

Original Article

Effect of Personalized Complementary Feeding Counseling Combined with Routine Child Health Care on Growth and Developmental Outcomes in Infants

Mubashra Tariq¹, Ayesha Nazir Hashmi¹, Fariha Asghar²¹ Dimensions: Institute for Autism, Special Education, Physical Rehabilitation & Psychological Services, Lahore, Pakistan² University of Lahore, Lahore, Pakistan

Corresponding Author: Fariha Asghar, Email: fariha.asghar@uipt.uol.edu.pk

Received: 11 August 2026

Revised: 08 September 2026

Accepted: 16 September 2026

Published: 30 September 2026

How to Cite: Mubashra Tariq, Ayesha Nazir Hashmi, & Fariha Asghar. (2026). Effect of Personalized Complementary Feeding Counseling Combined with Routine Child Health Care on Growth and Developmental Outcomes in Infants. *Journal of Health and Rehabilitation Research*, 6(9), 1–11.

ABSTRACT

Background: Appropriate complementary feeding during infancy is essential for physical growth and developmental progression. Generalized feeding advice may not adequately address differences in infant nutritional requirements, feeding practices, and caregiver circumstances. **Objective:** To evaluate the effect of personalized complementary feeding counseling combined with routine child health care on growth and developmental outcomes in infants. **Methods:** A prospective controlled interventional study included 46 infants attending Dimensions: Institute for Autism, Special Education, Physical Rehabilitation & Psychological Services, Lahore, Pakistan. The intervention group (n=23) received individualized complementary feeding counseling alongside routine child health care, whereas the control group (n=23) received routine care alone. Anthropometric measurements and developmental outcomes were assessed at baseline and follow-up. Data were analyzed using IBM SPSS Statistics version 26.0, with baseline-adjusted comparisons where appropriate. **Results:** Mean weight increased by 1.29 kg in the intervention group compared with 0.79 kg in the control group. Adjusted between-group differences favored the intervention for weight (0.49 kg; 95% CI 0.18–0.80; p=0.003), recumbent length (1.43 cm; 95% CI 0.39–2.47; p=0.008), and head circumference (0.48 cm; 95% CI 0.09–0.87; p=0.017). Greater improvements were also observed across gross motor, fine motor, communication, cognitive, and personal-social developmental domains. The adjusted difference in total developmental score was 20.8 points (95% CI 11.4–30.2; p<0.001). **Conclusion:** Personalized complementary feeding counseling integrated into routine child health care was associated with more favorable anthropometric and developmental outcomes than routine care alone. Further controlled investigations are required to establish the reproducibility and longer-term clinical significance of these findings. **Keywords:** complementary feeding; infant nutrition; growth; child development; nutrition counseling; child health care.

INTRODUCTION

Infancy is characterized by rapid physical growth, neurological maturation, and the progressive acquisition of developmental abilities. Adequate nutrition during this period is fundamental to healthy growth and development. Although exclusive breastfeeding is recommended during the first six months of life, increasing nutritional requirements subsequently necessitate the introduction of safe, nutritionally adequate, and developmentally appropriate complementary foods alongside continued breastfeeding. The complementary feeding period, generally extending from 6 to 23 months of age, represents an important transition during which insufficient dietary quantity, poor nutrient density, and inappropriate feeding practices can adversely affect nutritional status and health. Inadequate complementary feeding may contribute to impaired weight gain, linear growth faltering, micronutrient deficiencies, increased susceptibility to illness, and unfavorable developmental outcomes (1,2).

Appropriate complementary feeding involves more than introducing solid or semisolid foods at a particular age. Its effectiveness depends on the timing of introduction, dietary diversity, meal frequency, consistency, portion size, nutrient density, food hygiene, and caregiver responsiveness to the infant's feeding cues. These practices are influenced by household resources, cultural traditions, maternal knowledge, caregiver confidence, food availability, and the infant's nutritional and developmental characteristics. Consequently, a uniform feeding message may be insufficient for families whose circumstances and feeding difficulties differ considerably. Individualized counseling

offers an opportunity to translate established nutritional recommendations into practical guidance that reflects an infant's specific requirements and the caregiver's capacity to implement dietary changes (3,4).

Personalized complementary feeding counseling generally begins with an assessment of existing feeding practices and the identification of nutritional inadequacies or potentially inappropriate feeding behaviors. Recommendations may address dietary variety, age-appropriate meal frequency, food texture, portion sizes, nutrient-dense food choices, continued breastfeeding, responsive feeding, and safe food preparation. Repeated counseling encounters provide opportunities to reinforce appropriate practices, assess caregiver understanding, identify barriers to adherence, and adapt recommendations to changes in growth and feeding behavior. Previous interventions conducted in Pakistan have demonstrated that structured complementary feeding education delivered through trained health personnel can influence caregiver practices and selected child growth outcomes, supporting the relevance of counseling-based approaches within local health-care settings (5,6).

Routine child health care provides an established platform for nutritional assessment and preventive services. Clinical visits may include growth monitoring, immunization, general health assessment, developmental surveillance, caregiver education, and early identification of feeding-related problems. However, the content and intensity of nutritional counseling can vary across clinical settings. General advice delivered during routine consultations may not sufficiently address individual dietary inadequacies, socioeconomic constraints, or caregiver misconceptions. Evidence from South Asian populations indicates that complementary feeding practices are shaped by multiple contextual factors, while systematic reviews have shown that caregiver education can improve feeding knowledge and behavior, although the magnitude of associated nutritional benefits is variable (7,8).

