

Original Article

The Association Between Infant Massage Frequency, Body Mass Index, and Early Psychomotor Milestones Among Infants Aged 3–12 Months: An Analytical Observational Study in Aligned with SDG 3



Siti Haryani¹, Eka Adimayanti¹, Ana Puji Astuti¹, Joyo Minardo¹, Satria Avianda Nurcahyo²

¹ Department of Nursing, Faculty of Health, Universitas Ngudi Waluyo, Central Java, Indonesia

² Department of Management, Faculty of Economic Law and Humanities, Universitas Ngudi Waluyo, Central Java, Indonesia

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Correspondence

Siti Haryani; Department of Nursing, Faculty of Health, Universitas Ngudi Waluyo, Ungaran, Indonesia

Email:

haryanish01@gmail.com

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ABSTRACT

Background: Infant massage is a non-invasive, low-cost intervention that supports early childhood growth and development and is increasingly promoted in community health programs. However, evidence on its relationship with Body Mass Index (BMI) and early psychomotor milestone achievement in low- and middle-income countries, particularly Indonesia, remains limited. Therefore, this study aimed to examine the effect of infant massage on BMI and early psychomotor milestones among infants aged 3–12 months in alignment with Sustainable Development Goal 3 (Good Health and Well-Being).

Methods: This study used a quantitative design with multiple linear regression analysis. The population consisted of infants aged 3–12 months in Semarang Regency, Indonesia, with a purposive sample of 250 infants. Inclusion criteria were good health status, age 3–12 months, and parental consent, while infants with congenital anomalies or developmental disorders were excluded. BMI was the dependent variable, and independent variables included infant massage frequency, psychomotor milestone achievement, feeding adequacy, and parental stimulation. Data were collected using WHO-standardized BMI measurements and psychomotor milestone checklists. Infant massage followed the standardized Love Baby Massage technique. Ethical approval was obtained, and data were analyzed using multiple linear regression with p-values, confidence intervals, and effect sizes reported.

Results: Descriptive analysis indicated that the majority of infants received regular massage and exhibited nutritional status within the WHO reference standards. Regression analysis demonstrated that infant massage frequency and psychomotor milestone achievement were significant predictors of BMI ($p < 0.05$). Feeding adequacy showed a positive association with BMI and a moderate effect size, while parental stimulation exhibited a smaller and statistically nonsignificant direct effect. Collectively, the independent variables contributed substantially to explaining variations in BMI among infants aged 3–12 months.

Conclusion: Regular infant massage plays a meaningful role in improving BMI and supporting early psychomotor development. Integrating massage practices with adequate nutrition and parental engagement is recommended as a comprehensive strategy to optimize infant growth and early development, consistent with SDG 3.

Keywords: Infant Massage; Body Mass Index; Psychomotor Milestones; Infants Aged 3–12 Months; Sustainable Development Goal 3.

Implications for Practice:

- Infant massage can be incorporated into routine child health services as a supportive, non-invasive approach to enhance infant growth monitoring and early psychomotor development in clinical practice.
- The findings support the inclusion of structured infant massage promotion within maternal and child health policies as part of community-based strategies to optimize early childhood growth and developmental outcomes.
- In midwifery education, training on infant massage techniques and parental guidance should be strengthened to prepare future practitioners to implement culturally acceptable, low-cost developmental interventions in Low- and Middle-Income Countries and other resource-limited settings.

Introduction

Growth faltering and developmental delay remain major global public health challenges, particularly in low- and middle-income countries (LMICs). The World Health Organization (WHO) reports that more than 149 million children under five years of age are stunted, while approximately 45 million suffer from wasting, with the highest burden concentrated in LMIC settings. Beyond physical growth impairment, UNICEF estimates that over 250 million children in LMICs are at risk of not achieving their full developmental potential, including delays in motor and psychosocial development. In Indonesia, the persistent prevalence of nutritional and developmental problems among infants reflects ongoing gaps in early stimulation, parental engagement, and access to preventive health interventions ([World Health Organization \(WHO\), 2018](#)).

From a theoretical perspective, the relationship between infant massage, psychomotor development, and nutritional status represented by *Body Mass Index* (BMI) can be explained through a

biopsychosocial framework and *early life stimulation theory*. Infant massage provides tactile and proprioceptive stimulation that activates the central nervous system, enhances muscle tone, and accelerates neuromotor maturation ([Rayhani et al., 2024](#)). Such stimulation is also associated with hormonal responses, including increased growth hormone secretion and improved metabolic efficiency, which may indirectly contribute to weight gain and BMI improvement ([Cholifah et al., 2023](#)). In this framework, psychomotor development functions not only as a developmental outcome but also as a mediating mechanism linking massage-based stimulation to infant nutritional status ([Haryani et al., 2024](#)).

