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Version Post-print/accepted manuscript

Citation (published version) van den Heuvel, M., Chen, Y., Abdullah, K., Maguire, J. L., Parkin, P. C., Birken, C. S., and on behalf of the TARGet Kids! Collaboration (2017) The concurrent and longitudinal associations of temperament and nutritional risk factors in early childhood. *Pediatric Obesity*, 12: 431–438. doi: 10.1111/ijpo.12161.

Publisher's Statement This is the peer reviewed version of the following article: van den Heuvel, M., Chen, Y., Abdullah, K., Maguire, J. L., Parkin, P. C., Birken, C. S., and on behalf of the TARGet Kids! Collaboration (2017) The concurrent and longitudinal associations of temperament and nutritional risk factors in early childhood. *Pediatric Obesity*, 12: 431–438. doi: 10.1111/ijpo.12161, which has been published in final form at DOI: 10.1111/ijpo.12161. This article may be used for non-commercial purposes in accordance with Wiley Terms and Conditions for Self-Archiving.

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The concurrent and longitudinal associations of temperament and nutritional risk factors in early childhood

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Keywords: temperament, nutrition, early childhood

Running title: temperament and nutrition in early childhood

What is already known about this subject

- Temperament is increasingly identified as an important early childhood determinant of health
- High negative reactivity may be an early risk factor for childhood obesity
- Increased self-regulation might be protective for childhood obesity

What this study adds

- Three year old children with higher effortful control had reduced nutritional risk factors and a reported healthier dietary intake at five years of age
- Higher negative affectivity was associated with a concurrent increased nutritional risk but was not associated with a change in nutritional risk over time
- This study did not identify any relationship between surgency and nutritional risk factors

Summary

Background: Early childhood temperament is increasingly recognized as an important attribute that may impact screen time use, outdoor play and childhood obesity. The relationship between temperament and nutrition in preschool children is less clear.

Objective: To investigate if temperament dimensions (negative affectivity, effortful control and surgency) in early childhood are associated with nutritional risk factors.

1 Methods: 678 children were followed (mean age at baseline visit 3.1 years; mean time to
2 follow-up 16.5 months). Parents reported on child temperament and nutritional risk
3 factors during regularly scheduled well-child clinic visits.

4 Results: A mixed effect model demonstrated a significant association between higher
5 negative affectivity (1.03; 95% CI 0.69 to 1.37) and higher effortful control (-0.88; 95%CI
6 -1.27 to -0.49) on concurrent nutritional risk, independent of covariates. Multivariate
7 linear regression analysis identified that higher effortful control, and not negative
8 affectivity, was significantly associated with a decrease in nutritional risk (-0.67; 95%CI -
9 1.10 to -0.24) over time, independent of covariates. There was no relationship identified
10 between surgency and nutritional risk.

11
12 Conclusion: Three year old children with higher effortful control had reduced nutritional
13 risk at 5 years of age. Future nutritional risk prevention strategies may benefit from
14 interventions to increase effortful control in early childhood.

16 **Introduction**

17 Nutrition plays an essential role in growth and development, academic success and in
18 the social- and emotional well-being of children (1,2). Important examples of nutrition
19 related risk factors and health outcomes in young children include prolonged bottle use
20 contributing to iron deficiency and increased screen time and excessive intake of sugar
21 sweetened beverages contributing to obesity (2,3). Nutritional risk has been defined as
22 “the presence of risk factors that can lead to impaired nutritional status” (4).

23 Many child-, family- and social factors and their complex interactions influence
24 child nutrition (5). Temperament has been defined as biologically based individual
25 differences in reactivity and self-regulation, influenced over time by heredity and
26 experience (6). Each child has 3 main reactive dispositions of temperament: 1) negative

1 affectivity (e.g. sadness, discomfort), 2) effortful control (e.g. attention shifting, focusing,
2 inhibitory, activational control) 3) extraversion/ surgency (e.g. positive emotionality,
3 activity, impulsivity) (7).

4 A recent workshop conducted by the National Institute of Health identified the
5 need for studies that address how individual differences in early temperament contribute
6 to obesity (8). Emerging evidence suggests that high negative reactivity may be an early
7 risk factor for childhood obesity (9-12). Other studies also identified associations
8 between low effortful control, high negative affectivity and more television viewing and
9 reduced outdoor play in young children (13,14). Additionally, a recent study by Leung et
10 al (2015) in low-income preschoolers revealed that high levels of surgency predicted
11 more food responsiveness and enjoyment of food leading to a higher concurrent Body
12 Mass Index (BMI) (15). Only one study investigated the relationship between
13 temperament and food-intake directly. They concluded that both internalizing (anxious,
14 dependent) and externalizing (hyperactive, aggressive) temperament in 18-month old
15 children were risk factors for consuming more sweet drinks and foods at 3 and 7 years
16 (16). In addition, somewhat contradictory to the study of Leung et al, this study also
17 reported that high surgent (active, sociable) 18-month old infants were more likely to
18 consume a healthy diet with higher intake of fruits and vegetables daily at 3 and 7 years.
19 However this study was limited by assessment of temperament at only one time point
20 (18 months) and used a non-validated measure of temperament (16).