The relevance of complementary feeding extends beyond anthropometric growth. Nutrient adequacy during infancy supports physiological processes involved in central nervous system maturation, motor development, language acquisition, cognition, and social interaction. Nevertheless, the relationship between complementary feeding practices and developmental milestones is complex, and developmental outcomes are influenced by biological, environmental, and caregiving factors in addition to nutrition. Evidence synthesized in previous systematic reviews indicates the importance of evaluating developmental outcomes carefully rather than assuming that improvements in feeding practices necessarily produce corresponding developmental gains (9).

Responsive feeding interventions have also highlighted the importance of caregiver–infant interaction during meals. Feeding approaches that recognize hunger and satiety cues, encourage age-appropriate self-feeding, and promote supportive caregiver responses may influence feeding behavior and interaction quality. Studies evaluating responsive feeding programs have demonstrated improvements in selected caregiver and child behaviors, although effects on anthropometric outcomes have not been uniform. These findings indicate that feeding interventions may act through several behavioral and nutritional pathways and that their effectiveness requires assessment using both nutritional and developmental measures (10,11).

Despite the established importance of complementary feeding, uncertainty remains regarding the additional value of individualized nutritional counseling when delivered alongside routine child health services, particularly in clinic-based settings where caregivers already receive general health advice. Many intervention studies have concentrated on nutritional knowledge, feeding practices, or physical growth, whereas fewer have simultaneously evaluated several developmental domains within the same clinical intervention framework. An integrated assessment may provide a broader understanding of whether personalized counseling is associated with favorable changes in infant health beyond anthropometry alone. Accordingly, the present study aimed to compare growth and developmental outcomes among infants receiving personalized complementary feeding counseling combined with routine child health care and those receiving routine child health care alone. The study hypothesized that infants receiving the combined intervention would demonstrate more favorable changes in anthropometric indicators and developmental scores than infants receiving routine care.

MATERIALS AND METHODS

A prospective controlled interventional study was conducted at Dimensions: Institute for Autism, Special Education, Physical Rehabilitation & Psychological Services, Lahore, Pakistan to examine the association of personalized complementary feeding counseling, delivered in addition to routine child health care, with infant growth and developmental outcomes. The study involved two parallel comparison groups assessed before and after the intervention period. A total of 46 infants attending the clinic were included, of whom 23 received personalized complementary feeding counseling alongside routine child health care and 23 received routine child health care alone.

The comparison was intended to determine whether individualized nutritional guidance provided additional benefits beyond those associated with usual clinical services.

The study population comprised infants within the complementary feeding age range who attended Dimensions: Institute for Autism, Special Education, Physical Rehabilitation & Psychological Services, Lahore, Pakistan with a parent or primary caregiver. Infants considered appropriate for the initiation or continuation of complementary feeding and whose caregivers provided informed consent were eligible for inclusion. Infants with severe congenital abnormalities, major neurological disorders, serious acute or chronic illnesses likely to independently affect feeding, physical growth, or developmental progression, and conditions requiring specialized therapeutic diets were excluded. These criteria were intended to limit the influence of major clinical conditions that could independently affect the principal study outcomes.

Participant recruitment was undertaken among infants presenting to the clinic who fulfilled the eligibility criteria. The final study population comprised 46 infants, distributed equally between the two groups. Baseline assessments were completed before evaluating subsequent changes in anthropometric and developmental outcomes. Information was collected from accompanying caregivers and available clinical records, as appropriate. Recorded characteristics included infant age and sex, breastfeeding status, existing complementary feeding practices, meal frequency, dietary diversity, food consistency, and other feeding-related characteristics relevant to nutritional assessment. These variables were considered when describing the study population and interpreting potential differences between the intervention and comparison groups.

The intervention consisted of personalized complementary feeding counseling integrated with routine child health care. Counseling was adapted to the infant's age, current feeding pattern, nutritional requirements, anthropometric status, feeding difficulties, and caregiver-reported dietary practices. The approach emphasized practical identification and correction of feeding inadequacies rather than the exclusive delivery of uniform dietary instructions. Caregivers received individualized guidance on the appropriate introduction and progression of complementary foods, age-appropriate meal frequency, dietary diversity, food consistency and texture, suitable portion sizes, nutrient-dense food selection, continued breastfeeding, hygienic food preparation, and responsive feeding practices. Counseling addressed feeding behaviors and dietary choices in relation to the infant's developmental readiness and the household's usual food preparation and feeding practices.

Particular attention was directed toward identifying potentially modifiable problems in the infant's existing dietary pattern. Recommendations were adapted to household circumstances to facilitate practical implementation. Counseling was reinforced during follow-up encounters, allowing previously discussed feeding practices to be reviewed and recommendations to be adjusted according to nutritional progress, emerging feeding difficulties, and caregiver-reported adherence. This approach was consistent with the principles of individualized, age-appropriate, and responsive complementary feeding described in established infant-feeding guidance (1,4).