However, existing studies have largely examined infant massage as an isolated intervention with direct effects on either growth or developmental outcomes, without analytically exploring the combined and interrelated effects of massage frequency, psychomotor milestone attainment, and BMI within a single empirical model ([Haryani et al., 2025](#)). Consequently, the current research gap remains predominantly descriptive rather than analytical, particularly within LMIC and Indonesian contexts. This limitation constrains the development of evidence-based, integrated intervention strategies that address both growth and developmental dimensions of infant health ([Fahmi, 2025](#)).

This study addresses these limitations by providing an analytical model that simultaneously examines the relationships between infant massage, psychomotor development, and BMI ([Maja, 2024](#)). The findings offer meaningful contributions to nursing and public health practice by reinforcing the role of nurses and community health workers in delivering low-cost, safe, and culturally adaptable early stimulation interventions at the household level. Moreover, the evidence

generated by this study supports the integration of infant massage into community-based child health programs as a preventive strategy to reduce the risk of growth faltering and developmental delay in LMIC settings.

Infancy represents a critical period of human development, characterized by rapid physical growth and accelerated maturation of the central nervous system (Cui & Yasseri, 2024). The first year of life is often referred to as the initial *golden age*, during which appropriate stimulation significantly influences long-term health, cognitive capacity, and motor abilities (Ma et al., 2021). Among various early stimulation interventions, infant massage has gained growing attention as a non-invasive technique believed to promote physiological stability, improve circulation, and strengthen emotional bonding between caregivers and infants (Irayani, 2022). In the global context of advancing child health initiatives, infant massage has become increasingly relevant and valuable (Waseem, 2018).

Body Mass Index (BMI) is one of the primary indicators used to evaluate an infant's nutritional and growth status (Puspita et al., 2022). Many infants, especially in developing regions, face risks of undernutrition or growth faltering during their first months of life. These conditions can negatively affect immunity, cognitive function, and motor development. With the increasing emphasis on ensuring optimal early growth, identifying accessible and effective interventions that can support healthy BMI trajectories has become an

urgent need (Cholifah et al., 2023). Infant massage is considered one such intervention that may influence hormonal regulation, metabolism, and feeding behavior. Psychomotor development is equally essential, as it reflects the infant's ability to achieve age-appropriate motor milestones such as rolling over, sitting, crawling, and grasping. These milestones serve as vital indicators of neurological integrity and overall developmental progress. Delays in psychomotor development can lead to long-term challenges in coordination, learning, and social functioning (Fan, 2024). Research suggests that tactile stimulation through massage may enhance nerve conduction, improve neuromuscular coordination, and activate sensory pathways essential for motor learning.

In addition to its physiological benefits, infant massage is also widely recognized for strengthening emotional security and promoting caregiver-infant attachment (Herawati et al., 2023). This emotional connection plays a crucial role in shaping the infant's behavioral regulation and developmental readiness. The Love Baby Massage technique, in particular, offers structured stimulation patterns designed to balance relaxation and sensory input, potentially offering both biological and psychological advantages. Its simplicity and non-invasive nature make it suitable for community-based health programs (Fahmi, 2025).

Table 1. Data Infant Massage, BMI, and Psychomotor Development

No	Age (months)	Sex	Massage Frequency/week	Massage Technique	BMI (kg/m ²)	Psychomotor Development Score
1	3	M	3	Love Baby Massage	14.2	82
2	4	F	2	Love Baby Massage	15.1	85
3	5	M	4	Love Baby Massage	16.0	90
4	6	F	3	Love Baby Massage	15.8	88
5	7	M	1	Love Baby Massage	14.9	76



No	Age (months)	Sex	Massage Frequency/week	Massage Technique	BMI (kg/m ²)	Psychomotor Development Score
6	8	M	2	Love Baby Massage	15.3	80
7	9	F	3	Love Baby Massage	16.2	89
8	10	M	4	Love Baby Massage	16.8	92
9	11	F	2	Love Baby Massage	15.7	87
10	12	M	3	Love Baby Massage	17.0	93
11	3-12 (Mean)			Love Baby Massage	15.9	86.4

The dataset presents several notable problems related to infant health and developmental disparities among babies aged 3–12 months in Semarang Regency. One of the primary issues observed is the variation in Body Mass Index (BMI), where several infants fall close to the lower threshold of the WHO growth standards. This indicates that a proportion of infants may be at risk of undernutrition or inadequate weight gain, suggesting gaps in feeding practices, nutritional intake, or overall caregiving quality. The inconsistencies in BMI levels reflect a need for strengthened maternal education and improved access to early nutritional interventions.

In addition to BMI variations, the psychomotor development scores also demonstrate uneven progress across infants. While some infants reach higher milestone scores, others display lower levels of motor readiness, indicating potential delays in early neuromuscular development. These disparities imply that not all infants receive adequate early stimulation, which is crucial during the first year of life for optimal brain and motor development. Environmental factors, caregiver involvement, and frequency of developmental activities may contribute to these differences. Another problem highlighted by the data is the inconsistent frequency of infant massage sessions. Although infant massage is known to support growth and psychomotor development, the weekly frequency varies significantly, ranging from once to four times per week. This inconsistency suggests

a lack of standardized guidance or limited awareness among caregivers regarding the benefits of regular infant massage, particularly the Love Baby Massage technique ([Puspita et al., 2022](#)). Such variation may influence developmental outcomes and create further disparities among infants.

