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# Recovery in Young Children with Weight Faltering: Child and Household Risk Factors

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## Abstract

**Objective—**To examine whether weight recovery among children with weight faltering varied by enrollment age and child and household risk factors.

**Study design—**Observational, conducted in an interdisciplinary specialty practice with a skill-building mealtime behavior intervention, including coaching with video-recorded interactions. Eligibility included age 6–36 months with weight/age <5$^{th}$ percentile or crossing of two major percentiles. Children were categorized as <24 months vs ≥24 months. Child and household risk factors were summed into risk indices (top quartile, elevated risks, vs. reference). Outcome was weight/age z-score change over 6 months. Analyses were conducted with longitudinal linear mixed-effects models, including age by risk index interaction terms.

**Results—**Enrolled 286 children (mean age 18.8 months, SD 6.8). Significant weight/age recovery occurred regardless of risk index or age. Mean weight/age z-score change was significantly greater among younger, compared with older age (0.29 vs. 0.17, p=0.03); top household risk quartile, compared with reference (0.34 vs. 0.22, p=0.046); and marginally greater among top child risk quartile, compared with reference (0.37 vs. 0.25, p=0.058). Mean weight/age z-score change was not associated with single risk factors, or interactions; greatest weight gain occurred in most underweight children.

**Conclusions—**Weight recovery over 6 months was statistically significant, although modest, and greater among younger children and among children with multiple child and household risk factors. Findings support Differential Susceptibility Theory, whereby some children with multiple risk factors are differentially responsive to intervention. Future investigations should evaluate components of the mealtime behavior intervention.

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**Keywords**

Failure-to-thrive; Differential Susceptibility Theory; child growth; intervention; responsive feeding; mealtime habits

Growth monitoring is a central component of pediatric primary care.[1] Failure-to-thrive (weight faltering)[2] in the first 1000 days (conception to age 24 months) has been associated with long-term negative health and developmental consequences.[3] Strategies to prevent weight faltering often focus on child, family, and household risk factors that have been associated with weight faltering.[2, 4, 5] Child risks include prematurity,[6] low birth weight,[6] stunting[7, 8] (an indicator of chronic undernutrition), developmental delays,[2] and concurrent medical problems.[2] Feeding problems (e.g., food refusal, pickiness) are common among children with weight faltering.[9] Temperamentally easy children establish self-regulatory feeding behaviors,[10] whereas temperamentally difficult children tend to resist change and be at risk for poor appetite and feeding problems, particularly if they are hypersensitive or dysregulated.[2, 4, 5] Although difficult temperament has been associated with feeding problems,[11] the association may be mediated by parental feeding practices.[12]

Family and household risks for weight faltering include lack of household stability indicated by multiple moves and crowding,[13, 14] single parenthood,[15] low maternal education,[16] maternal depressive symptoms,[17–19] mealtime stress,[9] poverty,[20, 21] and a history of maltreatment and incarceration.[22] Food insecurity in high-income countries has not been associated with weight faltering in young children,[23] but may limit the quality of available food, increasing the risk for nutritional deficiencies.[24]

Referrals to specialty clinics for weight faltering often result in weight recovery,[25,26] but little is known about how recovery relates to the multiple risk factors that frequently co-occur with weight faltering.[27]

In many cases, interventions are designed to reduce risk factors. However, Differential Susceptibility Theory (DST) suggests that some children are differentially susceptible to adversity and environmental interventions;[28] they may be both negatively affected by risk factors and positively affected by environmental interventions. If DST applies to children with weight faltering, children with multiple risk factors may have a positive response to a skill-building intervention. To examine this possibility, we implemented an intervention grounded in Social Cognitive Theory (SCT) in a Growth and Nutrition Clinic addressing mealtime behavior and eating habits through caregiver modeling and self-efficacy.[29, 30] For this study we examined whether children with multiple risk factors were differentially responsive to the intervention, and also whether children enrolled early in life, within the first 24 months, experienced better weight recovery than older children.

## Methods

Children experiencing weight faltering (weight/age <5$^{th}$ percentile or crossing two major percentiles) were referred by their primary care provider to an interdisciplinary specialty practice in a mid-Atlantic urban medical center from 2010 through 2014.

