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# Association between Body Mass Index and Gingival Inflammation Assessed by the Papillary Bleeding Index: Implications for Systemic Health Profiling

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## Abstract

Body Mass Index (BMI) is widely used as an indicator of systemic health and has been linked to inflammatory conditions. Gingival inflammation, which can be clinically assessed using the Papillary Bleeding Index (PBI), represents an early manifestation of periodontal inflammatory response and may reflect broader systemic health status. This study aimed to evaluate the relationship between Body Mass Index and gingival inflammation measured by the Papillary Bleeding Index among patients attending a dental teaching hospital. An observational analytic study with a cross-sectional design was conducted at the periodontology clinic of a dental teaching hospital in Indonesia. Body Mass Index was determined using standard anthropometric measurements and categorized according to the WHO Asia–Pacific classification. Gingival inflammation was assessed using the Papillary Bleeding Index based on Saxer and Mühlemann's criteria. Data were analyzed using Spearman's correlation test. The analysis demonstrated no statistically significant association between Body Mass Index and Papillary Bleeding Index ($r = -0.116$; $p = 0.249$). Although descriptive findings showed variation in gingival bleeding scores across different Body Mass Index categories, these differences did not reach statistical significance. The findings indicate that Body Mass Index was not significantly associated with gingival inflammation as assessed by the Papillary Bleeding Index in this study population. This suggests that body mass alone may not directly influence gingival inflammatory status in clinical dental settings. Nevertheless, they indice remain relevant descriptors of systemic and oral health and may provide contextual information for population-based and forensic-oriented health alongside with other biological parameters.

**Keywords:** Body mass index; Papillary bleeding index; Gingival inflammation; Periodontal health; Obesity; Cross-sectional study; Systemic health profiling; Dental hospital

## 1. Introduction

Body Mass Index (BMI) is a widely applied anthropometric indicator used to describe nutritional status and systemic health conditions. Abnormal BMI, particularly overweight and obesity, has been associated with chronic low-grade inflammation and an increased risk of various non-communicable diseases [1]. In recent years, increasing attention has been directed toward the influence of systemic metabolic conditions on oral health, especially periodontal tissues, which are highly sensitive to inflammatory changes [2].

Periodontal diseases are multifactorial inflammatory conditions primarily initiated by dental plaque but strongly influenced by host-related factors, including systemic health status. Gingival inflammation represents an early and reversible stage of periodontal disease and can be clinically assessed through bleeding responses during periodontal

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probing. The Papillary Bleeding Index (PBI), introduced by Saxer and Mühlemann, is a sensitive and practical clinical indicator for evaluating gingival inflammatory status based on the intensity of bleeding from the interdental papillae [5]. Due to its simplicity and reproducibility, PBI is frequently applied in both clinical practice and epidemiological studies [6].

Several studies have demonstrated an association between increased BMI and periodontal inflammation. Excess adipose tissue functions as an active endocrine organ capable of producing pro-inflammatory mediators such as tumor necrosis factor-α, interleukin-6, and leptin, which may exacerbate inflammatory responses in periodontal tissues [3]. Systematic reviews and cross-sectional studies have reported a higher prevalence and severity of periodontal disease among overweight and obese individuals compared with those with normal body weight [2,4]. Nevertheless, inconsistencies remain across studies, possibly due to differences in population characteristics, oral hygiene status, and methodological approaches.

From a broader perspective, oral inflammatory parameters such as gingival bleeding may reflect underlying systemic health conditions at the population level. Indicators such as BMI and PBI can therefore be interpreted not only as clinical periodontal parameters but also as components of biological health profiling [7]. This concept is relevant in public health surveillance and may provide supportive contextual information in forensic-oriented assessments, where systemic and oral health characteristics contribute to the reconstruction of biological profiles of individuals or populations [9, 10].

Despite growing interest in the relationship between systemic conditions and periodontal health, data derived from dental hospital-based populations in Indonesia remain limited. Therefore, this study aimed to analyze the association between Body Mass Index and gingival inflammation assessed by the Papillary Bleeding Index among patients attending a dental teaching hospital. Understanding this relationship may contribute to a more comprehensive interpretation of oral inflammatory indicators in relation to systemic health status.