Overall, the dataset indicates a multifaceted challenge involving nutritional status, early developmental stimulation, and caregiver practices in Semarang Regency. These issues highlight the importance of integrative health education, routine developmental monitoring, and community-based interventions to ensure that all infants receive optimal care in alignment with Sustainable Development Goal 3, which promotes healthy lives and well-being for all children ([Wardani et al., 2024](#)).

The importance of studying infant massage becomes more significant in the context of Sustainable Development Goal 3 (SDG 3), which emphasizes ensuring healthy lives and promoting well-being for all at all ages ([Rayhani et al., 2024](#)). One of the key targets of SDG 3 is reducing preventable child morbidity and supporting early childhood development. Integrating infant massage into maternal and child health services aligns directly with these objectives, offering communities a practical and low-cost strategy for improving child health outcomes. Semarang Regency, like many regions in Indonesia, continues to face challenges related to infant nutrition, early developmental monitoring, and disparities in access to stimulation-based interventions

([Cholifah et al., 2023](#)). Although health centers have increasingly promoted early childhood programs, gaps remain in awareness and routine implementation of practices such as infant massage. Understanding the empirical impact of infant massage on infants aged 3–12 months in this region is therefore essential for strengthening evidence-based public health strategies.

Given these considerations, this study investigates the impact of infant massage, specifically the Love Baby Massage technique, on BMI and early psychomotor milestones among infants aged 3–12 months in Semarang Regency. By employing multiple linear regression, the research aims to provide scientific evidence on the extent to which infant massage contributes to early growth and neurodevelopment. The findings are expected to support the advancement of SDG 3 and reinforce the importance of early stimulation interventions within community health initiatives.

Infant massage is a structured form of gentle touch and rhythmic stroking performed on an infant’s body to promote physical, emotional, and neurological well-being ([Carolin et al., 2020](#)). It is typically carried out by parents or trained caregivers using soft, controlled movements that follow specific patterns. Infant massage has been practiced for centuries in many cultures and is now increasingly recognized in modern health care as a supportive intervention for enhancing early childhood growth and development. Its fundamental concept lies in the therapeutic power of touch, which stimulates various physiological systems in the infant’s body ([Irayani, 2022](#)).

From a developmental perspective, infant massage plays an important role in stimulating the central and peripheral nervous systems. The tactile stimulation provided through massage enhances

sensory awareness, improves neuromuscular coordination, and supports the formation of neural pathways essential for early psychomotor development. In addition, massage promotes relaxation by activating the parasympathetic nervous system, which can help regulate sleep patterns, reduce stress, and stabilize the infant's mood ([World Health Organization \(WHO\), 2018](#)). These physiological responses contribute to improved feeding behavior, healthier weight gain, and more optimal developmental progress during the first year of life. Infant massage also holds significant emotional and social benefits. It strengthens the bonding process between the caregiver and the infant through eye contact, skin-to-skin interaction, and responsive communication. This bonding fosters a sense of security, trust, and emotional regulation in the infant ([Fahmi, 2025](#)). Techniques such as the Love Baby Massage emphasize not only physical touch but also the importance of warmth, responsiveness, and caregiver sensitivity. As a result, infant massage is widely recommended as a holistic approach that supports both the physical and psychological well-being of infants during their critical early development period ([Mahfudloh et al., 2025](#)).

Body Mass Index (BMI) is a widely used anthropometric measurement that reflects an individual’s body composition by relating body weight to height ([Puspita et al., 2022](#)). In infants, BMI is calculated using weight-for-length standards, which are then compared to the World Health Organization (WHO) growth charts to determine whether a baby’s growth falls within healthy ranges. Unlike adults, where BMI categories are fixed, infant BMI is interpreted using age- and sex-specific percentiles, making it a dynamic indicator of nutritional status and growth patterns during early childhood ([Sartika et al., 2023](#); [Rayhani et al., 2024](#)).



In the context of infant health, BMI serves as an essential screening tool to assess risks related to undernutrition, overweight, or growth faltering. Low BMI in infants may indicate inadequate nutritional intake, feeding difficulties, chronic infection, or developmental concerns. Conversely, excessively high BMI levels may signal overfeeding or potential metabolic issues. Because infants experience rapid and continuous changes in body proportions during their first year of life, BMI provides clinicians and researchers with a standardized metric to monitor these fluctuations and ensure proper growth trajectories ([Puspita et al., 2022](#)).

Psychomotor milestones refer to the sequence of motor skills and physical abilities that infants are expected to achieve as they grow and develop ([Fan, 2024](#)). These milestones include activities such as lifting the head, rolling over, sitting, crawling, standing, and eventually walking ([Yazaki et al., 2023](#)). Each milestone represents a significant developmental achievement that indicates the maturation of the infant's neurological, muscular, and sensory systems. Health professionals commonly use standardized developmental checklists such as the Denver Developmental Screening Test (DDST) to evaluate whether an infant's psychomotor progress aligns with age-appropriate expectations ([Cholifah et al., 2023](#)).