Infants in the control group received routine child health care without the additional structured personalized complementary feeding counseling intervention. Routine care comprised standard clinical assessment, monitoring of general health and physical growth, age-appropriate preventive health advice, and other child health services ordinarily provided during clinic attendance. Both groups therefore had access to routine clinical services, while the intervention group received additional individualized feeding assessment and counseling. The comparison was designed to evaluate differences associated with the addition of personalized nutritional guidance to usual care.

Anthropometric outcomes were evaluated at baseline and follow-up using body weight, recumbent length, and head circumference. Weight was obtained using an age-appropriate infant weighing scale, and recumbent length was assessed using infant length-measurement procedures. Head circumference was recorded as an additional indicator of physical growth. Measurements were expressed in kilograms or centimeters, as appropriate, and the same outcome definitions and measurement approaches were used for both groups. Changes between baseline and follow-up were calculated to describe physical growth over the observation period.

In addition to absolute anthropometric measurements, weight-for-age, length-for-age, and weight-for-length z scores were used to describe growth relative to standardized reference distributions. Weight-for-age and length-for-age indicators incorporated age and sex, while weight-for-length represented the relationship between body weight and recumbent length within the relevant reference distribution. Changes in these indicators were assessed alongside absolute growth measurements to distinguish increases associated with physical maturation from changes in relative

anthropometric status. Growth indicators were interpreted in the context of established infant nutritional assessment principles (1,3).

Developmental outcomes were evaluated at baseline and follow-up across five domains: gross motor, fine motor, communication or language, cognitive, and personal-social development. The same general assessment approach was applied to infants in both groups. Developmental performance was assessed through age-appropriate evaluation, with caregiver-provided information considered alongside direct assessment where required. Domain scores were used to describe developmental performance, and the total developmental score represented the combined values of the five assessed domains. Changes in individual domain scores and overall developmental performance were compared between the study groups. The assessment focused on differences in developmental score progression between infants receiving the combined intervention and those receiving routine clinical care alone.

Procedures intended to support data consistency included the application of common eligibility criteria, baseline documentation of participant characteristics, standardized recording units, and use of equivalent outcome definitions and assessment procedures across groups. Data were reviewed for completeness and internal consistency before statistical analysis. Potential sources of variation included differences in baseline anthropometric status, age, sex, breastfeeding practices, complementary feeding behaviors, and caregiver characteristics. These factors were considered when interpreting the findings, particularly because infant growth and developmental progression are influenced by both nutritional and non-nutritional determinants.

Data were entered, cleaned, and analyzed using IBM SPSS Statistics version 26.0. Categorical variables were summarized as frequencies and percentages. Continuous variables were expressed as means and standard deviations when approximately normally distributed, or as medians and interquartile ranges when distributional assumptions were not satisfied. Baseline comparisons between groups were evaluated using independent-samples t tests for normally distributed continuous variables and Mann-Whitney U tests for non-normally distributed continuous variables. Categorical variables were compared using chi-square or Fisher's exact tests, as appropriate. Within-group changes between baseline and follow-up were examined using paired-samples tests suitable for the distribution of each outcome.

Between-group comparisons of follow-up anthropometric and developmental outcomes incorporated baseline outcome measurements. Analysis of covariance was used where appropriate to estimate adjusted between-group differences while accounting for the corresponding baseline value. Estimates were summarized using adjusted mean differences, 95% confidence intervals, and p-values. Where available, effect-size estimates were also presented to support interpretation of the magnitude of between-group differences. All hypothesis tests were two-sided, and $p < 0.05$ was used as the threshold for statistical significance. Analyses were based on valid available observations, with the completeness of outcome data considered during statistical evaluation. Because several related anthropometric and developmental outcomes were examined, the results were interpreted in terms of their overall pattern and clinical relevance rather than individual significance tests alone.

The study was undertaken in accordance with ethical principles governing research involving human participants. Caregivers were informed about the study procedures and participation requirements, and informed consent was obtained from a parent or legal guardian before enrolment. Participation was voluntary, and confidentiality was maintained during data collection, analysis, and reporting. Personally identifiable information was excluded from the analytical dataset and study report.

RESULTS

A total of 46 infants were included in the analysis, with 23 participants in the personalized complementary feeding counseling plus routine child health care group and 23 in the routine care group. The baseline demographic and feeding characteristics of the two groups were broadly comparable. Mean age was 8.3 ± 1.4 months in the intervention group and 8.1 ± 1.5 months in the control group ($p = 0.642$). Male infants accounted for 52.2% and 47.8% of the respective groups, while current breastfeeding was reported for 82.6% and 78.3%. Appropriate meal frequency, adequate dietary diversity, and appropriate food consistency were observed in fewer than half of the participants in each group. No statistically significant baseline differences were identified for the characteristics presented in Table 1.

Both groups demonstrated increases in absolute anthropometric measurements between baseline and follow-up, although greater mean changes were observed among infants receiving personalized complementary feeding counseling. Mean body weight increased from 7.42 ± 0.86 kg to 8.71 ± 0.91 kg in the intervention group, corresponding to

a mean increase of 1.29 kg (95% CI 1.08–1.50; $p < 0.001$). In the control group, mean weight increased from 7.39 ± 0.82 kg to 8.18 ± 0.88 kg, representing a mean increase of 0.79 kg (95% CI 0.61–0.97; $p < 0.001$). The observed difference in mean weight change between groups was 0.50 kg.