21 The present study tested the hypothesis that in early childhood higher negative
22 affectivity and lower effortful control are associated with an increased nutritional risk and
23 an unhealthy dietary intake over time. Furthermore, because of this somewhat
24 contradictory evidence that children with high surgency were both at risk of high BMI,
25 and yet had a higher fruit and vegetable intake, our study aimed to add to the literature
26 and examined the impact of temperament on later dietary intake.

1

2 **Methods**

3 *Study Design and Setting*

4 This was a longitudinal cohort study of children, aged 3-5 years, recruited during
5 scheduled well-child clinic visits from primary care practices participating in *TARGet*
6 *Kids!* (17). *TARGet Kids!* is a community-based primary care research network in
7 Toronto, Canada. The study protocol, including recruitment procedures, has recently
8 been published (17).

9 At each annually scheduled well-child clinic visit standardized questionnaires
10 were completed by parents and anthropometric measures, including height and weight,
11 were collected by research assistants using standardized measures and procedures
12 (17). Children were included if they had a minimum of two assessments of both
13 temperament and nutritional risk. Exclusion criteria included children with health
14 conditions affecting growth (e.g. cystic fibrosis), any acute or chronic conditions (other
15 than asthma and high functioning autism), children with severe developmental delay and
16 families who were unable to communicate in English. All data generated from *TARGet*
17 *Kids!* were entered into a web-based data management system (Medidata Rave ®).
18 Ethics approval for the study was obtained from Research Ethics Boards of the Hospital
19 for Sick Children and St. Michael's Hospital, Toronto, Canada.

20

21 **Measures**

22 *Nutritional Risk*

23 The primary outcome was nutritional risk, as measured by the total score of the Nutrition
24 Screening Tool for Every Pre- schooler (NutriSTEP ®) (1). The NutriSTEP ® was
25 developed for children ages 3-5 years of age, and has been validated in multicultural
26 Canadian children by registered dietitians using a detailed history and 3-day dietary

recall (1). The NutriSTEP® includes 17 questions about nutritional risk factors including five domains; eating behaviors, dietary intake, parental concerns about food and activity (including food security), screen time duration and the use of supplements. Each question has 2-5 response options. Examples of questions include “My child is not hungry at meal times because he /she drinks all day”, “My child eats meals while watching TV” (response options: always, most of the time, sometimes, rarely, never).

We calculated the Total NutriSTEP® score by aggregating the score of each question (1). Higher total NutriSTEP® scores represent more nutritional risk factors and a greater nutritional risk (range of scores 0-68) (1). We used the continuous Total NutriSTEP® score as main outcome. For a secondary analysis, we dichotomized the Total NutriSTEP® score in two groups: high (Total NutriSTEP® score > 20) and low (Total NutriSTEP® score ≤ 20). In the clinical setting, the above-mentioned cut points are used; for children that have a Total NutriSTEP® score > 20 recommendations should be made to change the child’s eating and activity habits (1).

Unhealthy dietary intake was determined from the dietary intake domain score of the NutriSTEP® which included 6 questions about the intake of vegetables, fruit, grain, milk, meat or meat alternatives and ‘fast food’ (1). Higher scores of the dietary intake domain represent an unhealthier dietary intake (range of scores 0-24) (1).

Child Temperament Measure

Temperament was measured using the parent reported very short form of the Child Behavior Questionnaire (CBQ-VSF) for children 3 - 7 years (7). The CBQ-VSF includes 36 items and provides a comprehensive assessment of temperamental behavior patterns and has demonstrated satisfactory internal consistency, criterion validity and longitudinal stability (7,18). Parents were asked to rate their child on a 7-point scale ranging from 1 (extremely untrue of your child) to 7 (extremely true of your child). For

each child, the VSF-CBQ produced a summary score of each of the three separate temperament domains: Negative Affectivity, Effortful Control and Surgency. A child with a high level of negative affectivity has typically a lowered mood, is angry, fearful and very difficult to soothe (7). Children with a high level of effortful control have the capacity to suppress inappropriate responses, have better self-regulation and can maintain focus on task-related activities (7). Children with high surgency levels are impulsive, enjoy situations with high stimulus intensity and do not show discomfort in social situations (7).

