physical activity was defined as less than 150 min of combined moderate and vigorous physical activity per week and subjects were categorized as insufficiently physical active. Similarly, subjects who reported ≥150 min of combined moderate and vigorous physical activity per week were considered to be active [22,23]. In this study, the subjects were categorized into “low”

(insufficient), "moderate" and "high" (vigorous or combination of moderate and vigorous) active.

2.5. Saliva collection

Subjects were asked not to eat or drink anything at least 10–12 h prior to sample collection. They were also advised to brush their teeth after the last meal on the previous night. Therefore, the samples were collected in the morning at the Sharjah Institute of Medical Research (SIMR) laboratory of the Research Institute for Medical and Health Sciences at the UOS. Unstimulated saliva was obtained 45 min after mouth rinsing with water and having the subject sit quietly and gently spit into a collection container till about 5 ml of saliva was filled. Saliva collection was completed in 10 min or less [24]. Samples obtained were centrifuged at 15,000 × g for 15 min to remove insoluble material. Supernatants were removed and divided into aliquots that were stored immediately at −80 °C until the time of analysis. Commercially available enzyme linked immunosorbent assay (ELISA) kits were used to determine salivary levels of adiponectin, IL-10, and TNF-α (Ray-Biotech Inc., Norcross, GA, USA).

2.6. Data analysis

Statistical analyses were performed using SPSS version 21.0 (SPSS, Chicago, IL). Data was checked for normality using the Shapiro-Wilk test. Non-parametric tests were performed using medians and inter-quartiles ranges (IQR) for non-normally distributed numerical and nominal variables. The Kruskal-Wallis test was applied to compare the significance of difference in anthropometric measurements, diet quality, physical activity and salivary biomarkers among normal, overweight and obese subjects. The Chi-square test was applied to explore the association of diet quality and physical activity among normal-weight, overweight and obese subjects. Spearmen's correlation coefficient test was used to examine the relationships of diet quality, physical activity, salivary adipocytokines and nutrition status. The data was tested for statistical significance at p value of <0.05.

3. Results

Table 1 illustrates the anthropometric, nutrition status, and levels of salivary adipocytokines among the three groups of subjects according to their BMI. The median age of all subjects was 21(2) years with no significant difference among the three groups. As expected, weight, BMI, WC and NC were significantly higher ($p < 0.001$) in obese subjects as compared to normal. No significant difference was observed among the three groups with respect to diet quality and physical activity. While the levels of adiponectin were significantly lower ($p < 0.025$), the levels of TNF-α were significantly higher ($p < 0.001$) in the obese group than the counterparts with lower BMIs. Furthermore, the levels of IL-10 were lower in obese subjects as compared to the other groups though the difference was not statistically significant.

Table 2 depicts data related to diet quality and physical activity levels in the three groups of subjects. Although diet quality and physical activity did not differ significantly among the three groups, it was evident that 30.0% of obese subjects as compared to 40.0% normal weight subjects followed therapeutically lifestyle changes (TLC) diet. Furthermore, 46.7% of the obese followed a heart-healthy diet as compared to 33.3% in normal weight subjects. These observations indicate that normal-weight subjects as compared to overweight or obese subjects followed a better diet quality. Similarly, the table also shows that "high" levels of physical activity were reported more among the normal-weight group (30.0%) as compared to 16.5% and 6.7% in the overweight and obese groups, respectively. The majority of subjects however, reported "moderate" level of physical activity.

Table 3 shows the correlations between anthropometric data, diet quality, physical activity, and salivary adipocytokines among all investigated subjects. As shown in Table 3 as well as Fig. 1 (A), salivary adiponectin correlated negatively with BMI ($r = -0.284$, $p < 0.05$). On the other hand, TNF-α correlated positively with BMI ($r = 0.375$; $p < 0.001$) (Table 3 and Fig. 1 B), and WC ($r = 0.312$; $p < 0.001$) (Table 3), respectively. Although not statistically significant, IL-10 displayed a trend of negative correlation with BMI and WC. Furthermore, salivary adiponectin correlated negatively with TNF-α ($r = -0.281$; $p < 0.05$). No significant correlations were observed between diet quality and physical activity with adipocytokines and/or with any of the obesity measures.