Table 1. Baseline demographic and complementary feeding characteristics of study participants

Variable	Intervention (n=23)	Control (n=23)	p-value
Age, months, mean $\pm$ SD	8.3 ± 1.4	8.1 ± 1.5	0.642
Male, n (%)	12 (52.2)	11 (47.8)	0.768
Female, n (%)	11 (47.8)	12 (52.2)	0.768
Currently breastfed, n (%)	19 (82.6)	18 (78.3)	0.711
Appropriate meal frequency, n (%)	9 (39.1)	10 (43.5)	0.765
Adequate dietary diversity, n (%)	8 (34.8)	7 (30.4)	0.751
Appropriate food consistency, n (%)	10 (43.5)	9 (39.1)	0.765

SD, standard deviation. Values are presented as mean $\pm$ SD or n (%). p-values represent between-group baseline comparisons.

Recumbent length also increased in both groups. Infants in the intervention group demonstrated a mean increase of 4.6 cm, from 67.8 ± 3.4 cm to 72.4 ± 3.5 cm, compared with an increase of 3.1 cm, from 68.0 ± 3.2 cm to 71.1 ± 3.4 cm, in the control group. Similarly, mean head circumference increased by 1.7 cm in the intervention group and 1.2 cm in the control group. These results indicated greater observed absolute growth increments among infants receiving the combined intervention.

Changes in growth z scores showed a comparable pattern. Mean weight-for-age z score increased by 0.57 units in the intervention group compared with 0.19 units in the control group. Length-for-age z score increased by 0.49 and 0.17 units, respectively. Weight-for-length z score increased by 0.42 units in the intervention group, whereas the corresponding increase of 0.13 units in the control group was not statistically significant ($p = 0.087$). The pattern across these indicators suggested more favorable changes in relative anthropometric status among infants receiving individualized counseling, as summarized in Table 2.

Table 2. Changes in anthropometric growth outcomes from baseline to follow-up

Outcome	Group	Baseline, mean $\pm$ SD	Follow-up, mean $\pm$ SD	Mean change	95% CI	p-value
Weight, kg	Intervention	7.42 ± 0.86	8.71 ± 0.91	1.29	1.08 to 1.50	<0.001
	Control	7.39 ± 0.82	8.18 ± 0.88	0.79	0.61 to 0.97	<0.001
Recumbent length, cm	Intervention	67.8 ± 3.4	72.4 ± 3.5	4.6	3.9 to 5.3	<0.001
	Control	68.0 ± 3.2	71.1 ± 3.4	3.1	2.5 to 3.7	<0.001
Head circumference, cm	Intervention	43.2 ± 1.4	44.9 ± 1.3	1.7	1.4 to 2.0	<0.001
	Control	43.1 ± 1.3	44.3 ± 1.4	1.2	0.9 to 1.5	<0.001
Weight-for-age z score	Intervention	-0.88 ± 0.74	-0.31 ± 0.69	0.57	0.36 to 0.78	<0.001
	Control	-0.83 ± 0.71	-0.64 ± 0.70	0.19	0.03 to 0.35	0.022
Length-for-age z score	Intervention	-0.91 ± 0.79	-0.42 ± 0.72	0.49	0.28 to 0.70	<0.001
	Control	-0.87 ± 0.76	-0.70 ± 0.74	0.17	0.01 to 0.33	0.039
Weight-for-length z score	Intervention	-0.54 ± 0.68	-0.12 ± 0.63	0.42	0.22 to 0.62	<0.001
	Control	-0.50 ± 0.66	-0.37 ± 0.64	0.13	-0.02 to 0.28	0.087

SD, standard deviation; CI, confidence interval. Mean changes represent follow-up minus baseline values. Confidence intervals and p-values refer to the reported within-group changes.

Developmental Outcomes

Developmental scores increased across all five assessed domains in both groups, with larger mean increases consistently observed in the intervention group. Gross motor scores increased by 11.2 points in the intervention group and 6.7 points in the control group, yielding a between-group difference in mean change of 4.5 points ($p = 0.006$). Fine motor scores increased by 10.8 and 6.7 points, respectively, with a between-group difference of 4.1 points ($p = 0.009$).

Communication or language scores increased by 11.1 points in the intervention group compared with 6.4 points in the control group, corresponding to a between-group difference of 4.7 points ($p = 0.004$). Cognitive development scores increased by 11.3 and 6.7 points, respectively, yielding a difference of 4.6 points ($p = 0.005$). Personal-social development scores increased by 10.6 points in the intervention group and 6.8 points in the control group, producing a difference of 3.8 points ($p = 0.012$).

The overall developmental score demonstrated the largest absolute difference in change between the groups. Mean total developmental score increased from 220.4 ± 19.7 to 275.4 ± 20.2 in the intervention group, representing a mean

increase of 55.0 points. In the control group, the corresponding score increased from 222.0 ± 19.1 to 255.3 ± 21.0 , representing an increase of 33.3 points. The between-group difference in mean change was 21.7 points ($p < 0.001$). These findings are detailed in Table 3.

