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Association between Obesity, Hyperlipidemia, and Peri-Implant Tissue Health: A Systematic Review

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Abstract

Background: This systematic review aimed to evaluate the association between obesity and/or hyperlipidemia and peri-implant soft and hard tissue health, as well as inflammatory biomarker levels.

Methods: A systematic review was conducted in accordance with PRISMA guidelines. A comprehensive search was performed in MEDLINE (PubMed), Cochrane Library, EMBASE, and Scopus for studies published between December 2014 and December 2024. The time restriction was applied to ensure that included studies reflected contemporary implant protocols, standardized diagnostic criteria aligned with the 2017 World Workshop on Peri-Implant Diseases and Conditions, and current biomarker assessment methods; studies published before 2014 may not reflect current implant surface technologies or disease classification standards. Eligible studies included cohort and cross-sectional designs assessing peri-implant clinical parameters and inflammatory biomarkers in patients with obesity and/or hyperlipidemia. The included studies were predominantly observational and heterogeneous in design, exposure definitions, and outcome measurements, which limits the strength of the conclusions. Study quality was assessed using the Joanna Briggs Institute (JBI) Critical Appraisal Checklist.

Conclusions: Obesity and hyperlipidemia may be associated with less favorable peri-implant clinical parameters and increased inflammatory biomarker levels. However, due to the limited number of studies, their observational nature, and substantial heterogeneity, the findings should be interpreted with caution. Further well-designed longitudinal studies are required.

Keywords

Alveolar bone loss; Body mass index; Dental implants; Hyperlipidemias; Obesity.

Introduction

Dental implants have become an important aspect of modern dentistry, offering a long-lasting solution for replacing missing teeth [1]. The long-term success of dental implants relies heavily on the application of preventive measures and interventions to maintain peri-implant health, which is explained by stable bone levels, inflammat ion-free soft and hard tissues, and the absence of peri-implant diseases. These measures should be established before implant placement and consistently maintained throughout the patient's lifetime [2]. Systemic conditions such as obesity and hyperlipidaemia are gaining attention for their potential to influence peri-implant health and dental implant success [3]. By 2015, obesity had emerged as a major global health concern, affecting an estimated 603.7 million adults. Its prevalence has increased in the past few decades, and since 1980, obesity rates have doubled in more than 70 countries [4]. Excess body fat is associated with a persistent low-grade inflammatory state. The fat stored in hepatocytes and adipocytes encourages the release of inflammatory cytokines, including factor-alpha (TNF-α) and Interleukin-6 (IL-6), contributing to ongoing inflammation [5]. The degree of obesity is classified according to body mass index (BMI), a widely used metric to assess adult weight status. Body Mass Index (BMI) is determined by dividing a person's weight in kilograms by the square of their height in meters (kg/m^2). According to the World Health Organization (WHO), BMI is classified as follows: underweight (<18.5), normal weight (18.5–24.99), overweight (≥25), and obesity (≥30). Obesity is classified into three severity levels based on the risk of mortality: Class I (30–34.99, moderate risk), Class II (35–39.99, severe risk), and Class III (≥40, very severe risk). This classification is crucial to identify people who are at increased risk of health issues associated with abnormal weight [6]. An elevated BMI has been shown to contribute to approximately 4 million deaths globally, with nearly 40% of these deaths occurring in people who are classified as overweight rather than obese [4]. Hyperlipidaemia, on the other hand, is characterized by elevated levels of low-density lipoprotein (LDL), total cholesterol, triglycerides, or lipoproteins, and/or reduced levels of high-density lipoprotein (HDL) compared to the general population [7]. This condition has also been associated with increased levels of inflammatory cytokines in serum and gingival crevicular fluid (GCF), promoting a worse inflammatory state [8]. It is essential to distinguish between obesity and hyperlipidaemia, as they are related but do not always manifest together. Not all individuals with obesity are considered hyperlipidemic and vice versa [9].

Therefore, this systematic review aimed to evaluate the association between hyperlipidaemia and/or obesity and peri-implant tissue health in patients with existing functional dental implants by comparing individuals with and without these metabolic conditions.

Materials and Methods

Protocol and registration

This systematic review was conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines. The review protocol was registered in the PROSPERO database (**********).

The focused question was formulated according to the PICO framework, as presented in

Population (P)	Adult patients diagnosed with hyperlipidaemia and/or obesity with existing functional dental implants.
Intervention(I)	Assessment of peri-implant soft and hard tissue health and inflammatory biomarker levels (IL-1β, IL-6, and CRP) in patients with hyperlipidaemia and/or obesity.
Comparison(C)	Assessment of the same peri-implant parameters and biomarkers in patients without hyperlipidaemia and/or obesity (systemically healthy controls).
Outcomes(O)	The primary outcome was the evaluation of peri-implant soft and hard tissue health through clinical parameters, including bleeding on probing, probing depth, and marginal bone loss and the secondary outcome was the assessment of inflammatory biomarker levels (IL-1β, IL-6, and CRP).
Study Design(S)	Clinical trials, cohort studies, randomized controlled trials, and cross-sectional studies.

Table 1: PICOS.