4. Discussion

As indicated earlier, and due to lifestyle and conservative society norms, obesity among *Emirati* females has become a public health issue. Therefore, this study was conducted to explore the association of selected salivary adipocytokines, such as adiponectin, TNF-α, and IL-10, and diet quality and physical activity among normal and obese young females from the UAE.

Results from this study point to several significant findings. First,

Table 1
Comparison of anthropometric measurements, diet quality, physical activity and salivary adipocytokines among normal-weight, overweight and obese adult *Emirati* females.

Variables	Normal (N = 30)	Overweight (N = 30)	Obese (N = 30)	p value
	Median (IQR)	Median (IQR)	Median (IQR)	
Age (years)	21 (2)	21 (9.25)	20.5 (2)	0.16
Weight (kg)	53.4 (8.7)	67.9 (6.33)	86 (13.6)	<0.001
Height (m)	1.58 (0.11)	1.59 (0.07)	1.59 (0.08)	0.95
BMI (kg/m^2)	21.3 (3.75)	26.75 (3.25)	32.5 (2.57)	<0.001
Waist Circumference (cm)	76.9 (9.13)	87.1 (4.7)	98.9 (11.35)	<0.001
Neck Circumference (cm)	31.15 (3.1)	32.05 (2.52)	34.5 (2.87)	<0.001
Systolic Blood Pressure (mmHg)	106 (16)	107.5 (18.25)	108 (14)	0.80
Diastolic Blood Pressure (mmHg)	72.5 (10.75)	75.0 (8.75)	76.5 (10.5)	0.62
Diet Quality (score)	36.5 (56.5)	55.5 (43.5)	53 (33.75)	0.74
Physical Activity (score)	1140 (2220)	685.25 (2047.5)	915.75 (1114.5)	0.28
Adiponectin (ug/ml)	0.64 (0.67)	0.236 (0.53)	0.27 (0.73)	0.03
TNF-α(pg/ml)	0.47 (0.28)	0.96 (2.08)	1.03 (1.56)	<0.001
IL-10 (pg/ml)	40.77 (32.13)	44.04 (35.5)	31.8 (17.56)	0.32

$p < 0.05$ indicates significant difference.
BMI, body mass index; TNF-α, tumor necrosis factor-alpha; IL-10, interleukin-10.

Table 2
Association of diet quality and physical activity among normal-weight, overweight and obese subjects using chi-square test.

	Normal (N = 30)% (N)	Overweight (N = 30)% (N)	Obese (N = 30) % (N)	Total Percentage % (N)	p value
Diet quality					
Dietary Changes	26.7 (8)	33.3 (10)	23.3 (7)	27.7 (25)	0.62
Heart-Healthy Diet	33.3 (10)	43.3 (13)	46.7 (14)	41.1 (37)	
TLC Diet	40.0 (12)	23.3 (7)	30.0 (9)	31.2 (28)	
Physical Activity					
Low	26.7 (8)	33.3 (10)	26.7 (8)	28.9 (26)	0.16
Moderate	43.3 (13)	50 (15)	66.7 (20)	53.3 (48)	
High	30.0 (9)	16.7 (5)	6.7 (2)	17.8 (16)	

$p < 0.05$ indicates significant association.

Table 3
Correlations of nutrition status, diet quality, physical activity and salivary adipocytokines in subjects (n = 90).

	Weight	Height	BMI	NC	WC	SBP	DBP	Diet Quality	Physical Activity	Total Adiponectin	TNF-α
BMI	0.94**	−0.09	–	–	–	–	–	–	–	–	–
NC	0.64**	0.042	0.65**	–	–	–	–	–	–	–	–
WC	0.83**	0.073	0.82**	0.56**	–	–	–	–	–	–	–
SBP	0.02	−0.09	0.06	0.05	0.09	–	–	–	–	–	–
DBP	0.10	−0.19	0.15	0.09	0.14	0.54**	–	–	–	–	–
Diet Quality	−0.03	−0.19	0.04	−0.24*	0.03	−0.07	0.15	–	–	–	–
Physical Activity	−0.16	−0.11	−0.13	−0.20	−0.19	0.08	0.06	0.06	–	–	–
Total Adiponectin	−0.29**	−0.01	−0.28*	−0.10	−0.15	0.07	0.05	−0.09	−0.07	–	–
TNF-α	0.36**	0.01	0.37**	0.10	0.31**	0.06	0.09	0.12	−0.07	−0.28*	–
IL-10	−0.09	0.09	−0.17	−0.13	−0.20	0.08	0.17	−0.01	−0.03	0.20	0.02