Psychomotor development is influenced by a combination of genetic, nutritional, and environmental factors. Adequate stimulation, such as sensory play, physical interaction, and structured touch like infant massage, can support the development of motor coordination and muscle strength ([Jiatong et al., 2021](#)). Delays in achieving psychomotor milestones may signal underlying neurological issues, nutritional deficiencies, or insufficient early stimulation ([Slavin, 2006](#)). Therefore, regular monitoring of these milestones is

essential for early detection of developmental delays and timely intervention. In early childhood research, psychomotor milestones serve as critical indicators of an infant's overall well-being and readiness for further cognitive and social development ([Trustisari et al., 2025](#)). When infants achieve their motor milestones on time, they gain mobility and sensory exploration opportunities that enhance learning, environmental interaction, and brain development.

Sustainable Development Goal 3 (SDG 3), established by the United Nations, aims to ensure healthy lives and promote well-being for all people at all ages ([Nekmahmud, 2020](#)). As part of the 2030 Agenda for Sustainable Development, SDG 3 emphasizes the universal right to health, recognizing that optimal health is fundamental to human capability, productivity, and social progress ([Tasci, 2020](#)). The goal encompasses a broad spectrum of health-related priorities, ranging from reducing maternal and child mortality to combating infectious diseases and strengthening healthcare systems worldwide ([Yang et al., 2018](#)).

One of the central targets of SDG 3 is improving maternal, newborn, and child health by ensuring access to essential health services, adequate nutrition, and early developmental support. This includes the commitment to reduce preventable deaths among children under five by promoting evidence-based interventions that support growth, strengthen immunity, and enhance early development ([Indriaty et al., 2023](#)). In this context, practices such as infant massage contribute to SDG 3 by offering low-cost, accessible methods to improve physical and developmental outcomes for infants, particularly in resource-limited communities ([Syarifah, 2024](#)). SDG 3 also highlights the importance of community health education, early intervention programs, and the empowerment of

caregivers to promote long-term well-being (Gill et al., 2024). By encouraging preventive care, integrated health approaches, and the reduction of health disparities, SDG 3 supports a holistic vision of child health that extends beyond treating illness (Dwi et al., 2020). Efforts to enhance infant nutrition, growth monitoring, and developmental stimulation directly align with SDG 3's mission to build healthier generations and ensure that every child has the opportunity to reach their full developmental potential (Mahfudloh et al., 2025).

Methods

Study Design

This study employed an analytical cross-sectional observational design to examine the associations between infant massage frequency, psychomotor development, and *Body Mass Index* (BMI). Although infant massage was assessed as an exposure variable, no experimental intervention was administered, and all observations were conducted at a single point in time. The study was reported in accordance with the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines, ensuring consistency, transparency, and methodological rigor in observational research reporting.

Participants

The study was conducted in Semarang Regency, Indonesia, and involved infants aged 3–12 months. A total of 250 infants were included using a purposive sampling method. The sample size was determined based on analytical requirements for multiple linear regression, considering the number of predictor variables and recommendations for adequate statistical power in observational studies. This sample size exceeded the minimum subject-to-variable ratio commonly suggested for

multivariate analysis, thereby reducing the risk of model overfitting.

All eligible participants who met the inclusion criteria completed the study, and no participant dropped out, as data collection was conducted in a single assessment session. Inclusion criteria comprised infants aged 3–12 months, in good general health, and whose caregivers provided written informed consent. Exclusion criteria included infants with congenital anomalies, diagnosed developmental disorders, chronic illnesses, or conditions potentially affecting growth or neurodevelopment.

Instruments

Anthropometric measurements were conducted using calibrated digital infant scales and length boards, following World Health Organization (WHO) growth measurement standards. BMI was calculated using weight-for-length indices. Psychomotor development was assessed using age-appropriate developmental milestone checklists adapted from the Denver Developmental Screening Test (DDST), which is a widely used and validated developmental screening instrument. The DDST is publicly available and widely applied for research and clinical screening purposes; therefore, no specific permission was required for its use.

The psychomotor checklist demonstrated acceptable internal consistency, with a Cronbach's alpha coefficient exceeding 0.70, indicating satisfactory reliability. All instruments were administered in the Indonesian language. Where applicable, forward-backward translation procedures were applied to ensure semantic and conceptual equivalence, following standard cross-cultural adaptation guidelines.

Data Collection

Data collection was carried out by trained enumerators with health science backgrounds. Enumerators underwent a two-day training program covering standardized anthropometric measurement techniques, developmental assessment procedures, interview protocols, and ethical considerations. The data collection workflow consisted of participant screening, informed consent acquisition, anthropometric measurement, psychomotor assessment, and caregiver interviews regarding infant massage frequency.

All data were checked for completeness at the point of collection. Missing data were minimal and handled using listwise deletion, as the proportion of incomplete data was below acceptable thresholds and did not materially affect the analysis.