Search strategy

A comprehensive electronic search was conducted in MEDLINE (PubMed), Cochrane Library, EMBASE, and Scopus for studies published between December 1, 2014, and December 1, 2024. The time restriction was applied to ensure that included studies reflected contemporary implant protocols, standardized diagnostic criteria (including those established at the 2017 World Workshop on Peri-Implant Diseases and Conditions), and current biomarker assessment methods. Studies published before 2014 are unlikely to align with current implant surface designs, loading protocols, or disease classification systems, reducing comparability with present-day clinical practice. The search strategy combined Medical Subject Headings (MeSH) and free-text terms related to dental implants, metabolic conditions (obesity and/or hyperlipidemia), and peri-implant health outcomes using Boolean operators (AND, OR). Within each concept, synonyms and related terms were combined with OR, and the three concepts were linked with AND. A representative PubMed search strategy is presented below: ("dental implants" OR "peri-implant") AND ("obesity" OR "body mass index" OR "BMI" OR "hyperlipidemia" OR "dyslipidemia") AND ("probing depth" OR "bleeding on probing" OR "marginal bone loss" OR "IL-1β" OR "IL-6" OR "CRP") The full database-specific search strategies are provided in (**Table 2**). Reference lists of included studies were manually screened to identify additional relevant studies.

Database	Full Search String
PubMed	("dental implants"[MeSH] OR "implant-supported"[Title/Abstract] OR "implantology"[Title/Abstract] OR "peri-implant"[Title/Abstract]) AND ("obesity"[MeSH] OR "obese"[Title/Abstract] OR "body mass index"[MeSH] OR "BMI"[Title/Abstract] OR "overweight"[MeSH] OR "hyperlipidemia"[Title/Abstract] OR "hyperlipidemias"[MeSH] OR "dyslipidemia"[Title/Abstract] OR "hypercholesterolemia"[MeSH] OR "hypertriglyceridemia"[Title/Abstract] OR "cholesterol"[MeSH] OR "cholesterol, LDL"[MeSH] OR "cholesterol, HDL"[MeSH] OR "cholesterol, VLDL"[MeSH]) AND ("peri-implant health"[Title/Abstract] OR "peri-implant tissue health"[Title/Abstract] OR "peri-implantitis"[Title/Abstract] OR "peri-implant diseases"[Title/Abstract] OR "marginal bone loss"[Title/Abstract] OR "bone resorption"[MeSH] OR "probing depth"[Title/Abstract] OR "bleeding on probing"[Title/Abstract] OR "biomarkers"[MeSH] OR biomarkers[Text Word] OR "cytokines"[MeSH] OR cytokines[Text Word] OR "inflammatory markers"[Text Word] OR "IL-1β"[Title/Abstract] OR "IL-6"[Title/Abstract] OR "C-Reactive Protein"[MeSH] OR "CRP"[Title/Abstract])

Cochrane Library	([MeSH descriptor: Dental Implants, explode all trees] OR "implant-supported" OR "implantology" OR "peri-implant") AND ([MeSH descriptor: Obesity, explode all trees] OR "obese" OR [MeSH descriptor: Body Mass Index, explode all trees] OR "BMI" OR "hyperlipidemia" OR [MeSH descriptor: Hyperlipidemias, explode all trees] OR "dyslipidemia" OR [MeSH descriptor: Hypercholesterolemia, explode all trees] OR "hypertriglyceridemia" OR [MeSH descriptor: Cholesterol, LDL, explode all trees] OR [MeSH descriptor: Cholesterol, HDL, explode all trees]) AND ("peri-implant health" OR "peri-implantitis" OR "marginal bone loss" OR "probing depth" OR "bleeding on probing" OR [MeSH descriptor: Biomarkers, explode all trees] OR [MeSH descriptor: Cytokines, explode all trees] OR "inflammatory markers" OR "IL-1β" OR "IL-6" OR [MeSH descriptor: C-Reactive Protein, explode all trees] OR "CRP")
EMBASE	('dental implant'/exp OR 'implant-supported':ab,ti OR 'implantology':ab,ti OR 'peri-implant':ab,ti) AND ('obesity'/exp OR 'obese':ab,ti OR 'body mass index'/exp OR 'BMI':ab,ti OR 'overweight'/exp OR 'hyperlipidemia'/exp OR 'dyslipidemia':ab,ti OR 'hypercholesterolemia'/exp OR 'hypertriglyceridemia':ab,ti OR 'low density lipoprotein'/exp OR 'high density lipoprotein'/exp) AND ('peri-implant health':ab,ti OR 'peri-implantitis':ab,ti OR 'marginal bone loss':ab,ti OR 'probing depth':ab,ti OR 'bleeding on probing':ab,ti OR 'biomarker'/exp OR 'cytokine'/exp OR 'inflammatory marker':ab,ti OR 'interleukin 1beta'/exp OR 'interleukin 6'/exp OR 'C reactive protein'/exp OR 'CRP':ab,ti) AND [2014–2024]/py AND [english]/lim
Scopus	(TITLE-ABS-KEY("dental implants" OR "implant-supported" OR "implantology" OR "peri-implant")) AND (TITLE-ABS-KEY("obesity" OR "obese" OR "body mass index" OR "BMI" OR "overweight" OR "hyperlipidemia" OR "dyslipidemia" OR "hypercholesterolemia" OR "hypertriglyceridemia" OR "cholesterol" OR "LDL" OR "HDL")) AND (TITLE-ABS-KEY("peri-implant health" OR "peri-implantitis" OR "peri-implant disease" OR "marginal bone loss" OR "probing depth" OR "bleeding on probing" OR "biomarkers" OR "cytokines" OR "inflammatory markers" OR "IL-1β" OR "IL-6" OR "C-reactive protein" OR "CRP")) AND PUBYEAR > 2013 AND PUBYEAR < 2025 AND LANGUAGE(english)