## 2. Material and methods

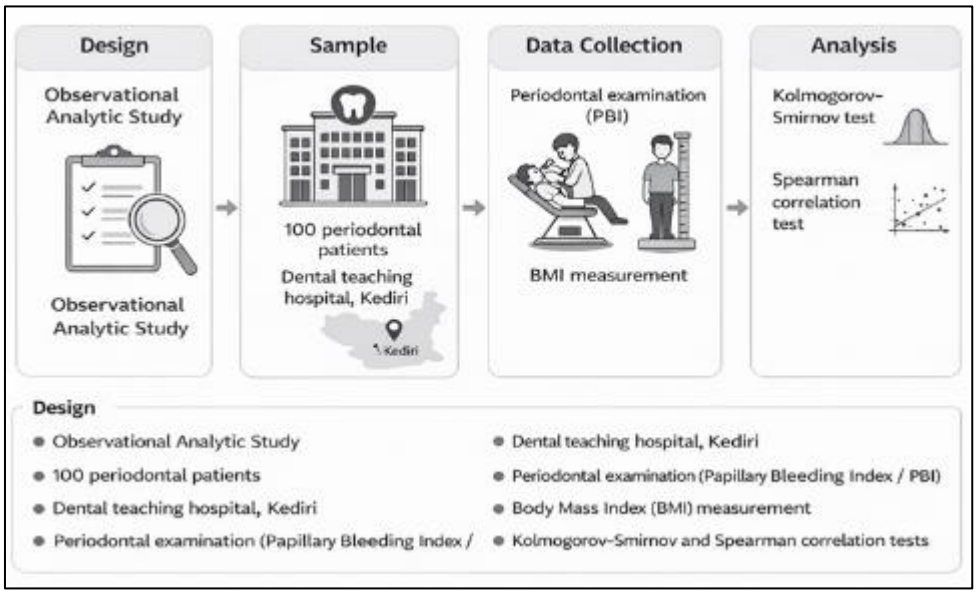


**Figure 1** Graphical abstract showing the material and methods of Papillary Bleeding Index scores across Body Mass Index values among study participants

### 2.1. Study Design and Setting

This study employed an observational analytic design with a cross-sectional approach. The research was conducted at the Periodontology Clinic of a dental teaching hospital in Indonesia (please see figure 1). Data collection was carried out over a one-month period in July 2024.

### 2.2. Study Population and Sample

The study population consisted of patients attending the periodontology clinic during the study period (see figure 1). The sample size was determined using the Lemeshow formula for an unknown population, with a confidence level of 95% and a margin of error of 10%, resulting in a minimum required sample of 96 participants. To account for potential data incompleteness, the sample size was rounded up to 100 patients. Participants were selected using a non-probability sampling technique with an accidental sampling method, whereby eligible patients encountered during the study period were invited to participate.

### 2.3. Inclusion and Exclusion Criteria

Inclusion criteria were patients attending the periodontology clinic, having complete dental medical records, and providing written informed consent. Exclusion criteria included patients with incomplete medical records, systemic conditions that could significantly influence Body Mass Index or gingival bleeding status, pregnant patients, professional athletes or bodybuilders, and patients who had recently undergone periodontal treatment that could affect Papillary Bleeding Index scores.

### 2.4. Variables of the Study

The independent variable in this study was Body Mass Index, while the dependent variable was gingival inflammation assessed using the Papillary Bleeding Index.

### 2.5. Measurement of Body Mass Index

Body Mass Index was calculated by dividing body weight in kilograms by the square of height in meters ($kg/m^2$). Body weight was measured using a digital weighing scale, and height was measured using a stature meter. Measurements were performed with participants standing upright, barefoot, and wearing light clothing. Body Mass Index values were classified according to the World Health Organization Asia–Pacific criteria into underweight, normal, overweight, and obese categories [8].

### 2.6. Assessment of Gingival Inflammation

Gingival inflammation was assessed using the Papillary Bleeding Index based on the criteria proposed by Saxer and Mühlemann [5]. Periodontal probing was performed gently at the interdental papillae of index teeth using a periodontal probe. Bleeding intensity was scored on a scale from 0 to 4, ranging from no bleeding to excessive bleeding immediately after probing. The Papillary Bleeding Index score for each participant was obtained by averaging the bleeding scores across the examined sites.