Caregivers were invited to participate in a weight recovery study that was approved by the University's Institutional Review Board. Over 95% of caregivers agreed and signed informed consent for themselves and their child. Inclusion criteria were age 6–36 months, oral feeding, and no known genetic disorders. Caregivers did not receive compensation. Children who completed at least two follow-up evaluations were retained in the longitudinal analysis.

The procedures were part of usual care in the interdisciplinary practice. Medical records were reviewed and caregivers completed an intake evaluation, including questionnaires on demographics, service receipt, feeding patterns, and child temperament. Children were weighed and measured by a trained medical assistant. The enrollment evaluation included individual clinician evaluations (pediatrician, psychologist, and dietitian) and a video-recorded mealtime observation.[31,32]

At the conclusion of the initial evaluation, families received a notebook with the child's growth chart, a calendar, information on infant/toddler nutrition and development, and specific recommendations. A comprehensive report was sent to the referring physician and children were scheduled for a follow-up appointment.

During all visits, children were undressed to a clean diaper or underpants and weighed and measured in triplicate using standardized procedures. Z-scores for growth varibles were calculated based on age- and sex-specific CDC growth charts.[33]

Data on 7 child risk factors and 9 household risk factors were collected at enrollment (Table I). The 2-item Food Security Screener (FSS)[34] was added to the intake procedure after the study was initiated and therefore not included in the risk indices.

## Intervention

The skill-building mealtime behavior intervention was provided to all families as part of usual care in the clinic and included 4 components

**Access to healthy food—**Families were counseled to provide a healthy and diverse diet (fruits, vegetables, dairy, whole grains, and meat), to avoid high sugar/salt, low nutrient dense foods and beverages, and to increase calories in their children's food by adding butter, oil, cheese, or peanut butter, and if necessary, to give nutritional supplements after meals, not as meal replacements.

**Healthy eating habits—**To build healthy habits, families were encouraged to establish consistent routines (times and places) for family meals and snacks, eliminate grazing,[37] minimize distractions (television), engage in pleasant conversation about daily events, and eat together with children seated at eye level with their caregivers to promote modeling.[38]

**Appetite and Autonomy—**To increase appetite, children should be hungry at meals, encouraged to touch and pick up food (progressing from finger feeding to utensils),[39] and be actively involved in meal preparation.[40]

**Responsive Feeding—**Responsive feeding refers to the caregiver-child relationship.[41] Through a coaching process, caregivers viewed the video-recorded mealtime interaction and were shown how to model positive behaviors from themselves and respond to their child's cues. Caregivers were encouraged to decide where and when mealtimes occur and what food is offered; children decide how much to eat.[42] This strategy was designed to help caregivers build confidence in the child's self-regulatory ability to determine hunger and satiety, without pressuring, coaxing, or bribing.

### Statistical analyses

The dependent variable was change in weight/age z-score.[35] Bivariate associations between individual child and household risk factors were not significantly associated with change in weight/age z-score. Child and household risk factors were summed to form the Child Risk Factor Index (CR) and Household Risk Factor Index (HR).[36] The top quartile (≥ 4 risk factors for both indices) represented high child or household risk factors, and the bottom three quartiles served as the reference.

The three independent variables were CR, HR, and age at enrollment. The top quartile CR and HR were compared with the reference. Enrollment age was divided into < 24 months vs. ≥ 24 months. The independent variables were not correlated (r=0.02–0.08, p>0.17). Estimated weight gain was calculated at 6 months.

Bivariate associations among demographic variables, independent variables, and change in weight/age were assessed using the Wilcoxon Rank-Sum test, the Pearson Chi-square test, ANOVA, and the t-test where appropriate. Separate longitudinal linear mixed-effects models with random intercept (due to variation in follow-up duration) were developed for each independent variable (CR, HR, and age at enrollment). To examine moderating effects among the independent variables, interaction terms were formed (CR/HR, age/CR, and age/HR). To examine how enrollment anthropometry related to weight gain extremes, we conducted post hoc analyses comparing the top weight gain quartile with the bottom weight gain quartile. P values < 0.05 were considered significant and due to the exploratory nature of the investigation, p values <0.10 were considered marginal. Analyses were conducted using SAS 9.3 (Cary, NC).