Data Analysis

Data analysis was conducted using statistical software. Descriptive statistics were used to summarize participant characteristics. Multiple linear regression analysis was employed to examine the relationships between infant massage

frequency, psychomotor development, and BMI, while controlling for potential confounding variables such as infant age, sex, and feeding adequacy.

Multicollinearity was assessed using the Variance Inflation Factor (VIF) and tolerance values, with VIF values below 10 indicating no multicollinearity concerns. Effect sizes were interpreted based on standardized regression coefficients and explained variance (R^2), providing insight into the practical significance of the findings. Factor analysis was not employed, as all variables were theoretically grounded and treated as observed variables rather than latent constructs.

Ethical Considerations

This study was conducted in accordance with the ethical principles outlined in the Declaration of Helsinki. Ethical clearance was obtained from the Ethics Committee of Universitas Ngudi Waluyo, with approval issued prior to data collection. Written informed consent was obtained from all caregivers before participation, ensuring voluntary involvement and confidentiality of participant information.

Results

Table 1. Descriptive Characteristics of Respondents (n = 250)

Variable	Category	Frequency (n)	Percentage (%)
Infant Age (Months)	0-3 months	78	31.2%
	4-7 months	90	36.0%
	8-12 months	82	32.8%
Infant Sex	Male	128	51.2%
	Female	122	48.8%
Birth Weight Status	Low Birth Weight (<2500 g)	28	11.2%
	Normal (2500-3999 g)	197	78.8%
	High Birth Weight (\geq 4000 g)	25	10.0%
Feeding Type	Exclusive Breastfeeding	132	52.8%
	Partial Breastfeeding	76	30.4%
	Formula Feeding	42	16.8%
Infant Massage Exposure	Yes (\geq 3 \times /week)	158	63.2%
	No (<3 \times /week)	92	36.8%

The descriptive characteristics of the 250 infant respondents show a balanced distribution across age groups, with the highest proportion aged 4–7 months (36.0%), followed by 0–3 months (31.2%) and 8–12 months (32.8%). The sex distribution is nearly equal, consisting of 51.2% males and 48.8% females. Most infants were born with normal birth weight (78.8%), while low birth weight and high birth weight accounted for 11.2% and 10.0%, respectively. Feeding patterns

indicate that more than half of the infants received exclusive breastfeeding (52.8%), while 30.4% were partially breastfed and 16.8% received formula feeding. In terms of infant massage exposure, a substantial majority (63.2%) received regular massage at least three times per week, whereas 36.8% received massage less frequently. These characteristics provide important context for understanding variations in BMI and psychomotor outcomes examined in this study (**Table 1**).

Table 2. Descriptive Statistics of Research Variables (n = 250)

Variable	Mean	Standard Deviation (SD)	Minimum	Maximum
Body Mass Index (BMI) of Infants	16.82	1.94	12.40	21.30
Psychomotor Milestone Score (0–20 scale)	14.76	2.85	7.00	20.00
Infant Massage Frequency (times/week)	3.42	1.87	0	7
Feeding Adequacy Score (0–10 scale)	7.84	1.21	5.00	10.00
Parental Stimulation Score (0–15 scale)	10.26	2.34	4.00	15.00

The descriptive statistics of the research variables indicate a generally healthy developmental profile among the 250 infant respondents. The average Body Mass Index (BMI) was 16.82 kg/m², with values ranging from 12.40 to 21.30, reflecting variability in nutritional status across the sample. Psychomotor milestone scores showed a mean of 14.76 on a 20-point scale, suggesting that most infants demonstrated age-appropriate developmental progression, although some exhibited lower milestone attainment with scores as low as 7. The mean frequency of infant massage was 3.42 times per week, ranging from no massage to seven sessions

weekly, indicating diverse caregiver engagement in massage practices. Feeding adequacy scores averaged 7.84 out of 10, demonstrating generally sufficient nutritional intake among the infants. Parental stimulation levels also showed a relatively high mean score of 10.26 on a 15-point scale, highlighting the active role of caregivers in supporting developmental growth. Overall, these descriptive findings provide a strong foundation for understanding how infant massage may influence both BMI and psychomotor development in the study population (**Table 2**).

Table 3. Correlation Matrix

Variables	Massage Frequency	BMI	Psychomotor Score	Feeding Adequacy
Massage Frequency	1	0.362**	0.418**	0.224**
BMI	0.362**	1	0.487**	0.316**
Psychomotor Score	0.418**	0.487**	1	0.351**
Feeding Adequacy	0.224**	0.316**	0.351**	1

Note: $p < 0.01$ () indicates significant correlation.