Table 2: Database-specific search strategies used in the electronic literature search.

Category	Inclusion Criteria	Exclusion Criteria
Publication language & date	Published in English between December 2014 and December 2024	Not published in English
Study design	RCTs, cohort studies, cross-sectional studies, case-control studies	Reviews, systematic reviews, meta-analyses, editorials, commentaries, case reports, conference abstracts
Population	Human adults (≥ 18 years) with functional dental implants	Participants under 18 years of age; pregnant patients
Obesity (Exposure)	BMI ≥ 30 kg/m² (WHO Class I–III)	Systemic conditions other than obesity or hyperlipidemia
Hyperlipidemia (Exposure)	Total cholesterol ≥ 200 mg/dL, LDL ≥ 130 mg/dL, triglycerides ≥ 150 mg/dL, or HDL < 40 mg/dL (men) / < 50 mg/dL (women)	-
Outcomes	At least one of: PD, BOP, MBL, IL-1β, IL-6, or CRP	No relevant peri-implant outcome reported
Sample size	Minimum 10 participants	-
Other		Animal studies; retracted articles

Table 3: Inclusion and Exclusion Criteria.

Data extraction

Data extraction was performed independently and in duplicate by two reviewers (L.B. and L.P.) using a pre-piloted standardized extraction form. Discrepancies were resolved through discussion; when agreement could not be reached, a third reviewer (G.J.) was consulted. The following data were extracted from each included study: study characteristics (author, year, country, study design, sample size, follow-up duration), patient demographics (age, sex), implant-related variables (number, type, location), metabolic parameters (BMI values and lipid profiles), clinical peri-implant outcomes (probing depth, bleeding on probing, marginal bone loss), and inflammatory biomarkers (IL-1β, IL-6, CRP).

Clinical parameters were extracted as reported in the original studies without recalculation. PD was recorded as mean values per implant site. BOP was recorded as reported by each study - either as a percentage of bleeding sites or as a mean score per implant - and the reporting format was noted for each study. MBL was recorded as the mean radiographic bone loss in millimetres. Inflammatory biomarkers were extracted alongside the sample type used (saliva, serum, or peri-implant crevicular fluid), since differences in sample source preclude direct comparison across studies.

When a patient had multiple implants, patient-level mean values were used where available. When only implant-level or site-level data were reported, these were extracted as provided by the original authors and noted accordingly. For cohort studies reporting data at multiple timepoints, data from the longest available follow-up were extracted to represent the most comprehensive outcome data. Cross-sectional studies do not incorporate a follow-up period; therefore, data were extracted from the single reported assessment time point.

Outcomes of interest

The primary outcomes were peri-implant clinical parameters, including PD, BOP, and MBL, reflecting peri-implant soft and hard tissue health. The secondary outcomes were inflammatory biomarkers, including IL-1β, interleukin-6, and CRP, measured in saliva, serum, or peri-implant crevicular fluid.

Study selection process

Study selection was conducted in several sequential stages following PRISMA guidelines [10]. Initially, records were identified through electronic searches of four databases (MEDLINE/PubMed, Cochrane Library, EMBASE, and Scopus) using predefined keywords and Boolean combinations (**Table 2**). Additional records were identified through manual screening of the reference lists of all included studies. Duplicate records were removed both automatically and manually before screening. Following deduplication, titles and abstracts were independently screened by two reviewers (L.B. and L.P.) using an online screening tool (Rayyan®, Qatar Computing Research Institute, HBKU, Doha, Qatar). Full-text articles of all potentially eligible studies were subsequently retrieved and independently assessed by both reviewers against the predefined eligibility criteria. Disagreements at any stage were resolved through discussion between the two reviewers or, where consensus could not be reached, by consultation with a third reviewer (G.J.). Inter-reviewer agreement was assessed using Cohen's kappa coefficient (k) at both the title and abstract screening stage and the full-text assessment stage.

Risk of bias across studies

The methodological quality of the included studies was assessed using the Joanna Briggs Institute (JBI) Critical Appraisal Checklists for cohort and analytical cross-sectional studies [11]. Each criterion was rated as “yes”, “no”, “unclear”, or “not applicable”. The overall methodological quality of each study was categorized based on the proportion of positive responses, as follows: low risk of bias (>70% positive responses), moderate risk of bias (50–69%), and high risk of bias (<50%). The results of the risk-of-bias assessment were explicitly incorporated into the interpretation of findings. Studies with specific methodological weaknesses, such as absence of confounding control or unclear exposure definitions, were given reduced interpretive weight, and conclusions were formulated with appropriate caution to reflect the limitations of the available evidence.