Table 3. Developmental outcomes at baseline and follow-up

Developmental domain	Group	Baseline, mean $\pm$ SD	Follow-up, mean $\pm$ SD	Mean change	Between-group difference	p-value
Gross motor	Intervention	44.6 ± 6.2	55.8 ± 6.0	11.2	4.5	0.006
	Control	45.1 ± 6.0	51.8 ± 6.3	6.7		
Fine motor	Intervention	43.9 ± 5.8	54.7 ± 5.9	10.8	4.1	0.009
	Control	44.2 ± 5.7	50.9 ± 6.1	6.7		
Communication/language	Intervention	42.8 ± 6.4	53.9 ± 6.2	11.1	4.7	0.004
	Control	43.0 ± 6.3	49.4 ± 6.4	6.4		
Cognitive development	Intervention	44.1 ± 6.1	55.4 ± 6.0	11.3	4.6	0.005
	Control	44.4 ± 6.0	51.1 ± 6.2	6.7		
Personal-social development	Intervention	45.0 ± 5.9	55.6 ± 5.8	10.6	3.8	0.012
	Control	45.3 ± 5.8	52.1 ± 5.9	6.8		
Total developmental score	Intervention	220.4 ± 19.7	275.4 ± 20.2	55.0	21.7	<0.001
	Control	222.0 ± 19.1	255.3 ± 21.0	33.3		

SD, standard deviation. Mean change represents follow-up minus baseline. Between-group differences represent intervention-group change minus control-group change. p-values refer to the reported between-group comparisons.

Baseline-Adjusted Between-Group Comparisons

Following adjustment for baseline outcome values, the differences in anthropometric and developmental outcomes continued to favor the intervention group. The adjusted mean difference in body weight was 0.49 kg (95% CI 0.18–0.80; $p = 0.003$), with a reported effect size of 0.74. Adjusted differences were also observed for recumbent length (1.43 cm; 95% CI 0.39–2.47; $p = 0.008$) and head circumference (0.48 cm; 95% CI 0.09–0.87; $p = 0.017$). The adjusted mean differences in weight-for-age, length-for-age, and weight-for-length z scores were 0.35, 0.30, and 0.27 units, respectively, with confidence intervals excluding zero.

Adjusted comparisons of developmental outcomes demonstrated a similar pattern. The largest domain-specific adjusted difference was observed for communication or language development (4.36 points; 95% CI 1.31–7.41; $p = 0.006$), followed by cognitive development (4.28 points; 95% CI 1.22–7.34; $p = 0.007$) and gross motor development (4.12 points; 95% CI 1.08–7.16; $p = 0.009$). Adjusted differences for fine motor and personal-social development were also statistically significant.

The adjusted mean difference in total developmental score was 20.8 points (95% CI 11.4–30.2; $p < 0.001$), with a reported effect size of 0.96. This estimate was slightly lower than the unadjusted between-group difference in mean change of 21.7 points, while maintaining the same direction of association. The adjusted results are summarized in Table 4.

Table 4. Baseline-adjusted between-group differences in anthropometric and developmental outcomes

Outcome	Mean difference	95% CI	Effect size	p-value
Weight, kg	0.49	0.18 to 0.80	0.74	0.003
Recumbent length, cm	1.43	0.39 to 2.47	0.67	0.008
Head circumference, cm	0.48	0.09 to 0.87	0.59	0.017
Weight-for-age z score	0.35	0.08 to 0.62	0.63	0.012
Length-for-age z score	0.30	0.03 to 0.57	0.55	0.031
Weight-for-length z score	0.27	0.02 to 0.52	0.52	0.036
Gross motor score	4.12	1.08 to 7.16	0.66	0.009
Fine motor score	3.85	0.94 to 6.76	0.64	0.011
Communication/language score	4.36	1.31 to 7.41	0.70	0.006
Cognitive score	4.28	1.22 to 7.34	0.68	0.007
Personal-social score	3.51	0.58 to 6.44	0.58	0.020
Total developmental score	20.8	11.4 to 30.2	0.96	<0.001

CI, confidence interval. Estimates are adjusted for the corresponding baseline outcome value. Positive differences favor the personalized counseling group. Effect-size values are retained from the reported analysis.

DISCUSSION

The present study evaluated the relationship between personalized complementary feeding counseling integrated with routine child health care and changes in growth and developmental outcomes among infants. The principal finding was

that infants receiving individualized feeding counseling demonstrated greater improvements in absolute anthropometric measurements, growth z scores, and developmental domain scores than those receiving routine care alone. These differences remained evident in baseline-adjusted analyses. The findings suggest that individualized nutritional guidance may offer additional value within routine pediatric services, although the observational comparison of intervention groups does not establish that counseling alone was responsible for the observed changes.

The greater increases in body weight, recumbent length, and head circumference observed in the intervention group are consistent with the broader understanding that complementary feeding practices influence nutritional adequacy during a period of rapid physiological growth. As infants transition from exclusive breastfeeding to family foods, insufficient dietary quantity, low nutrient density, and inappropriate feeding frequency may contribute to inadequate nutrient intake. Individualized counseling can address these problems by tailoring recommendations to the infant's developmental stage, baseline growth status, and household dietary practices. Previous studies have demonstrated that nutrition-focused caregiver interventions can improve selected feeding behaviors and growth-related outcomes, although the magnitude of benefit varies across populations and intervention approaches (5,6,12).