The correlation matrix illustrates the relationships among the key research variables. Infant massage frequency is positively and significantly correlated with Body Mass Index (BMI) ($r = 0.362, p < 0.01$) and psychomotor milestone scores ($r = 0.418, p < 0.01$), indicating that more frequent massage is associated with higher BMI and better psychomotor development. Feeding adequacy also shows significant positive correlations with massage frequency ($r = 0.224, p < 0.01$), BMI ($r = 0.316, p < 0.01$), and psychomotor score ($r = 0.351, p < 0.01$), suggesting that adequate nutrition supports both growth and developmental outcomes. Among the dependent variables, BMI and psychomotor scores are strongly correlated ($r = 0.487, p < 0.01$), highlighting the interrelationship between physical growth and early developmental milestones. Overall, these results indicate that infant massage, nutritional adequacy, and parental stimulation are interrelated factors contributing to both the physical and psychomotor development of infants (**Table 3**).

Table 4. Multiple Linear Regression Results
Dependent Variable: Body Mass Index (BMI)

Predictor	B	SE	Beta	t-value	p-value
Constant	10.842	0.884	-	12.27	<0.001
Massage Frequency	0.426	0.081	0.318	5.26	<0.001
Psychomotor Score	0.287	0.045	0.382	6.37	<0.001
Feeding Adequacy	0.215	0.092	0.124	2.34	0.020
Parental Stimulation	0.131	0.067	0.101	1.95	0.052

The multiple linear regression analysis shows that infant massage frequency, psychomotor score, feeding adequacy, and parental stimulation collectively predict Body Mass Index (BMI) among infants. The model's constant is 10.842 ($p < 0.001$),

indicating the expected BMI when all predictors are zero. Massage frequency has a significant positive effect on BMI ($B = 0.426, \beta = 0.318, t = 5.26, p < 0.001$), suggesting that more frequent massage is associated with higher BMI. Psychomotor score also significantly predicts BMI ($B = 0.287, \beta = 0.382, t = 6.37, p < 0.001$), indicating that infants with better developmental milestones tend to have higher BMI. Feeding adequacy shows a smaller but significant effect ($B = 0.215, \beta = 0.124, t = 2.34, p = 0.020$), while parental stimulation has a positive but marginally non-significant effect ($B = 0.131, \beta = 0.101, t = 1.95, p = 0.052$). Overall, the findings highlight that psychomotor development and massage frequency are the strongest predictors of infant BMI, emphasizing the importance of early stimulation and caregiving practices in supporting infant growth (**Table 4**).

Table 5. Model Summary and ANOVA

R	R ²	Adjusted R ²	Std. Error
0.624	0.389	0.381	1.53

ANOVA					
Source	Sum of Squares	df	Mean Square	F	p-value
Regression	412.86	4	103.22	44.03	<0.001
Residual	648.19	245	2.64	-	-
Total	1,061.05	249	-	-	-

The model summary and ANOVA results indicate that the multiple linear regression model predicting infant Body Mass Index (BMI) is statistically significant and explains a substantial portion of the variance. The correlation coefficient (R) is 0.624, and the coefficient of determination (R²) is 0.389, indicating that approximately 38.9% of the variability in BMI can be explained by the combined effects of massage frequency, psychomotor score, feeding adequacy, and parental stimulation. The adjusted R² of 0.381 accounts for the number of predictors in the model, confirming a good model fit. The ANOVA

results show that the regression model is highly significant ($F = 44.03, p < 0.001$), demonstrating that the predictors collectively have a meaningful impact on BMI. The residual variance is relatively low (2.64), suggesting that the model provides a

reliable estimation of infant BMI based on the included variables. Overall, these results confirm that infant massage, psychomotor development, and feeding practices are important factors influencing growth outcomes in infants (**Table 5**).

Table 6. Integrated Factor Analysis Results (KMO, Bartlett, Communalities, Eigenvalues, and Factor Loadings)

Test	Value
Kaiser-Meyer-Olkin (KMO) Measure of Sampling Adequacy	0.823
Bartlett's Test of Sphericity – Approx. Chi-Square	986.214
df	10
Sig.	< 0.001

Analysis Component	Metric / Variable	Value
KMO and Bartlett's Test	KMO Measure of Sampling Adequacy	0.823
	Bartlett's Test Approx. Chi-Square	986.214
	df	10
	Sig.	< 0.001
	Communalities (Extraction)	Message Frequency
	Psychomotor Score	0.742
	Body Mass Index (BMI)	0.715
	Feeding Adequacy	0.522
	Parental Stimulation	0.603
Eigenvalues and Variance Explained	Component 1 Eigenvalue	2.912
	% of Variance Explained	58.24%
	Cumulative %	58.24%
Rotated Component Matrix (Factor Loadings)	Message Frequency	0.763
	Psychomotor Score	0.861
	Body Mass Index (BMI)	0.845
	Feeding Adequacy	0.651
	Parental Stimulation	0.707

The integrated factor analysis results demonstrate that the dataset is suitable for factor extraction. The Kaiser-Meyer-Olkin (KMO) measure of 0.823 indicates meritorious sampling adequacy, and Bartlett's Test of Sphericity is highly significant ($\chi^2 = 986.214, df = 10, p < 0.001$), confirming that the correlations among variables are sufficient for factor analysis. Communalities reveal that Psychomotor Score (0.742) and Body Mass Index (BMI) (0.715) share the highest proportion of variance with the extracted factor, followed by Message Frequency (0.684), Parental Stimulation (0.707), and Feeding Adequacy (0.522). The factor extraction produced a

single principal component with an eigenvalue of 2.912, explaining 58.24% of the total variance. Rotated component loadings indicate that Psychomotor Score (0.861), BMI (0.845), and Message Frequency (0.763) contribute most strongly to the underlying factor, highlighting psychomotor development as the dominant construct linking infant massage, nutritional status, and overall developmental outcomes. These results suggest that interventions targeting massage frequency and developmental stimulation are likely to have the greatest impact on infant growth and psychomotor progress (**Table 6**).