Data synthesis

Due to clinical and methodological heterogeneity among the included studies, a meta-analysis was not performed. Variability in study design, definitions of obesity and hyperlipidemia, implant characteristics, and outcome measurements precluded quantitative pooling of the data. Therefore, the results were synthesized qualitatively. Extracted data were organized and summarized in tables.

(**Table 4**) presents the general characteristics of the included studies, including author, year of publication, study design, sample size, follow-up duration, and patient demographics. (**Table 7**) summarizes implant-related variables and peri-implant clinical outcomes, including PD, BOP, and MBL, while inflammatory biomarker data (IL-1β, IL-6, and CRP) are presented separately in (**Table 8**). The risk-of-bias assessment findings were explicitly incorporated into the interpretation of results. Given that five of six studies were classified as good quality and one as moderate quality, and that all included studies were observational with inherent susceptibility to confounding, the reported associations should be interpreted as indicative rather than conclusive. The predominance of cross-sectional designs, combined with incomplete control of confounders such as smoking, diabetes, and oral hygiene practices, limits the ability to draw causal inferences.

Results

Search results and study selection

A total of 71 records were initially identified through electronic database searches (MEDLINE/PubMed: n = 49, Cochrane Library: n = 2, EMBASE: n = 12, Scopus: n = 8). After the removal of 2 duplicate records, 69 articles remained for screening. Following title and abstract screening, 44 records were excluded as they did not meet the predefined inclusion criteria. Consequently, 25 full-text articles were assessed for eligibility. After full-text evaluation, 19 studies were excluded for the following reasons: seven were animal studies [12–18], one was a non-English publication [19], one was a case series [20], one had no accessible full text [21], one was a retracted article [22],], and eight did not meet the inclusion criteria [23–30]. Finally, six studies fulfilled all eligibility criteria and were included in this systematic review (Figure 1). Notably, no RCTs were identified; all included studies were observational in design. Inter-reviewer agreement between the two reviewers (L.B. and L.P.) was high, with Cohen's kappa coefficients of k = 0.90 for title and abstract screening and k = 1.00 for full-text assessment, indicating excellent agreement.

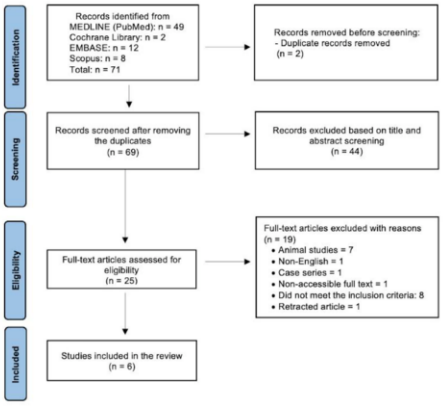


Figure 1: PRISMA 2020 flow diagram of the study selection process.

Quality assessment of the included studies

The quality of methodological studies was assessed using the JBI critical appraisal checklist for cohort and cross-sectional studies [11]. The evaluations for each study are presented in (**Tables 5 and 6**). All studies were of good quality except one [36], which was rated as moderate quality.

Study characteristics

The main study characteristics of the included articles are summarized in (**Table 4**). The included studies consisted of one prospective cohort study [33], one retrospective cohort study [35], and four cross-sectional studies [31,32,34,36]. A total of 374 patients were included across all studies.

Author	Year	Follow-up	Study design	Patients (n)			Age (y[mean])		Gender (n, males/females)	
				Total	Test group	Control group	Test group	Control group	Test group	Control group
Abduljabbar T. et al. Vohra et al. [32]	2016	NR	Cross-sectional study	72	35	37	44.05 (35.4–54.7) Group 1: 49.3 (42–56) Group 2: 51.8 (40–54) Group 3: 50.4 (45-59)	43.1 (33.7–52.5) Group 4: 52.1 (39-58)	35/0	37/0
	2017	NR	Cross-sectional study	84	59	25			NR	NR
Alkhudhairy et al. [33]	2018	1 year, 2 years, 5 years	Prospective cohort study	38	20	18	48.6 (41-55)	52.6 (42-57)	8-Dec	8-Oct
Alasqah et al. [34]	2018	NR	Cross-sectional study	50	25	25	61 ± 9.9	59 ± 9.2	13/12	14/11
Alshiddi et al. [35]	2019	1-year, 3-year	Retrospective Cohort study	70	35	35	47.6 (32-54)	44.3 (35-57)	35/0	35/0
Mehta R et al. [36]	2023	NR	Cross-sectional study	60	40	20	Group A: 51.3 Group B: 50.9	Group C: 48.3	Group A: 8-Dec Group B: 13/7	Group C: 8-Dec

Table 4: Characteristics of the included studies.