## Results

The sample included 286 children (age 6–36 months (mean 18.8, SD 6.8)). Based on caregiver report, over half the children were Black (59%) and 20% of households were food insecure (Table II). The majority of children had weight/age and weight/length scores below −2 z-scores (2.3$^{rd}$ percentile) (86% and 53%, respectively), few (12%) had length/age below −2 z- scores (Table II).

The most prevalent child risk factors were medical co-morbidities (38%) and hypersensitivity (33%). Approximately one-quarter experienced low birth weight/prematurity, developmental risk, or feeding problems. The most prevalent household risk factor was single caregiver (56%). Approximately one-quarter experienced crowding, low maternal education, depressive symptoms, mealtime stress, or incarcerated family member.

Between 8–11% of the children were exposed to maltreatment, extreme poverty, or multiple moves.

Follow-up criteria were met by 202 (71%) of the children; mean duration was 7.3 (2.6) months. None of the enrollment measures of weight/age, weight/length, and length/age and none of the individual risk factors were associated with change in mean weight/age z-score.

### Child Risk Factor Index

Children in the top quartile CR had significantly lower weight/age z-scores at enrollment than the reference group (p=0.03; Table III). Both groups experienced significant improvement in weight/age z-scores (p<0.0001). The top quartile had marginally greater mean weight/age zscore change than the reference (0.37 vs. 0.25, p=0.058), eliminating differences in mean weight/age z-score by CR status after 6 months. The interaction terms were not significant.

### Household Risk Factor Index

Household risk factors were not associated with weight/age z-scores at enrollment (Table III). Children in the top quartile HR and the reference group experienced significant improvement in weight/age z-score over 6 months (p<0.0001), with greater mean weight/age z-score change among the top quartile group than the reference (0.34 vs. 0.22, p=0.046). The interaction terms were not significant.

### Age at Enrollment

Younger children (< 24 months) had lower weight/age z-scores than older children (≥ 24 months) at enrollment (−2.47 vs. −2.21), but the differences were not significant, p=0.10. Both groups had significant improvement in weight/age z-scores; younger children had greater mean weight/age z-score change (0.29 vs 0.17, p=0.03), reducing differences in mean weight/age z-score by age after 6 months. The interaction terms were not significant.

### Post hoc analyses of extreme differences in weight/age change

When the sample was divided into quartiles by change in weight/age over the 6 month period, the top quartile had a weight/age change of 0.88 z-scores and the bottom quartile had a change of −0.12 z-scores. In a comparison of enrollment data, the top quartile (greatest weight gain) vs. the bottom quartile had lower weight/age z scores [−3.04 (0.91) vs. −2.25 (1.03) respectively; p <0.0001] and lower weight/length z-scores [−2.66 (1.25) vs. −1.69 (1.07) respectively; p<0.0001]. There were no differences in enrollment length [−1.19 (0.86) for the top quartile vs −1.11 (1.05) for the bottle quartile; p =0.68].

## Discussion

Children with failure-to-thrive (weight faltering) experienced statistically significant, although modest, weight gains over 6 months. The absence of associations between individual risk factors and improvement in weight/age is consistent with risk accumulation theory,[27, 30] whereby the combination of risk factors, rather than single risks, increases vulnerability.

The association between high CR scores with low weight/age at enrollment verifies that the CR captured aspects of children's health associated with poor growth, such as prematurity, low birth weight, and co-morbid medical conditions. Although children experienced significant weight gain, regardless of their CR scores, children with high CR scores experienced marginally greater weight gain than children with low CR scores, even though several of the risk factors were immutable. One possible explanation, consistent with DST, is that in the context of both low weight/age and multiple child risk factors, caregivers may have adopted components of the mealtime behavior intervention. However, systematic data on intervention adherence were not available.