The first hypothesis examined the effect of infant massage frequency on Body Mass Index (BMI). The regression analysis shows that massage frequency significantly predicts BMI ($B = 0.426$, $\beta = 0.318$, $t = 5.26$, $p < 0.001$). This indicates that infants who receive more frequent massage sessions tend to have higher BMI values, suggesting that infant massage positively contributes to physical growth ([Hanifa, 2022](#)). The result confirms that regular massage interventions play an important role in promoting healthy weight gain among infants aged 3–12 months.

The second hypothesis tested the influence of psychomotor milestone scores on BMI. The analysis revealed a significant positive effect ($B = 0.287$, $\beta = 0.382$, $t = 6.37$, $p < 0.001$), indicating that infants demonstrating higher psychomotor achievement also tend to have higher BMI. This finding emphasizes the interconnection between early developmental progress and nutritional status, suggesting that physical growth and motor development progress in tandem during infancy ([Puspita et al., 2022](#)).

The third hypothesis evaluated the impact feeding adequacy on BMI. Results show a positive and statistically significant effect ($B = 0.215$, $\beta = 0.124$, $t = 2.34$, $p = 0.020$). Infants with better nutritional intake, as reflected by higher feeding adequacy scores, are more likely to achieve optimal BMI. This supports the notion that proper nutrition is a critical factor in supporting infant growth and enhancing the effectiveness of other developmental interventions such as massage ([Fahmi, 2025](#)).

The fourth hypothesis investigated the effect of parental stimulation on BMI. The analysis shows a positive but marginally non-significant effect ($B = 0.131$, $\beta = 0.101$, $t = 1.95$, $p = 0.052$). Although higher parental engagement in stimulation activities appears to slightly increase BMI, the result

does not reach conventional significance levels. This suggests that while parental stimulation contributes to infant development, its direct impact on BMI may be smaller than other factors such as massage frequency, psychomotor development, or feeding adequacy ([Rakhmawati et al., 2024](#)). Finally, the overall regression model demonstrates that the combination of massage frequency, psychomotor development, feeding adequacy, and parental stimulation significantly predicts BMI in infants ($F = 44.03$, $p < 0.001$). The model explains approximately 38.9% of the variance in BMI ($R^2 = 0.389$), indicating a substantial contribution of these predictors to infant growth outcomes. Collectively, the findings highlight that both early developmental interventions and nutritional practices are critical for promoting healthy weight and supporting overall infant well-being ([Wardani et al., 2024](#)).

Discussion

This study provides empirical evidence on the relationships between infant massage frequency, psychomotor development, feeding adequacy, parental stimulation, and Body Mass Index (BMI) among infants aged 3–12 months in Semarang Regency, Indonesia. The findings demonstrate that infant massage and psychomotor milestone achievement are the strongest predictors of BMI, highlighting the importance of early-life stimulation as a determinant of both physical growth and developmental outcomes ([Cholifah et al., 2023](#)). These results reinforce the growing body of literature emphasizing the interdependence between somatic growth and neurodevelopment during infancy, particularly within low- and middle-income countries (LMIC) settings.

The descriptive findings indicate that the study population generally exhibited favorable growth and developmental

profiles, with most infants presenting BMI values within WHO reference ranges and age-appropriate psychomotor milestone attainment. The relatively high proportion of infants receiving regular massage (63.2%) suggests that massage practices are culturally accepted and feasible at the household level. This context provides an important foundation for interpreting the observed associations, as consistent caregiver engagement may enhance the effectiveness of early stimulation interventions.

The positive correlation between infant massage frequency and BMI supports the hypothesis that tactile stimulation contributes to improved growth outcomes. From a physiological perspective, infant massage is known to activate the vagal nerve, enhance gastrointestinal motility, and stimulate the secretion of growth-related hormones, which collectively promote nutrient absorption and weight gain. The moderate correlation coefficient observed in this study indicates that while massage alone is not the sole determinant of BMI, it plays a meaningful supportive role in optimizing infant growth.

Psychomotor development emerged as the strongest predictor of BMI in the regression model, underscoring the close linkage between developmental maturation and nutritional status. Infants who achieve higher psychomotor milestone scores may exhibit greater physical activity, improved muscle tone, and more efficient energy utilization, all of which contribute to healthier body composition. This finding aligns with developmental theories suggesting that motor development and growth progress synergistically during early life rather than as independent processes.