Group A = mean BMI of 33.7 kg/m², Group B = mean BMI of 37.9 kg/m², Group C = mean BMI of 23.1 kg/m², Group 1 = mean BMI of 32.2 kg/m², Group 2 = mean BMI of 38.8 kg/m², Group 3 = mean BMI of 44.3 kg/m², Group 4 = mean BMI of 21.1 kg/m². Data are presented as n (males/females). NR = not reported.

Author	Year of publication	Study design	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11
Alkhudhairy et al. [33]	2018	Prospective cohort study	+	+	+	+	+	+	+	+	+	-	+

Alshiddi et al. [35]	2019	Retrospective Cohort study	+	+	+	+	+	+	+	+	+	?	+

Table 5: Results of cohort studies from the Joanna Briggs Institute Critical Appraisal Checklist.

Abbreviations: N/A = Not applicable, ? = Unclear, + = Yes, - =

Author	Year of publication	Study design	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8
Abduljabbar T. et al. [31]	2016	Cross-sectional study	+	+	+	+	?	-	+	+
Vohra et al. [32]	2017	Cross-sectional study	+	+	+	+	+	+	+	+
Alasqah et al. [34]	2018	Cross-sectional study	+	+	+	+	+	-	+	+
Mehta R et al. [36]	2023	Cross-sectional study	+	+	+	+	-	-	+	+

Table 6: Results of cross-sectional studies from the Joanna Briggs Institute Critical Appraisal Checklist.

Abbreviations: N/A = Not applicable, ? = Unclear, + = Yes, - = No

Follow-up (months)

Four of the six included studies were cross-sectional in design and therefore did not include a follow-up period; data from these studies were extracted from the single reported assessment timepoint. The remaining two studies [33,35] employed longitudinal cohort designs and provided follow-up data at multiple timepoints, with maximum durations of 60 months and 36 months, respectively. For these longitudinal studies, data from the longest available observation period were extracted to represent the most comprehensive long-term outcomes available. In studies reporting multiple follow-up timepoints, data from the latest available follow-up period were extracted, as specified in the data extraction protocol

Probing depth

All six studies evaluated PD in obese and/or hyperlipidemic patients compared with normal-weight controls (**Table 7**). Four studies [31-33,36] reported statistically significant increases in PD, while two [34,35] observed non-significant differences. These findings collectively suggest that obesity and/or hyperlipidemia may be associated with increased peri-implant probing depth.

Author	Site of dental implant	Type of dental implant	Obesity parameters (Mean BMI)		Hyperlipidaemia parameters		Follow-up (months)	PD (mm)		BOP (%/present/absent)		MBL (mm)	
			Test group	Control group	Test group	Control group		Test group	Control group	Test group	Control group	Test group	Control group

Abduljabbar et al. [31]	Maxilla / Mandible (premolar and molar region)	ITI Straumann, Moderately rough surfaces	36.2 kg/m²	24.3 kg/m²	NR	NR	NR	4.4 (SD 2.1-5.3) *(p < 0.05)*	2.1 (SD 1.8-2.5)	28.2 (SD 16.5-33.4) *(p < 0.05)*	10.1 (SD 4.5-15.1)	3.4 (SD 2.5-4.7) *(p < 0.05)*	0.8 (SD 0-2.4)
Vohra et al. [32]	Maxilla / Mandible	NR	Group 1: 32.2 Group 2: 38.8 Group 3: 44.3	Group 4: 21.1	Group 1: LDL (mg/dl): 105 ± 21 HDL (mg/dl): 41 ± 7 Total Cholesterol (mg/dL): 195 ± 37 Triglyceride (mg/dL): 156 ± 22 Group 2: LDL (mg/dl): 108 ± 24 HDL (mg/dl): 43 ± 6	Group 4: LDL (mg/dl): 101 ± 22 HDL (mg/dl): 41 ± 6 Total Cholesterol (mg/dL): 178 ± 28 Triglyceride (mg/dL): 140 ± 17	NR	Group 1: 2.4 (SD 1.9-2.8) *(p < 0.05* vs G2, G3, G4) Group 2: 3.1 (SD 2.7-3.8) *(p < 0.05* vs G1, G4) Group 3: 3.6 (SD 2.3-4.1)	Group 4: 1.2 (SD 0.6-2.0)	Group 1: 19.1 (SD 13.4-22.4) *(p < 0.05* vs G2, G3, G4) Group 2: 25.4 (SD 16.7-32.5) *(p < 0.05* vs G1, G4) Group 3: 27.8 (24.3 - 32.8)	Group 4: 11.7 (SD 5.1-14.6)	Group 1: 1.8 (SD 1.9-3.3) *(p < 0.05* vs G2, G3, G4) Group 2: 2.6 (SD 2.4-4.5) *(p < 0.05* vs G1, G4) Group 3: 2.7 (SD 3.3-5.1)	Group 4: 0.9 (SD 0-2.5)