The absence of a relation between household risk factors and children's weight/age at enrollment suggests that children's early growth may be more closely linked to prenatal and child level factors than household factors. However, children with high HR scores, representing multiple risks, experienced significantly greater weight gain than children with low HR scores during the intervention period. This finding may suggest that children in high risk situations are more susceptible to positive interventions than children in low risk situations, as theorized by DST.[28, 43] The pickiness and feeding problems that are relatively common among children with weight faltering[9] often increase through toddlerhood.[44] In the context of multiple household risk factors, caregivers may have had limited tolerance and resources to handle feeding problems, potentially resorting to non-productive and controlling strategies of forcing or pressuring children to eat.[45] These strategies are generally unsuccessful,[46] often resulting in caregiver frustration and stressful mealtime interactions. Multi-risk households may have created readiness to adopt a skill-building mealtime behavior intervention.

Although children experienced significant weight gain regardless of enrollment age, children under age 24 months experienced significantly greater weight gain than older children, regardless of risk factors. A possible explanation may be that younger children and their parents can adopt changes such as complementary feeding and structuring mealtime routines as they are acquiring skills, whereas older children and parents have developed maladaptive mealtime habits that are difficult to change.[39, 40]

The children with the greatest weight gain over six months were the thinnest at enrollment, based on weight/age or weight/length. These children were the most vulnerable, with signs of malnutrition, and therefore the most responsive to interventions, with a mean weight gain that approximated 1.5 percentiles. In contrast, the children who gained the least weight were the heaviest at enrollment, perhaps suggesting that they may have been small, but not necessarily experiencing weight faltering and therefore unable to gain catch-up weight. Enrollment length was not related to weight/age change. The relatively low rate of stunting (12%) suggests that chronic undernutrition was relatively rare and it is unlikely that constitutional short children were mislabeled as faltering.

This study has several methodological limitations. First, in the absence of a control group, the children's improvement cannot be attributed to the intervention. Second, many of the risks were evaluated through caregiver report and may reflect recall bias. Third, as noted, there were no systematic data on intervention adherence or on the mechanisms that

contributed to changes in weight gain. Fourth, there may be other factors that contribute to weight gain that were not addressed in the current study. Finally, findings do not generalize beyond low-income, predominantly Black children with weight faltering who sought primary care and were referred to an interdisciplinary specialty practice.

There are also important strengths, including the systematic examination of child and household risk factors, the longitudinal follow-up and analysis of children with weight faltering, the implementation of an SCT-informed practice-based intervention focused on positive habit formation, and the application of DST to weight faltering, a relatively common clinical problem with adverse outcomes.

The differential findings related to child and household risk factors and child age serve as a reminder that context and accumulation of risks play important roles in children's weight recovery. Although risks may undermine children's growth, children may be differentially responsive to SCT-grounded, skill-building interventions, in keeping with the principles of DST.[47] In addition, the weight recovery among children under 24 months illustrates the importance of intervening early in life during habit formation.

Weight recovery among children with weight faltering was significant, but modest, in an interdisciplinary specialty practice. Overall, weight recovery was greater among younger children and children with multiple child and/or household risk factors. Future investigations could evaluate components of the mealtime behavior intervention, including strategies such as video-recorded mealtime feedback, using a randomized trial design in either home-based or practice-based platforms. Early weight faltering may be a marker for significant risks to children's growth, particularly in the context of child and household risk factors.

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## Abbreviations

| | |
|---|---|
| **DST** | Differential Susceptibility Theory |
| **SCT** | Social Cognitive Theory |
| **CR** | Child Risk Factor Index |
| **HR** | Household Risk Factor Index |
| **IQR** | Interquartile range |
| **SD** | Standard deviation |