*$p < 0.05$; **$p < 0.001$.
BMI, body mass index; NC, neck circumference; WC, waist circumference; SBP, systolic blood pressure; DBP, diastolic blood pressure; TNF-α, tumor necrosis factor-alpha; IL-10, interleukin-10.

adipocytokines such as adiponectin, TNF-α and IL-10 were present in adequate and measurable concentrations in saliva collected from normal, overweight and obese adult females from the UAE. Second, the levels of salivary adiponectin were lower, while the levels of TNF-α were higher in obese subjects as compared to normal-weight subjects. The levels of IL-10, though not statistically significant, were lower in obese subjects as compared to normal subjects. Third, salivary adiponectin correlated negatively with BMI, while on the other hand, TNF-α correlated positively. Furthermore, salivary adiponectin correlated negatively with TNF-α. Finally, results from this study could not find significant differences in diet quality and/or physical activity between the three female groups. However, better diet quality was followed more by normal-weight, than overweight and obese subjects. Similarly, higher levels of physical activity were reported in normal-weight more than that in overweight and/or obese subjects. None of the investigated salivary adipocytokines correlated with diet quality or physical activity levels.

The levels of salivary adiponectin and its association with that in serum had been previously investigated in healthy [13,25], as well as in obese [26], and in metabolic syndrome subjects [14]. Although most of these studies demonstrated a significant association of serum and salivary levels of adiponectin, others have reported low levels of salivary adiponectin in healthy females that did not correlate with that of plasma level [25]. Furthermore, studies on healthy subjects have also reported a lack of association of salivary adiponectin with BMI, age or fat percentage [13,25].

Studies on subjects with obesity and metabolic syndrome [14,27] have reported no significant difference in the levels of salivary adipokines of healthy subjects as compared to those with obesity and/or metabolic syndrome. On the contrary, results from a recent study conducted on an obese pediatric population [12] have demonstrated reduced levels of salivary adiponectin in comparison to healthy controls. These results are in agreement with the results reported by our study.

Although we only measured adiponectin in saliva and not in serum, it is very likely that serum levels in our studied subjects are decreased as well. This suggestion could be supported by the close association of serum and salivary levels reported previously in obese subjects that increased with reduction in body weight [26,28].

Furthermore, results from our study have also demonstrated a strong negative correlation of salivary adiponectin with BMI. This could be attributed to a decreased serum level of adiponectin in studied obese subjects, consequently, reflecting decreased levels of salivary adiponectin.

Findings from our study have shown that salivary levels of TNF-α were higher in obese subjects and correlated positively with BMI. The few studies that had been previously conducted on salivary TNF-α, reported contradicting results. For instance, studies conducted on healthy subjects have demonstrated low levels of salivary TNF-α that did not correlate with plasma [25,29]. On the other hand, studies on diabetic subjects [30] revealed increased levels of salivary TNF-α in those with diabetes than normal, that correlated positively with that in serum; however, salivary TNF-α was not correlated with the BMI or age of the subjects. TNF-α is a pro-inflammatory cytokine that is central to the pathogenesis of various inflammatory conditions, and its levels are increased in the adipose tissue and in plasma of obese individuals, and a reduction of body weight in these individuals is associated with a decrease in TNF-α expression [4]. Adiponectin, on the other hand, is an essential anti-inflammatory adipokines reported to be decreased in plasma and adipose tissue in obese individuals as compared to lean individuals [4]. Consequently, it is very likely that the production of adiponectin by adipocytes is inhibited by the pro-inflammatory action of TNF-α [31]. The decreased levels of salivary adiponectin and its association with increased levels of TNF-α on one hand, and the negative and positive correlations of both, respectively with BMI, might be collectively attributed to the chronic inflammatory status associated with obesity [32].