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					Total								
					Cholesterol								
					(mg/dL):								
					199 ± 37								
					Triglyceride (mg/dL):								
					165 ± 22								
					Group 3:								
					LDL (mg/dl):								
					116 ± 24								
					(p < 0.05 vs G4)								
					HDL (mg/dl):								
					45 ± 6								
					Total								
					Cholesterol								
					(mg/dL):								
					209 ± 44								
					(P < 0.05 vs G4)								
					Triglyceride (mg/dL):								
					178 ± 28								
					(p < 0.05 vs G4)								
Alkhudhairy et al.	Posterior Maxilla /		33.2	21.1	LDL (mg/dl):	LDL (mg/dl):		3.69 ± 0.22		0.78 ± 0.06		0.91 ± 0.17	
[33]	Mandible		kg/m²	kg/m²	109 ± 21	94 ± 21		*(p < 0.01)*		*(p < 0.01*		*(p < 0.01)*	
		Straumann Bone Level Implants			*(p < 0.05)*		60 months		2.46 ± 0.18		0.57 ± 0.07		0.55 ± 0.18
						HDL (mg/dl):							
						42 ± 6							
					HDL (mg/dl):								
					43 ± 8	Total							
					(NS)	Cholesterol							

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						(mg/dL):						
					Total	179 ± 29						
					Cholesterol							
					(mg/dL):	Triglyceride (mg/dL):						
					194 ± 36	139 ± 16						
					(p < 0.05)							
					Triglyceride (mg/dL):							
					164 ± 21							
					(p < 0.05)							
Alasqah et al.	Maxilla /				LDL (mg/dl):	LDL (mg/dl):		2.6 ± 0.18		29.3 ± 11.5		1.9 ± 0.1	
[34]	Mandible				108 ± 22	92 ± 21		(NS)		*(p = 0.017)*		*(p = 0.022)*	
					(p = 0.043)								
						HDL (mg/dl):							
					HDL (mg/dl):	41 ± 5							
					44 ± 7								
					(NS)	Total							
						Cholesterol							
		NR	36.8 kg/m²	23.6 kg/m²	Total Cholesterol	(mg/dL):	NR		2.3 ± 0.21		13.7 ± 3.6		0.7 ± 0.3
					(mg/dL):	173 ± 30							
					196 ± 34								
					(p = 0.015)	Triglyceride (mg/dL):							
						133 ± 17							
					Triglyceride: (mg/dL):								
					167 ± 25								
					(p = 0.012)								
Alshiddi et al.	Anterior	Narrow and			NR	NR		(NDIs)	(NDIs)	(NDIs)	(NDIs)	(NDIs)	(NDIs)

	Maxilla /	Standard Diameter											
[35]	Mandible							2.87 ± 0.23	2.23 ± 0.19	0.39 ± 0.04	0.29 ± 0.05	0.45 ± 0.20	0.36 ± 0.12
			34.7 kg/m²	22.8 kg/m²			36 months	*(p = NS)*	(SDIs)	*(p < 0.05)*	(SDIs)	(p > 0.05)	(SDIs)
								(SDIs)	2.46 ± 0.23	(SDIs)	0.28 ± 0.04	(SDIs)	0.40 ± 0.21
								3.11 ± 0.22		0.44 ± 0.06		0.50 ± 0.16	
								(p = NS)		*(p < 0.05)*		*(p > 0.05)*	
Mehta et al.	Posterior Mandible	NR	Group A: 33.7 kg/m²	Group C: 23.1 kg/m²	NR	NR	NR	Group A:	Group C: 1.3	NR	NR	Group A:	Group C:
[36]								2.9				2.1	0.8
			Group B: 37.9 kg/m²					*(p < 0.0000)*				*(p < 0.0000)*	
								Group B:				Group B:	
								3.2				2.7	
								(p < 0.0000)				*(p < 0.0000)*	

Table 7: Studies characteristics and clinical parameters.

NR= not recorded, mg/dL= milligrams per decilitre, PD = probing depth, BOP = bleeding on probing, MBL = marginal bone loss, NDIs = narrow diameter implants, SDIs = standard diameter implants, NS = Not Significant, CRP = C-reactive protein, IL-1β = interleukin-1β, IL-6 = interleukin-6, mg/L = milligrams per litter, pg/mL = picograms per millilitre. Group A = mean BMI of 33.7 kg/m², Group B = mean BMI of 37.9 kg/m², Group C = mean BMI of 23.1 kg/m², Group 1 = mean BMI of 32.2 kg/m², Group 2 = mean BMI of 38.8 kg/m², Group 3 = mean BMI of 44.3 kg/m², Group 4 = mean BMI of 21.1 kg/m².

Bleeding on probing

Five studies [31–35] evaluated BOP in obese and/or hyperlipidemic patients compared with normal-weight controls (**Table 7**). Despite differences in reporting formats - some presenting the percentage of bleeding sites and others using mean values per implant site - all studies observed higher BOP in the test groups. Five studies [31–35] found statistically significant increases in BOP. Overall, the findings indicate that obesity and hyperlipidemia are generally associated with greater peri-implant bleeding tendency compared with healthy controls.

Marginal bone loss

All six studies evaluated MBL in obese and/or hyperlipidemic patients compared with normal-weight controls (**Table 7**). In every study, the test groups showed greater mean bone loss, although the degree and statistical significance varied. Taken together, these results indicate a consistent trend toward increased peri-implant bone loss in patients with metabolic disorders such as obesity and/or hyperlipidemia, but the evidence should be interpreted cautiously given the heterogeneity of study designs and outcome assessments.