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## Table 1

Child and Household Risk Factors Gathered at Enrollment

| Risk Factors | Source | Criteria |
|---|---|---|
| **Child** | | |
| Low-birth-weight/prematurity. | Caregiver report, medical record | Birth-weight < 2500 g or gestational age < 37 weeks |
| Stunting | Measured | Length/age <−2 z-scores |
| Temperament: Hypersensitivity and dysregulation | Hypersensitive and dysregulation subscales, Temperament and Atypical Behavior Scale (TABS)[48] | Top quartile |
| Medical Co-morbidities | Caregiver report, medical record | Medical specialty services |
| Developmental Risk. | Parents' Evaluation of Developmental Status (PEDS)[49] | > 1 developmental concern or early intervention services. |
| Feeding Problems | Feeding subscale, Behavioral Pediatrics Feeding Assessment Scale (BPFAS)[50] | Top quartile |
| **Household** | | |
| Moves | Caregiver report | ≥ 2 in the past year |
| Crowding | Caregiver report | >2 child/adult ratio or > 6 household members |
| Single | Caregiver report | Not married |
| Maternal education | Caregiver report | < high school education/GED |
| Depression | 2-item depression screening questionnaire[51] | Endorsement of ≥ 1 item |
| Mealtime stress | Parent subscale, BPFAS[50] | Top quartile |
| Extreme poverty | Caregiver report | Receipt of Temporary Assistance for Needy Families |
| Maltreatment | Caregiver report | Child Protective Services |
| Incarceration | Caregiver report | Incarceration of family membe |

**Table 2**

Child and family demographic characteristics at enrollment (N=286)

| | |
|---|---|
| Child's sex – n (%) | |
| Male | 144 (50%) |
| Female | 142 (50%) |
| Child's age, mon – mean (SD) | 18.8 (6.8) |
| Child's race – n (%) | |
| Black | 170 (59%) |
| White | 83 (29%) |
| Other | 33 (12%) |
| Child's enrollment anthropometry – n (%) | |
| Weight/age < −2.0 z-scores | 246 (86%) |
| Length/age < −2.0 z-scores | 34 (12%) |
| Weight/length < −2.0 z-scores | 152 (53%) |
| Weight/age z-score change* – mean (SD) | 0.3 (0.4) |
| Children followed up – n (%) | 202 (71%) |
| Follow-up time, months – mean (SD) | 7.3 (2.6) |
| Mother's age, years – mean (SD) | 28.8 (6.4) |
| Mother employed – n (%) | 153 (55%) |
| Risk Factor Indices – median (IQR) | |
| Child Risk Factor Index | 2 (1–3) |
| Household Risk Factor Index | 2 (1–3) |
| Household Food Insecurity** – n (%) | 13 (20%) |

*Change from enrollment to 6 months

**Food insecurity was assessed for 65 (23%) of the 286 enrolled participants

SD: Standard deviation
IQR: Inter-quartile range

## Table 3

Linear mixed-effects models predicting change in weight/age z-score over 6 months (N=202)

| | **Enrollment Mean** *(95% CI)* | **6-Month Change** *(95% CI)* | **6-Month Mean** *(95% CI)* | **p-value**[a] |
|---|---|---|---|---|
| **Child Risk Factor Index** | | | | |
| Top Quartile | −2.82 *(−3.17, −2.43)* | 0.37 *(0.27, 0.48)* | −2.45 *(−2.56, −1.79)* | < **0.0001** |
| Reference | −2.36 *(−2.51, −2.21)* | 0.25 *(0.20, 0.31)* | −2.10 *(−2.25, −1.95)* | < **0.0001** |
| **p-value**[b] | **0.03** | **0.058** | **0.10** | |
| **Household Risk Factor Index** | | | | |
| Top Quartile | −2.55 *(−2.88, −2.21)* | 0.34 *(0.24 0.43)* | −2.21 *(−2.55, −1.88)* | < **0.0001** |
| Reference | −2.33 *(−2.49, −2.17)* | 0.22 *(0.16, 0.28)* | −2.11 *(−2.27, −1.94)* | < **0.0001** |
| **p-value**[b] | **0.26** | **0.046** | **0.60** | |
| **Age at Referral** | | | | |
| ≥ 24 Months | −2.21 *(−2.48, −1.94)* | 0.17 *(0.08, 0.26)* | −2.04 *(−2.31, −1.77)* | < **0.001** |
| < 24 Months | −2.47 *(−2.62, −2.32)* | 0.29 *(0.24, 0.35)* | −2.18 *(−2.33, -2.02)* | < **0.0001** |
| **p-value**[b] | **0.10** | **0.03** | **0.88** | |

[a] p-value for significant within-group 6-month change in weight/age z-score from enrollment

[b] p-value for significant group difference in enrollment mean, 6-month change, and 6-month mean weight/age z-score