Covariates

Relevant parental and family characteristics were assessed with a standardized survey instrument developed for *TARGet Kids!*, based on the Canadian Community Health Survey (19). Neighborhood income was measured using median neighborhood income from census data. The height and weight of children and their parents were measured using established protocols, and BMI was standardized to z-score BMI (zBMIs) using the World Health Organization growth standards (20). Parent BMI refers to the BMI of the parent who attended the clinic visit. In our study 85.5% was maternal BMI and 17.4% paternal BMI and in 91.3% the same parent attended all visits.

A number of child, parent and household characteristics may also contribute to the relationship between temperament and nutritional risk. For example mothers with a university education and older mothers have been shown to have more positive toddler feeding practices (21). The following clinically important covariates, that we identified from literature were included in all adjusted analysis models: child factors (age, sex, z-BMI), parent factors (maternal education, maternal age and parent BMI) and household factors (neighborhood income) (2,16,21).

Statistical Analysis

1 We calculated means, standard deviations and percentages to characterize the study
2 population, each of the three domains of temperament (Negative Affectivity, Surgency,
3 Effortful Control and Surgency), nutritional risk (Total NutriSTEP® score) and unhealthy
4 dietary intake (dietary domain score NutriSTEP®) at the baseline clinic visit and at
5 follow-up visits.

6 For the cross-sectional analysis we tested the overall association between the 3
7 temperament domains and the Total NutriSTEP® score. The analysis included all
8 temperament domains and the Total NutriSTEP® score at all three clinic visits
9 simultaneously (T1, T2, T3) adjusted for covariates above (Figure 1). We used a mixed
10 effect model to accommodate the correlation within subjects. We performed the same
11 analysis with the dietary intake domain score of the NutriSTEP® as an outcome. A
12 secondary cross-sectional analysis was performed using mixed effect logistic regression
13 analysis with the dichotomized Total NutriSTEP® score as outcome.

14 For the longitudinal analysis we used multivariate linear regression model with
15 correlated error structures to examine the effect of the three temperament domains on
16 changes in Total NutriSTEP® score over time accounting for within-subject level
17 correlations, while adjusting for the previous Total NutriSTEP® score and covariates.
18 The multivariate linear regression model used the change in Total NutriSTEP® score
19 (between preceding visits) as dependent variable and the three temperament domains at
20 the previous visit as main explanatory variables. For example, for the first follow-up visit
21 (T2) we used previous temperament and Total NutriSTEP® score from the baseline visit
22 (T1) (Figure 1). The same analysis was performed for the secondary outcome, using the
23 dietary intake domain score of the NutriSTEP®.

24 In all models we tested for interactions between age and the three temperament
25 domains; we planned a-priori to perform a stratified analysis by age groups if any
26 significant interactions were identified. Additionally we hypothesized that the impact of

negative affect could be different depending on the child's effortful control, and we tested for this interaction in the longitudinal model. It is unclear if child z-BMI is a true confounder of the relationship between temperament and nutritional risk, and therefore we performed a sensitivity analysis without child z-BMI (5,9). Figure 1 presents a schematic representation of our statistical analysis. Data was analyzed using R version 3.0.3. (22).

Results

678 children met inclusion criteria. All children had at least two clinic visits and 135 children had three clinic visits. The mean follow-up time was 16.5 months. Child, parent and household characteristics are presented in table 1.

Cross-sectional overall association between temperament and nutritional risk (see Figure 1)

Mixed effect modeling demonstrated that higher negative affectivity was associated with an increased Total NutriSTEP® score adjusted for covariates (adjusted *B* estimate 1.03; 95% CI 0.69 to 1.37). In contrast, higher effortful control was associated with a decreased Total NutriSTEP® score (adjusted *B* -0.88; 95%CI -1.27 to -0.49). No association was identified between surgency and the Total NutriSTEP® score (Table 2). The overall association between the temperament domains and unhealthy dietary intake demonstrated similar, but smaller effects, for both higher negative affectivity (adjusted *B* 0.31; 95% -0.12 to 0.50) and higher effortful control (adjusted *B* -0.66; 95% -0.80 to -0.44) (Table 2).

Logistic regression analysis of the dichotomized measure of the Total NutriSTEP® score identified that children with higher negative affectivity had an increased odds of nutritional risk (high vs. low: OR 1.58; 95%CI 1.11 to 2.27). In

contrast, higher effortful control was associated with a reduced nutritional risk (high vs. low: OR 0.34; 95%CI 0.22 to 0.53). No association between surgency and nutritional risk was identified.