Inflammatory biomarkers

Four studies evaluated inflammatory markers, but the samples used to measure them differed - saliva, blood (serum), and peri-implant crevicular fluid (PICF). This variation limited direct comparison between studies (**Table 8**). Two studies [31,34] measuring local samples (saliva or PICF) reported significantly higher IL-1β and IL-6 levels in obese or hyperlipidemic patients compared with controls (all $p < 0.001$), suggesting increased local peri-implant inflammatory activity. In contrast, the two studies that assessed systemic inflammation through serum CRP [32,36] also found higher CRP levels in the test groups, but the differences were smaller and one study [36] showed relatively high baseline CRP in controls.

Author	Biomarkers assessed	Sample type	Inflammatory biomarkers	
			Test group	Control group
Abduljabbar et al. [31]	IL-1β, IL-6	Saliva	IL-1β (pg/mL): 2462.7 (SD 1947.5– 2964.4) *(p < 0.001)* IL-6 (pg/mL): 361.3 (SD 300.5–406.2) *(p < 0.001)*	IL-1β (pg/mL): 1088.3 (SD 845.6– 1258.4) IL-6 (pg/mL): 133.2 (SD 108.6–144.6)
Vohra et al. [32]	CRP	Blood	Group 1: CRP (mg/L): 3.18 (SD 2.65–3.34) Group 2: CRP (mg/L): 3.34 (SD 2.97–3.89) Group 3: CRP (mg/L): 3.97 (SD 3.85–4.16) *(p < 0.05* vs G1, G2, G4)	Group 4: CRP (mg/L): 2.56 (SD 1.77–2.83)
Alkhudhairy et al. [33]	NR	NR	NR	NR
Alasqah et al. [34]	IL-1β, IL-6	PICF	IL-1β (pg/mL): 284.82 ± 27.8 *(p < 0.001)* IL-6 (pg/mL): 2697.5 ± 101.6 *(p < 0.001)*	IL-1β (pg/mL): 158.73 ± 23.9 IL-6 (pg/mL): 1359 ± 88.4
Alshiddi et al. [35]	NR	NR	NR	NR
Mehta et al. [36]	CRP	Blood	CRP (mg/L): Group A: 3.28 (SD 0.82) *(p < 0.0001)* CRP (mg/L): Group B:	CRP (mg/L): Group C: 3.61 (SD 0.51)

			3.65 (SD 0.95)	

Table 8: Inflammatory biomarkers.

Discussion

This review investigated the potential association between obesity and hyperlipidaemia and peri-implant soft and hard tissue health. Six [31-36] articles were analysed to evaluate these associations. Each included a test group with obesity and/or hyperlipidaemia and a control group without these conditions. A clinical comparison of BOP, PD, and MBL was made to assess differences between the groups, along with an evaluation of inflammatory biomarkers, to determine their potential association with these conditions.

The findings of this review suggest a possible association between obesity and/or hyperlipidaemia and peri-implant soft and hard tissue changes. The first clinical parameter assessed was PD. Monje and Salvi [37] demonstrated that, unlike natural teeth, the anatomy of peri-implant tissues characterized by the absence of periodontal ligament and the parallel/circumferential orientation of collagen fibers along the implant's long axis, makes probing depth measurements more complex. A healthy peri-implant sulcus typically measures around 1-3 mm, but variations can occur depending on the implant type, prosthetic design, and tissue biotype.

All studies in this review [31–36] reported greater peri-implant probing depths in obese and/or hyperlipidemic patients compared with controls, with differences reaching up to approximately 2.4 mm. However, not all studies demonstrated statistically significant differences (**Table 7**). This aligns with Wang et al. [38] which found indirectly that PD were deeper in obese and/or hyperlipidemic individuals. The observed association between obesity, hyperlipidaemia, and increased probing depth may be related to the chronic low-grade inflammatory state frequently reported in these metabolic conditions, which has been associated with increased cytokine production and altered immune responses. This information is further supported by the reviewed studies, which generally reported higher levels of inflammatory biomarkers, including IL-1β, IL-6, and CRP, in the test groups compared with controls [31–36]. These findings suggest that deeper probing depths observed in obese and/or hyperlipidemic patients may be associated with chronic low-grade systemic inflammation and increased cytokine activity. However, given the observational nature of the included studies, a causal relationship cannot be established. Studies have shown that elevated levels of IL-1β and IL-6 are strongly associated with peri-implant inflammation. Additionally, recent findings by Ustaoğlu and Erdal [39] found that triglyceride levels were significantly higher in the peri-implantitis group compared to controls. Their study revealed a positive correlation between triglyceride levels and peri-implant parameters such as PD and BOP, suggesting that lipid metabolism disturbances contribute to peri-implant disease independently of BMI. Gündoğar and Uzunkaya [40] and Song et al. [41] reported that patients with peri-implantitis exhibited significantly higher levels of IL-1β and IL-6 in peri-implant crevicular fluid compared to healthy implant sites, suggesting

that persistent systemic inflammation may be associated with increased local cytokine activity in peri-implant tissues and with peri-implant soft tissue changes.