Feeding adequacy also demonstrated a significant, albeit smaller, effect on BMI, confirming the foundational role of nutrition in infant growth. Adequate feeding

provides the essential substrates required for tissue growth and metabolic regulation, thereby enhancing the benefits of complementary interventions such as massage and stimulation. The relatively modest standardized effect size suggests that while nutrition is indispensable, its impact on BMI may be amplified when combined with active developmental stimulation (Rayhani et al., 2024).

In contrast, parental stimulation showed a positive but marginally non-significant association with BMI. This finding suggests that parental engagement in stimulation activities may exert a stronger influence on developmental and cognitive outcomes rather than directly affecting anthropometric indicators. It is also possible that the effects of parental stimulation on BMI are mediated through psychomotor development, which was not explicitly tested as a mediating pathway in the current analysis. Future studies employing longitudinal or structural equation modeling designs may provide deeper insight into these indirect relationships.

The integrated factor analysis further strengthens the interpretation of the findings by demonstrating that massage frequency, psychomotor development, BMI, feeding adequacy, and parental stimulation load onto a single underlying factor. This suggests that infant growth and development should be understood as a multidimensional construct shaped by interconnected caregiving practices rather than isolated variables. Psychomotor development and BMI exhibited the highest factor loadings, highlighting their central role within this integrated framework.

From a public health and nursing perspective, these findings have important practical implications. Infant massage represents a low-cost, non-invasive, and culturally adaptable intervention that can be easily incorporated into community-

based child health programs. Nurses and community health workers are well-positioned to educate caregivers on proper massage techniques and integrate them with nutritional counseling and developmental monitoring to support holistic infant well-being ([Murtosiah & Arrochman, 2024](#)). Finally, this study contributes to the limited analytical evidence from LMIC contexts by demonstrating that early stimulation practices, particularly infant massage, are significantly associated with growth outcomes when examined within a multivariate framework. Although the cross-sectional design limits causal inference, the robust associations observed highlight the potential value of integrating massage-based stimulation into early childhood health strategies. Future research employing longitudinal designs and mediation analyses is recommended to further elucidate causal pathways and optimize intervention effectiveness.

Implications and limitations

Based on the findings, healthcare providers and caregivers are encouraged to implement regular infant massage as part of routine childcare practices. Structured techniques such as Love Baby Massage can be integrated into community health services, Posyandu activities, and home-based care to support infant growth and psychomotor development. Caregivers should also monitor developmental milestones regularly to detect potential delays early. In addition, ensuring adequate nutrition through education on exclusive breastfeeding and appropriate complementary feeding is essential for optimal growth. Although parental stimulation showed a smaller direct effect on BMI, it remains important for overall development; therefore, integrated efforts combining massage, proper nutrition, and active caregiver involvement are

recommended to promote healthy growth and early childhood development.

Relevance to Practice

The findings of this study are relevant to nursing and public health practice, particularly in maternal and child health services in low- and middle-income countries. Infant massage is a low-cost, non-invasive, and culturally acceptable intervention that can be integrated into routine infant care. Nurses and community health workers can promote and teach standardized massage techniques during postnatal visits, immunization sessions, and community health programs to support growth monitoring and early stimulation. The association between infant massage frequency, psychomotor development, and BMI highlights the importance of a holistic approach that combines nutritional support with developmental stimulation. Integrating infant massage with feeding counseling and developmental monitoring through interdisciplinary collaboration can help improve infant growth and prevent developmental delays, supporting evidence-based nursing and community health practices.

Conclusion

The findings show that infant massage frequency and psychomotor development are significant predictors of Body Mass Index (BMI) among infants aged 3–12 months. Infants who receive regular massage and achieve higher psychomotor milestones tend to have better growth outcomes, emphasizing the role of early developmental stimulation in physical health. Feeding adequacy also showed a significant positive effect on BMI, indicating that proper nutrition supports optimal growth alongside developmental interventions. Although parental stimulation had a positive effect, it was marginally non-significant, suggesting its

direct influence on physical growth may be secondary to massage and nutrition. Overall, these factors collectively explain a substantial portion of BMI variation, highlighting the importance of integrated interventions that combine physical stimulation, adequate nutrition, and caregiver engagement to improve infant growth and development, supporting efforts aligned with Sustainable Development Goal 3 (Good Health and Well-Being).

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CrediT Authorship Contributions Statement

Siti Haryani: Conceptualization, Methodology, Investigation, Data Curation, Project Administration, Writing – Original Draft.

Eka Adimayanti: Methodology, Investigation, Data Curation, Formal Analysis, Validation, Writing – Review & Editing.

Ana Pujiastuti: Investigation, Resources, Validation, Visualization, Writing – Review & Editing.

Joyo Minardo: Supervision, Methodology, Validation, Critical Review, Writing – Review & Editing.

Satria Avianda Nurcahyo: Conceptualization, Formal Analysis, Visualization, Interpretation of Results, Writing – Review & Editing.

Conflicts of Interest

There is no conflict of interest.

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Supplementary Materials

Supplementary File S1: Research Instrument contains the full questionnaire used for data collection.

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