### 2.7. Data Collection Procedure

Eligible participants were identified based on inclusion and exclusion criteria (see figure 1). After obtaining informed consent, demographic and clinical data were collected from medical records. Anthropometric measurements were then performed to calculate Body Mass Index, followed by periodontal examination to assess Papillary Bleeding Index scores. All measurements were conducted by trained personnel to ensure consistency.

### 2.8. Statistical Analysis

Data were processed and analyzed using Statistical Package for the Social Sciences (SPSS) (see figure 1). Descriptive statistics were used to summarize participant characteristics. Normality of data distribution was assessed using the Kolmogorov–Smirnov test, followed by a homogeneity test using Levene's test. Correlation analysis between Body Mass Index and Papillary Bleeding Index was performed using Pearson's correlation test for normally distributed data or Spearman's rank correlation test for non-normally distributed data. A p-value of less than 0.05 was considered statistically significant.

## 3. Results and discussion

A total of 100 patients attending the periodontology clinic of a dental teaching hospital were included in this study. The study was conducted from October to November 2024. Participants were undergoing periodontal treatment at the time of data collection.

### 3.1. Demographic Characteristics

**Table 1** Distribution of Participants by Age Group

| No. | Age | Frequency | Percentage |
|---|---|---|---|
| 1 | 20-50 years | 98 | 98% |
| 2 | > 50 years | 2 | 2% |
| 3 | Total | 100 | 100% |

**Table 2** Distribution of Participants by Sex

| No. | Sex | Frequency | Percentage |
|---|---|---|---|
| 1 | Women | 53 | 53% |
| 2 | Men | 47 | 47% |
| 3 | Total | 100 | 100% |

The majority of participants were aged between 20 and 50 years (98%), while only 2% were older than 50 years (see table 1). Female participants accounted for 53% of the sample, whereas male participants comprised 47% (see table 2).

### 3.2. Descriptive Statistics of BMI and PBI

**Table 3** Minimum and maximum Values of BMI and PBI by Sex

| No. | Parameter | Sex | Minimum | Average Minimum | Maximum | Average Maximum |
|---|---|---|---|---|---|---|
| 1 | BMI | Women | 37.5 | 24.6 | 13.6 | 24.6 |
| 2 | PBI | Men | 3.25 | 1.01 | 0.00 | 1.01 |

Table 3 showed the descriptive analysis showed that the mean Body Mass Index score of the participants was 24.6, indicating a population at risk of overweight or obesity. The mean Papillary Bleeding Index score was 1.01, which was categorized as very good gingival condition. The maximum BMI value recorded was 37.5 (obesity class II), observed in a female participant aged 22 years. The highest PBI score was 3.25 (poor gingival condition), observed in a male participant aged 29 years. Conversely, the minimum BMI value was 13.6 (underweight), while the minimum PBI score was 0.0, indicating no gingival bleeding.

### 3.3 Normality and Homogeneity Testing

**Table 4** Normality Test Results (Kolmogorov–Smirnov Test) and Homogeneity Test Results (Levene's Test)

| No. | Parameter | P value of Kolmogorov-Smirnov | P value of Levene's Test |
|---|---|---|---|
| 1 | BMI | 0.79 | 0.00 |
| 2 | PBI | 0.003 | 0.00 |

Normality testing using the Kolmogorov–Smirnov test showed that both BMI and PBI data were normally distributed ($p > 0.05$). Homogeneity testing using Levene's test indicated non-homogeneous variance ($p < 0.05$) (please see table 4). However, variance homogeneity is not an absolute requirement for correlation analysis.

### 3.4 Correlation between Body Mass Index and Papillary Bleeding Index

**Table 5** Correlation between Body Mass Index and Papillary Bleeding Index (Spearman Test))

| No. | Parameter | Pearson Correlation | Sig. (2 tailed) |
|---|---|---|---|
| 1 | BMI | -0.116 | 0.249 |
| 2 | PBI | 1000 | 0.249 |

Correlation analysis using Spearman's test revealed no statistically significant relationship between Body Mass Index and Papillary Bleeding Index ($r = -0.116$; $p = 0.249$) (see table 5). This finding indicates that variations in BMI were not significantly associated with gingival bleeding severity among the study participants.