A similar pattern was observed when evaluating bleeding on probing (BOP). Five [31-35] studies in this systematic review reported higher BOP in the test group, generally reaching statistical significance (**Table 7**). This information aligns with Sales-peres et al. [42] who reported that obese patients were found to have higher bleeding index when probing teeth compared to non-obese patients. The study of Jepsen et al. [43] highlights the importance of the assessment of BOP, they found that at implant sites the presence of BOP is a clear sign of inflammation, and its occurrence becomes more frequent and pronounced as the condition worsens. On the other hand, the absence of BOP is a strong indication that the peri-implant tissues are stable and healthy. While BOP serves as an important clinical marker, its reliability can be influenced by factors which are related to the patient and the dentist. On the patient's side, oral hygiene habits, smoking, body weight, and serum lipid levels can influence the situation. From the other side, the dentist-related factors may alter the bleeding tendencies. Dukka et al. [44] found that the presence of BOP is highly dependent on the angulation and force applied during probing, with its frequency increasing as probing pressure intensifies and improper angulation is used.

Another key inflammatory marker assessed was C-reactive protein (CRP). Li et al. [53] stated that CRP is the most strongly associated inflammatory biomarker with obesity. Two of the studies [32], [36] included in this review specifically examined CRP levels. Vohra et al. [32] observed that CRP levels increase proportionally with BMI. In contrast, Mehta et al. [36] reported a higher level of CRP in the control group, diverging from the expected pattern.

While the reviewed studies provide valuable insights into the possible association between obesity and hyperlipidaemia and peri-implant tissue health, several limitations must be acknowledged. First, all included studies were observational (four cross-sectional and two cohort studies), making it impossible to establish causality. Cross-sectional studies in particular capture only a single point in time and cannot determine the temporal relationship between metabolic status and peri-implant outcomes. Furthermore, the risk-of-bias assessment revealed that, while most studies were of good methodological quality, all were susceptible to confounding from factors not consistently controlled across studies. A lack of RCTs substantially weakens the strength of evidence, as observational studies are inherently prone to selection bias and residual confounding. Additionally, important confounders such as smoking, diabetes, systemic medication use, and oral hygiene practices were not consistently controlled across all studies, potentially influencing the reported associations. Variability in measurement techniques also presents a challenge, as probing depth and bleeding on probing are operator-dependent and can be influenced by angulation, pressure, and probe design. Furthermore, differences in study populations, including variations in BMI classification, metabolic status, and genetic predispositions, may have contributed to heterogeneity in the findings. This is particularly relevant because BMI alone may not accurately reflect metabolic health, as lean individuals can exhibit metabolic abnormalities while some obese individuals remain metabolically healthy. Notably, Mehta et al. [36] reported an unexpected pattern in CRP levels, suggesting that systemic inflammatory markers may be influenced by additional, yet unidentified, factors beyond obesity alone. Another limitation is that most of the studies were cross-sectional and no follow-up was presented which

may not fully capture the long-term effects of obesity and hyperlipidaemia on peri-implant health. Longitudinal studies with extended follow-up periods are necessary to determine the true impact on implant survival and stability.

Future research should focus on well-controlled, longitudinal studies with standardized methodologies to confirm these associations, minimize bias, and explore the underlying mechanisms in greater detail. Although the available evidence suggests a possible association between obesity, hyperlipidaemia, and adverse peri-implant clinical parameters, the findings should be interpreted with caution. The included studies were predominantly observational and cross-sectional, limiting causal inference and increasing susceptibility to residual confounding. Heterogeneity in study design, participant characteristics, and definitions of obesity and hyperlipidaemia, and outcome assessment methods may have further influenced the reported findings. Clinicians should be aware of the potential association between metabolic disorders and peri-implant tissue health; however, the current evidence is insufficient to support specific clinical recommendations or management protocols based solely on obesity or hyperlipidaemia status. Future well-designed longitudinal studies with standardized diagnostic criteria, outcome measures, and adequate control of confounding factors are needed to clarify these associations and determine whether these metabolic conditions influence long-term implant outcomes.

Conclusions

The included studies generally reported less favourable peri-implant clinical parameters in patients with obesity and hyperlipidemia, including greater PD, BOP, and MBL, compared with healthy controls. Several studies also reported elevated levels of inflammatory biomarkers (IL-1β, IL-6, and CRP) in saliva, serum, or peri-implant crevicular fluid among metabolically affected individuals, supporting a possible association between systemic low-grade inflammation and peri-implant tissue response. A tendency toward greater peri-implant deterioration with increasing BMI was noted in some studies; however, this association was not consistent across all findings. Overall, the available evidence suggests a possible association between metabolic disorders and less favourable peri-implant outcomes. However, given the predominantly observational and cross-sectional nature of the included studies, the findings should be interpreted with caution. Further well-controlled longitudinal studies with standardized methodologies are required to clarify these associations and their potential clinical significance.

Conflicts of interests

The authors report no conflicts of interest related to this study.

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