The observed anthropometric differences should nevertheless be interpreted in relation to the broader evidence on infant feeding interventions. Research involving complementary food supplementation and caregiver encouragement has demonstrated that improvements in feeding support do not always translate into substantial gains in body weight. Likewise, investigations of alternative complementary feeding approaches indicate that the relationship between feeding behavior and physical growth is influenced by multiple nutritional and contextual variables (13,14). The comparatively favorable growth pattern in the present study may reflect the practical advantage of addressing several feeding-related factors simultaneously rather than targeting a single dietary behavior. However, because individual nutrient intake and adherence were not presented as quantitative outcomes, the specific pathways responsible for the observed differences cannot be established.

Personalized counseling may have supported feeding practices by improving caregivers' understanding of infant nutritional needs and translating general recommendations into practical household actions. Differences in food accessibility, preparation methods, cultural feeding traditions, infant appetite, and caregiver confidence can interfere with the implementation of standardized advice. Individual assessment provides an opportunity to identify these barriers and formulate recommendations that are more readily incorporated into everyday care. Reinforcement during follow-up may also support the maintenance or adjustment of recommended practices as feeding requirements change. Nevertheless, caregiver adherence and dietary changes are potential explanatory factors rather than demonstrated mediators of the present findings, because the study did not report formal mediation analyses.

An important feature of the study was the assessment of developmental outcomes alongside anthropometric measures. Greater changes were observed across gross motor, fine motor, communication or language, cognitive, and personal-social developmental domains among infants receiving individualized counseling. The direction of these findings is compatible with research suggesting that nutritional support, responsive caregiving, and early developmental experiences can jointly influence child development. In Pakistan, Yousafzai and colleagues demonstrated the relevance of integrated responsive stimulation and nutrition interventions within community-based child health services. Their randomized factorial trial indicated that different intervention components may contribute differently to developmental and growth outcomes, emphasizing the need to distinguish nutritional effects from those associated with caregiver interaction and stimulation (15).

Longitudinal evidence from the same Pakistani research program further suggests that early interventions involving responsive stimulation and nutrition may influence subsequent developmental trajectories, although benefits differ according to the intervention component and developmental outcome assessed (16). These observations provide a relevant context for the present findings. Personalized feeding counseling may increase opportunities for caregiver–infant interaction through responsive feeding practices, encouragement of age-appropriate self-feeding, and greater attention to developmental readiness. Such mechanisms are biologically and behaviorally plausible but were not directly examined in this study. Consequently, the observed developmental differences should be regarded as associations occurring alongside the counseling intervention rather than definitive evidence of nutrition-mediated developmental improvement.

The findings also correspond with evidence from complementary feeding interventions undertaken in other low- and middle-income settings. Research in China has examined the effects of complementary food supplementation and dietary counseling on indicators such as anemia and linear growth, highlighting the potential importance of combining

nutritional support with caregiver guidance (17). A randomized educational intervention in rural Bangladesh demonstrated that complementary feeding education can improve selected feeding indicators, supporting the potential usefulness of targeted caregiver education (18). Similarly, a family empowerment intervention in Indonesia emphasized the contribution of caregiver involvement and family-level practices to complementary feeding and child growth (19). Although the designs, intervention intensities, and outcome measures differ from those of the present study, these investigations collectively suggest that nutritional counseling is most appropriately considered within the broader social and caregiving context of infant nutrition.

The association between complementary feeding and developmental outcomes also requires careful interpretation. A recent systematic review examining complementary feeding and children's development identified relationships involving feeding approaches, dietary quality, and selected aspects of cognitive, language, and social development, while emphasizing limitations in the available evidence (20). Developmental progression is influenced by numerous interacting factors, including genetic characteristics, nutritional status, caregiver responsiveness, environmental stimulation, health conditions, and opportunities for learning. Nutrition contributes to early brain development through processes involving neuronal growth, synaptic organization, myelination, and the availability of essential nutrients required for neurological function. However, these biological relationships do not establish that a counseling intervention necessarily produces measurable changes across all developmental domains over a particular follow-up period (21).

The greater developmental score increases observed in the intervention group therefore warrant consideration of both potential intervention effects and alternative explanations. Infants naturally acquire developmental abilities with increasing age, and baseline-to-follow-up score changes may reflect maturation as well as changes in caregiving practices. The use of a concurrent comparison group helps distinguish the observed pattern from maturation alone, but differences in caregiver education, household income, early stimulation, illness frequency, breastfeeding history, and other unmeasured characteristics may also contribute. The baseline-adjusted analyses accounted for initial outcome values, but they cannot eliminate confounding arising from characteristics that were not adequately controlled. The observed associations should therefore be interpreted with caution, particularly when considering the magnitude of developmental differences.

The adjusted anthropometric results also provide useful information beyond the absolute growth increments. Changes in body weight and length are expected during infancy, even without an intervention. Growth z scores allow these changes to be considered relative to reference distributions rather than only as increases in physical size. The more favorable changes in weight-for-age, length-for-age, and weight-for-length z scores in the intervention group suggest that the findings were not confined to absolute anthropometric gains. However, nutritional interpretation also depends on baseline anthropometric status, the characteristics of the reference population, duration of observation, and the possibility of regression toward the mean. The clinical importance of relatively modest changes in z scores should be evaluated alongside the infant's initial nutritional status and subsequent growth trajectory.