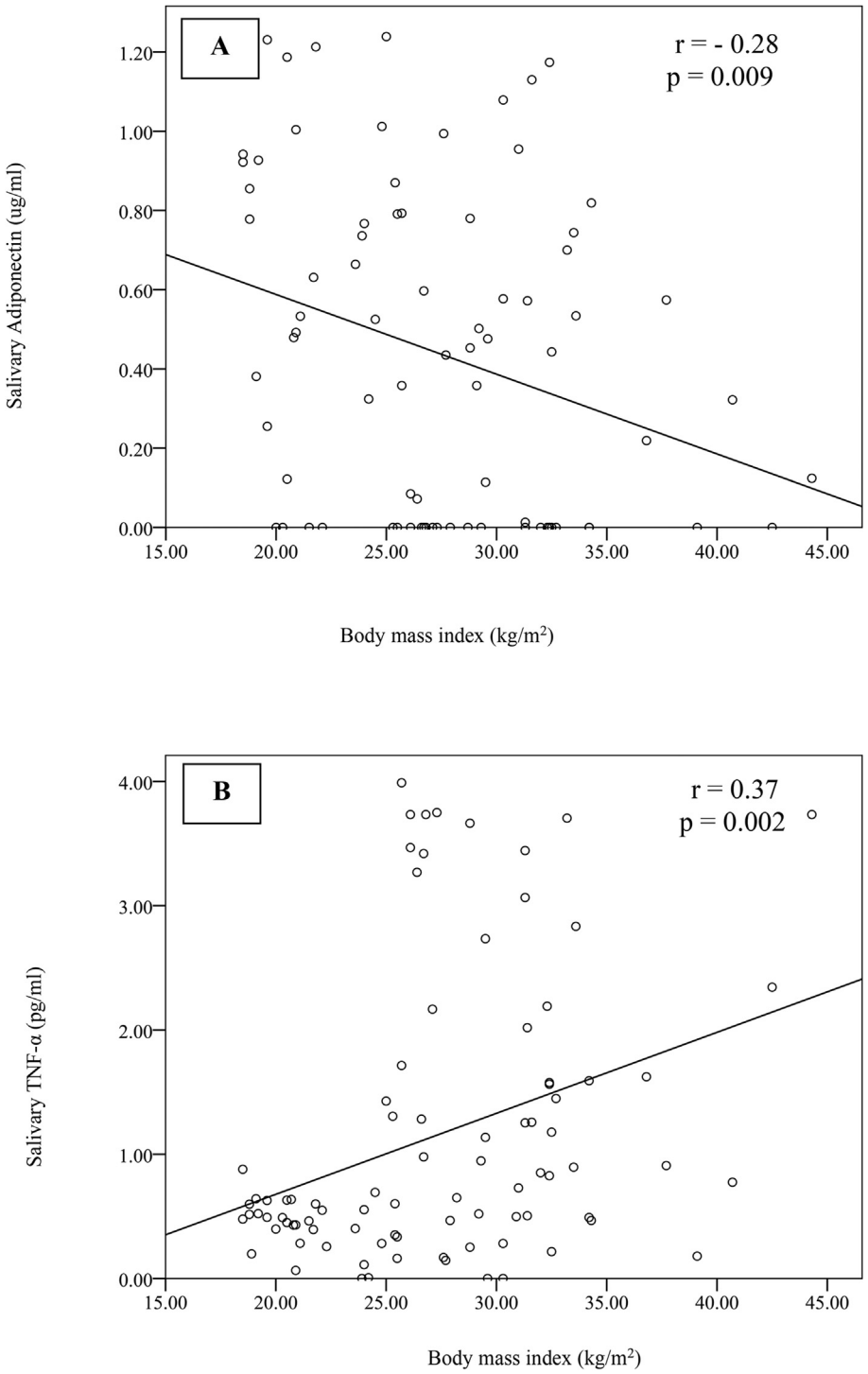

Fig. 1. Relationship of body mass index with salivary adiponectin (A) and TNF-α (B).