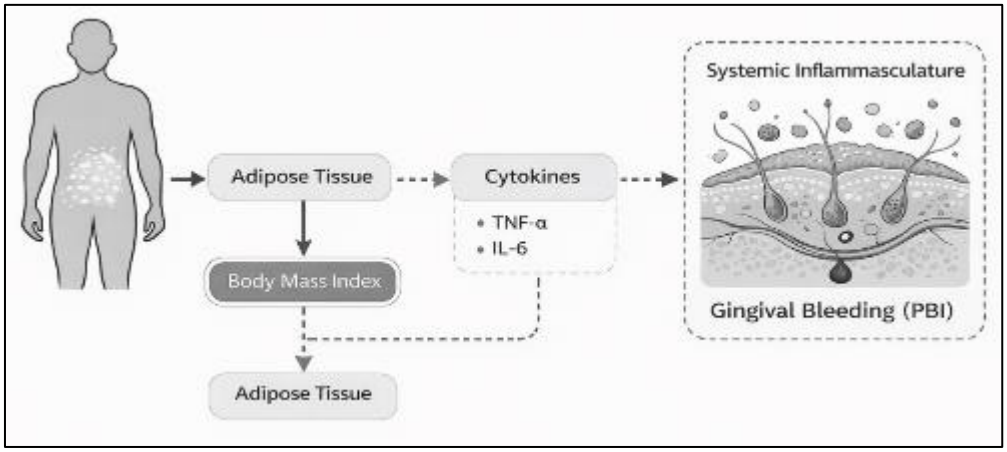


**Figure 2** Conceptual framework illustrating the proposed relationship between body mass index and gingival inflammation through systemic inflammatory pathways

Figure 2 illustrates a conceptual framework describing the proposed biological pathway linking Body Mass Index and gingival inflammation. Increased Body Mass Index is associated with greater adipose tissue mass, which functions as an active endocrine organ capable of producing pro-inflammatory mediators such as tumor necrosis factor-α and interleukin-6. These cytokines may contribute to systemic low-grade inflammation and influence microvascular responses within gingival tissues, potentially increasing vascular permeability and bleeding tendency as assessed by the Papillary Bleeding Index. Although the present study did not demonstrate a statistically significant association between Body Mass Index and gingival bleeding, this conceptual model provides a biological rationale for the hypothesized relationship and supports the interpretation of gingival inflammatory indices as contextual indicators of systemic health status in population-based and forensic-oriented frameworks. Within the clinical periodontal setting, the biological pathways illustrated in Figure 2 require translation into measurable and standardized clinical parameters. While systemic inflammatory processes may influence periodontal tissues at the microvascular level, their clinical expression must be assessed using reliable indices that reflect gingival inflammatory status. One such parameter is gingival bleeding response, which represents an early and sensitive indicator of periodontal inflammation.

Papillary Bleeding Index (PBI) is a widely accepted periodontal parameter for assessing gingival inflammation based on bleeding response following gentle probing of the interdental papillae [1, 11, 12]. In the present study, the majority of participants were adults aged 20–50 years, an age group in which early periodontal inflammatory changes commonly occur and may progress gradually depending on local and systemic risk factors [2]. This demographic profile reflects a clinically relevant population frequently encountered in dental hospital settings. Descriptive analysis demonstrated that the mean Body Mass Index of the participants was 24.6, which falls within the category of increased risk for overweight according to the WHO Asia–Pacific classification. Despite this, the mean Papillary Bleeding Index score was relatively low, indicating generally good gingival health among the study population. These findings suggest that elevated BMI does not necessarily correspond to increased gingival bleeding severity in all clinical contexts, particularly when oral hygiene practices and periodontal care are adequately maintained [13].

Correlation analysis revealed no statistically significant association between Body Mass Index and Papillary Bleeding Index. This finding indicates that variations in BMI were not directly associated with gingival bleeding severity among patients attending the dental teaching hospital. Similar findings have been reported in several studies, which suggested that body mass alone may not be a sufficient determinant of periodontal inflammatory status without the presence of additional modifying factors such as plaque accumulation, smoking habits, dietary patterns, and systemic diseases [3, 14].