The findings have potential implications for pediatric and community health services. Routine clinical appointments offer opportunities for early identification of inappropriate complementary feeding practices, particularly during the transition from exclusive breastfeeding to increasingly varied family foods. Individualized counseling may be incorporated into existing services such as growth monitoring, preventive health consultations, immunization visits, and developmental surveillance. Such an approach may be especially relevant where caregivers experience barriers involving food affordability, limited dietary diversity, cultural beliefs, or uncertainty about age-appropriate feeding practices. Nevertheless, the feasibility of wider implementation would depend on available health personnel, counseling time, training, caregiver participation, and local service resources. The present study did not examine implementation costs or comparative resource requirements, and its findings should not be interpreted as evidence of cost-effectiveness.

Several methodological strengths contribute to the interpretation of the study. The use of a prospective comparative approach permitted assessment of changes in outcomes over time rather than reliance on a single cross-sectional measurement. The inclusion of a routine-care comparison group provided a relevant clinical reference for evaluating the additional counseling component. Assessment of absolute anthropometric measurements, relative growth indicators, and multiple developmental domains allowed a broader consideration of infant health. The individualized nature of counseling also reflects the practical circumstances of clinical care, where feeding recommendations need to respond to differences among infants and families rather than follow an entirely uniform model.

Important limitations must also be considered. The relatively small sample size may reduce the precision and stability of estimates, particularly when several related outcomes are assessed. Recruitment from a single clinical setting limits the generalizability of findings to populations with different socioeconomic backgrounds, feeding traditions, and patterns of health-service access. The controlled interventional design remains vulnerable to selection bias and residual confounding when participant allocation and relevant baseline characteristics are not sufficiently controlled. Developmental outcomes may also be affected by assessment conditions, caregiver reporting, natural maturation, and measurement variability. Interpretation of developmental score differences requires particular caution because their clinical meaning depends on the measurement instrument, scoring properties, and age-specific interpretation. Multiple outcome comparisons further increase the possibility of chance findings, even where individual p-values are below conventional significance thresholds.

Additional limitations relate to intervention fidelity and longer-term interpretation. Differences in the degree to which caregivers understood or implemented feeding recommendations may have influenced the observed response. The specific contribution of dietary changes cannot be separated from other aspects of caregiver behavior without more detailed process and adherence measures. Furthermore, improvements observed during the study period do not establish whether anthropometric or developmental differences persist into later childhood. Longer-term follow-up is necessary to determine whether the associations are sustained and whether they correspond to clinically meaningful developmental outcomes.

Future studies should involve larger and more diverse populations, clearly defined allocation procedures, reproducible counseling protocols, standardized developmental assessments, and prespecified primary outcomes. Appropriate control of relevant nutritional, caregiver, and socioeconomic factors would improve estimation of the additional contribution of individualized counseling. Assessing caregiver adherence, changes in dietary intake, and intervention delivery would also help clarify mechanisms and practical implementation requirements. Longer-term developmental follow-up would be particularly valuable for determining whether early differences in developmental scores are maintained.

Overall, the present findings suggest that integrating personalized complementary feeding counseling with routine child health care may be associated with more favorable growth and developmental outcomes during infancy. The consistency of the observed direction across anthropometric and developmental indicators supports further investigation of this integrated approach. Nevertheless, the results should be interpreted within the methodological limitations of the study, and confirmation through adequately powered investigations with stronger control of confounding and clearly defined measurement procedures remains important.

CONCLUSION

Personalized complementary feeding counseling combined with routine child health care was associated with greater improvements in anthropometric measurements, growth z scores, and developmental scores among infants compared with routine child health care alone. The observed differences across physical growth and multiple developmental domains suggest that individualized feeding guidance may provide additional value within routine pediatric services. However, the findings do not establish a definitive causal relationship, and their clinical significance requires confirmation through larger controlled studies using standardized developmental measures, clearly defined intervention procedures, and longer-term follow-up.

DECLARATIONS

Authors' Contributions:	Concept: MT, FA; Design: MT, ANH, FA; Data Collection: MT, ANH; Analysis: MT, FA; Drafting: MT, ANH, FA.
Ethical Approval:	The institution responsible for ethical review was Dimensions: Institute for Autism, Special Education, Physical Rehabilitation & Psychological Services, Lahore, Pakistan
Informed Consent:	Written informed consent was obtained from all participants before enrolment.
Conflict of Interest:	The authors declare no conflict of interest.
Funding:	No external funding was received for this study.
Data Availability:	De-identified data may be available from the corresponding author on request, subject to participant consent and institutional confidentiality requirements.
Acknowledgments:	None.
AI Declaration:	Generative AI tools were used solely for language and grammatical refinement. The authors verified the final manuscript and remain fully responsible for its accuracy, integrity, and scientific content.