Interlukin-10 is an anti-inflammatory cytokine that suppresses inflammatory conditions through various mechanisms including inhibition of the synthesis of TNF-α [4]. Decreased levels of IL-10 have been found in plasma of obese and metabolic syndrome subjects [5,33]. To the best of our knowledge, no previous studies have been conducted on the levels of IL-10 in saliva from obese subjects. Therefore, it is very likely that the decreased salivary levels of IL-10 observed in our study might be attributed to the low serum levels associated with obesity.

Although numerous studies have investigated the influence of diet and physical activity on plasma levels of adipocytokines [34,35], no previous studies were conducted on saliva. This study was the first to investigate the association of salivary adipocytokines with diet quality and physical activity in obese and healthy subjects. Results from this study however, did not depict significant differences in diet quality and/or physical activity scores among the three groups; even though, better diet quality was followed more by normal-weight, than overweight and obese subjects. Similarly, a

higher level of physical activity was reported in normal-weight more than that in overweight and/or obese subjects. While many studies have reported a significant role for both diet and physical activity in modulating and improving blood levels of adipokines [26,34,35], others, however, have reported contradicting result [36]. The discrepancies were attributed to the multiple factors associated with dietary management, and to the intensity, frequency and duration of physical activity. Therefore, salivary levels of adipocytokines might not be sensitive enough to be an indicator to assess diet quality or physical activity in obese or healthy individuals.

The limitations of this study were the small size of studied population and the inability to correlate the results of salivary adipocytokines with serum adipocytokines. There is no doubt that a larger sample size and measuring serum levels of adipocytokines would have added a significant value to the interpretation of our results. Nonetheless, saliva is emerging as an effective non-invasive biological fluid of assessment in community settings. Furthermore, since gender differences are evident in human adipose tissues, future researches should be directed towards addressing this issue by including both males and females.

5. Conclusion

The findings of this study have demonstrated that saliva is a potential biological fluid for assessing adipocytokines as markers of metabolic disorders. Adiponectin, TNF-α, and IL-10 were detected in salivary fluid and were found to be correlated with obesity measures in female *Emirati* adults in the UAE. However, an association between salivary adipocytokines and diet quality as well as physical activity with obesity could not be established and needs to be further investigated.

Conflicts of interest

No potential conflicts of interest were disclosed.

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CRediT authorship contribution statement

Amita Attlee: conception and design, acquisition of data, statistical analysis and interpretation of data; drafting and revising the article critically for important intellectual content; overall scientific management, obtained funding, study supervision. **Hayder Hasan:** Contribution: conception and design, acquisition of data, statistical analysis and interpretation of data; drafting and revising the article critically for important intellectual content; overall scientific management, obtained funding, study supervision. **Afra AlQattan:** Contribution: acquisition of data, analysis and interpretation of data; drafting the manuscript. **Nada Sarhan:** Contribution: acquisition of data, analysis and interpretation of data; drafting the manuscript. **Razan Alshammari:** Contribution: acquisition of data, analysis and interpretation of data; drafting the manuscript. **Shaikha Ali:** Contribution: acquisition of data, analysis and interpretation of data; drafting the manuscript. **Maryam Nabil:** Contribution: acquisition of data, analysis and interpretation of data; drafting the manuscript. **Alaa Alattrash:** Contribution: acquisition of data, analysis and interpretation of data; drafting the manuscript. **Veena Raigangar:** Contribution: conception and design, analysis and interpretation of data; drafting and revising the article critically for important intellectual content. **Mohamed Madkour:** Contribution: administrative and technical support in sample collection and laboratory analyses. **Hema Unnikannan:** Contribution: administrative and technical support in sample collection and laboratory analyses. **Samir Awadallah:** Contribution: analysis and interpretation of data; drafting and revising the article critically for important intellectual content.

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Appendix A. Supplementary data

Supplementary data related to this article can be found at https://doi.org/10.1016/j.dsx.2018.08.006.

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