Sex-related differences were observed descriptively, with male participants exhibiting higher maximum PBI scores compared to females. This observation is consistent with previous epidemiological studies reporting a higher prevalence and severity of periodontal disease among males [4]. Behavioral factors such as smoking, alcohol consumption, and lower adherence to oral hygiene practices have been proposed as contributing factors to this pattern [5]. In contrast, female participants often demonstrate greater health awareness and preventive behaviors, which may contribute to better periodontal conditions despite variations in systemic health indicators. From a biological perspective, obesity has been associated with chronic low-grade inflammation mediated by adipose tissue–derived cytokines such as tumor necrosis factor-α, interleukin-6, and leptin [6]. These mediators have been implicated in the modulation of inflammatory responses within periodontal tissues. However, the absence of a significant association in this study may indicate that the inflammatory burden related to adiposity alone was insufficient to produce measurable changes in gingival bleeding, particularly in a population receiving periodontal care.

It is also important to consider the role of saliva and host immune response in periodontal health. Salivary flow rate and composition, which may be influenced by nutritional status, play a protective role in maintaining oral homeostasis and controlling microbial colonization [7]. Variations in these factors may partially explain why individuals with abnormal BMI do not consistently present with increased gingival inflammation, as reflected by PBI scores. From a broader population-based perspective, both Body Mass Index and gingival inflammatory indices may be viewed as components of systemic and oral health profiling. Although this study did not identify a significant association, these parameters remain valuable descriptors of an individual's biological and health background. In forensic-oriented contexts, particularly in population studies and contextual biological profiling, such indicators may provide supplementary information regarding nutritional status and inflammatory conditions when interpreted alongside other dental and biological data [8, 15].

The findings of this study should be interpreted in light of several limitations. The cross-sectional design precludes causal inference, and the study was conducted in a single dental teaching hospital, which may limit generalizability. Additionally, potential confounding variables such as smoking status, oral hygiene behavior, dietary intake, and systemic inflammatory conditions were not fully controlled. Future studies incorporating longitudinal designs, larger and more diverse populations, and comprehensive assessment of behavioral and systemic factors are recommended to further clarify the relationship between nutritional status and periodontal inflammation.

## 4. Conclusion

This study found no statistically significant association between Body Mass Index and gingival inflammation as measured by the Papillary Bleeding Index among patients attending a dental teaching hospital. Although the study population demonstrated a mean Body Mass Index within the at-risk category, gingival bleeding levels were generally low, indicating favorable gingival health. These findings suggest that Body Mass Index alone may not be a determining factor for gingival inflammatory status in clinical dental settings. Periodontal inflammation is likely influenced by a combination of local, behavioral, and systemic factors beyond body mass parameters. From a broader perspective, indicators such as Body Mass Index and gingival bleeding indices remain relevant descriptors of systemic and oral health. When interpreted within population-based and forensic-oriented frameworks, these parameters may contribute supplementary contextual information to biological health profiling when integrated with other dental and biological data. Future studies incorporating longitudinal designs and comprehensive assessment of confounding factors are recommended to further clarify the complex relationship between nutritional status and periodontal inflammation.

## Compliance with ethical standards

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### *Disclosure of conflict of interest*

The authors declare that there are no conflicts of interest regarding the publication of this manuscript. The authors have no financial or personal relationships with any institution or product that could have influenced the work reported in this paper.

### *Statement of ethical approval*

This study involved human participants and was conducted in accordance with ethical standards and institutional guidelines. Ethical approval was obtained from the Ethics Committee of Institut Ilmu Kesehatan Bhakti Wiyata Kediri (Ethical Clearance No. 335/FKG/EP/VIII/2024, dated 08 August 2024) and from the Health Research Ethics Committee of Rumah Sakit Gigi dan Mulut (RSGM) IIK Bhakti Wiyata (Ethical Clearance No. 079/RSGM/AK.8/X/2024, dated 02 October 2024).

### *Statement of informed consent*

Informed consent was obtained from all individual participants included in the study prior to their participation.

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