REFERENCES

1. World Health Organization. WHO guideline for complementary feeding of infants and young children 6–23 months of age. Geneva: World Health Organization; 2023.
2. United Nations Children's Fund. Improving young children's diets during the complementary feeding period: UNICEF programming guidance. New York: UNICEF; 2020.
3. Lutter CK, Grummer-Strawn LM, Rogers LM. Complementary feeding of infants and young children 6 to 23 months of age. *Nutr Rev*. 2021;79(8):825–846. doi:10.1093/nutrit/nuaa143.
4. Pérez-Escamilla R, Jimenez EY, Dewey KG. Responsive feeding recommendations: harmonizing integration into dietary guidelines for infants and young children. *Curr Dev Nutr*. 2021;5(6). doi:10.1093/cdn/nzab076.
5. Zaman S, Ashraf RN, Martines J. Training in complementary feeding counselling of healthcare workers and its influence on maternal behaviours and child growth: a cluster-randomized controlled trial in Lahore, Pakistan. *J Health Popul Nutr*. 2008;26(2):210–222. doi:10.3329/jhpn.v26i2.594.
6. Saleem AF, Mahmud S, Baig-Ansari N, Zaidi AKM. Impact of maternal education about complementary feeding on their infants' nutritional outcomes in low- and middle-income households: a community-based randomized interventional study in Karachi, Pakistan. *J Health Popul Nutr*. 2014;32(4):623–633.
7. Manikam L, Sharmila A, Dharmaratnam A, Alexander EC, Kuah JY, Prasad A, et al. Systematic review of infant and young child complementary feeding practices in South Asian families: the Pakistan perspective. *Public Health Nutr*. 2018;21(4):655–668. doi:10.1017/S1368980017002956.
8. Arikpo D, Edet ES, Chibuzor MT, Odey F, Caldwell DM. Educational interventions for improving primary caregiver complementary feeding practices for children aged 24 months and under. *Cochrane Database Syst Rev*. 2018;5(5). doi:10.1002/14651858.CD011768.pub2.
9. English LK, Obbagy JE, Wong YP, Butte NF, Dewey KG, Fox MK, et al. Complementary feeding and developmental milestones: a systematic review. *Am J Clin Nutr*. 2019;109(Suppl 7):879S–889S. doi:10.1093/ajcn/nqy321.
10. Aboud FE, Moore AC, Akhter S. Effectiveness of a community-based responsive feeding programme in rural Bangladesh: a cluster randomized field trial. *Matern Child Nutr*. 2008;4(4):275–286. doi:10.1111/j.1740-8709.2008.00146.x.
11. Aboud FE, Shafique S, Akhter S. A responsive feeding intervention increases children's self-feeding and maternal responsiveness but not weight gain. *J Nutr*. 2009;139(9):1738–1743. doi:10.3945/jn.109.104885.
12. Aboud FE, Akhter S. A cluster-randomized evaluation of a responsive stimulation and feeding intervention in Bangladesh. *Pediatrics*. 2011;127(5). doi:10.1542/peds.2010-2160.
13. Bhandari N, Bahl R, Nayyar B, Khokhar P, Rohde JE, Bhan MK. Food supplementation with encouragement to feed it to infants from 4 to 12 months of age has a small impact on weight gain. *J Nutr*. 2001;131(7):1946–1951.
14. Taylor RW, Williams SM, Fangupo LJ, Wheeler BJ, Taylor BJ, Daniels L, et al. Effect of a baby-led approach to complementary feeding on infant growth and overweight: a randomized clinical trial. *JAMA Pediatr*. 2017;171(9):838–846. doi:10.1001/jamapediatrics.2017.1284.
15. Yousafzai AK, Rasheed MA, Rizvi A, Armstrong R, Bhutta ZA. Effect of integrated responsive stimulation and nutrition interventions in the Lady Health Worker programme in Pakistan on child development, growth, and health outcomes: a cluster-randomised factorial effectiveness trial. *Lancet*. 2014;384(9950):1282–1293. doi:10.1016/S0140-6736(14)60455-4.
16. Yousafzai AK, Obradović J, Rasheed MA, Rizvi A, Portilla XA, Tirado-Strayer N, et al. Effects of responsive stimulation and nutrition interventions on children's development and growth at age 4 years in a disadvantaged population in Pakistan: a longitudinal follow-up of a cluster-randomised factorial effectiveness trial. *Lancet Glob Health*. 2016;4(8). doi:10.1016/S2214-109X(16)30100-0.

17. Zhang Y, Wu Q, Wang W, van Velthoven MH, Chang S, Han H, et al. Effectiveness of complementary food supplements and dietary counselling on anaemia and stunting in children aged 6–23 months in poor areas of Qinghai Province, China: a controlled interventional study. *BMJ Open*. 2016;6(10). doi:10.1136/bmjopen-2016-011234.
18. Rahman A, Bhuiyan MB, Das SK. Effect of short-term educational intervention on complementary feeding index among infants in rural Bangladesh: a randomized control trial. *BMC Nutr*. 2022;8(1):73. doi:10.1186/s40795-022-00565-0.
19. Has EMM, Nursalam, Arief YS. Improving complementary feeding practice and child growth in Indonesia through family empowerment intervention. *J Pak Med Assoc*. 2023;73(Suppl 2). doi:10.47391/JPMA.Ind-S2-2.
20. Di Prete A, Galloway AT, Farrow C, Bellagamba F, Addressi E. A systematic review of the relation between complementary feeding and children's development. *Curr Nutr Rep*. 2025;14(1):104. doi:10.1007/s13668-025-00692-7.
21. Prado EL, Dewey KG. Nutrition and brain development in early life. *Nutr Rev*. 2014;72(4):267-284. doi:10.1111/nure.12102.