Longitudinal effect of the three early temperament domains on changes in nutritional risk and unhealthy dietary intake (see Figure 1)

Table 2 presents the multivariate linear association between temperament and the change in nutritional risk at follow-up, adjusted for the previous Total NutriSTEP® score. Each one point higher effortful control at the previous clinic visit was associated with a significant reduction in the Total NutriSTEP ® score (adjusted B -0.67; 95%CI -1.06 to -0.28) at follow-up visits, independent of covariates. No significant associations were observed between either negative affectivity or surgency and a change in Total NutriSTEP ® score over time.

A similar result was demonstrated when examining the change in unhealthy dietary intake (Table 2). Each one point higher effortful control at the previous visit was associated with a healthier dietary intake (reduced NutriSTEP ® dietary intake domain score) at follow up (adjusted B -0.53; 95%CI -0.79 to -0.26), independent of covariates. No longitudinal relationship was identified between either negative affectivity or surgency and a change in unhealthy dietary intake.

No interactions between age and temperament were identified (data not shown). No interactions between effortful control and negative affect were identified (data not shown). No differences in results were identified when performing the analysis without child z-BMI (data available upon request).

Discussion

This study identified both a concurrent and longitudinal protective effect of higher effortful control on nutritional risk and dietary intake in early childhood. Children at age 3

1 who had higher effortful control had reduced nutritional risk and a reported healthier
2 dietary intake at age 5. Children with higher negative affectivity had a 1.6 times higher
3 odds and children with higher effortful control a 0.3 times reduced odds of concurrent
4 nutritional risk. This is the first study that examined temperament and nutritional risk
5 factors longitudinally in early childhood. We used data from a large prospective cohort of
6 children recruited from primary care settings and adjusted for important potential
7 confounders.

8 Contrary to our hypothesis, higher negative affectivity was not associated with a
9 change in nutritional risk over time. A mixed picture of the relation between greater
10 negative affectivity and weight related outcomes of children were also reported in a
11 recent review (9). One explanation could be that negative affectivity in preschool children
12 has been associated with both emotional overeating as well as food avoidant eating
13 behaviors such as food fussiness and less enjoyment of food, which can lead to mixed
14 effects on nutritional risk over time (23). Another explanation for finding only a
15 concurrent effect of negative affectivity could be differences in parenting style. In the
16 study of Leung et al, low-income preschoolers who experienced emotion regulation
17 difficulties were more likely to have tantrums over being denied food, but less likely to
18 eat in the absence of hunger (24). In other words, the negative behavior itself may not
19 be problematic for developing obesity; rather the caregivers' responses might be (9).

20 There are several possible mechanisms that might explain the concurrent and
21 longitudinal association between higher effortful control and lower nutritional risk and
22 healthier dietary intake. Firstly, children with higher effortful control may have a better
23 ability to focus their attention on their own satiety responses, which could result in less
24 concurrent excessive dietary intake (24). Secondly, children with higher effortful control
25 may be able to better redirect their emotions and behaviors. This may result in less
26 parental use of food or screen time over time to soothe their children (24,25). Finally, in

adults it has been demonstrated that stress can lead to a shift in preference from healthy foods to foods with high-added sugar and fats (26). Children with higher effortful control may have an improved ability to regulate their emotions and can better cope with stress over time, which could result in a lower preference for an unhealthy dietary intake (27,28).

This study did not identify a concurrent or longitudinal relationship between surgency and nutritional risk factors and dietary intake. Children with high surgency have a high approach motivation and they may therefore learn more quickly to enjoy fruits and vegetables (16). In contrast Leung et al identified that low-income preschoolers with higher surgency were more inclined to overeat in response to external cues and to eat in the absence of hunger (15,24). Surgency could also shape parenting behavior; parents may feed children with more surgent behavior more often (16). In our study, the relationship between surgency and nutritional risk factors could be absent because of differences in parenting behavior and possibly because of the inclusion of both the eating of fruits and vegetables and eating of 'fast food' in the dietary intake NutriSTEP[®] subscore.

Limitations of our study include the lack of measurement of parenting style. Parenting style could have a mediating influence on the development of temperament and nutritional risk factors in preschool children (9). Not all children had three clinic visits, however there were no significant differences between the two groups, except for zBMI for which we adjusted our analysis. Also, the parent that attended the clinic visit was not always the same parent. However both maternal and paternal BMI are established as independent risk factors for obesity in young children (29) .

Furthermore our study relied on parent report of temperament and nutritional risk, which could have lead to ascertainment bias. Our study was conducted with a large group of children in primary care offices, and therefore direct observation was not

feasible. However, both the NutriSTEP ® and the CBQ-VSF have demonstrated strong measurement properties when validated against direct observation (1,7). Although there is theoretical support to investigate the relationship between temperament and nutritional risk (including dietary intake), there was no theoretical base for a relationship between temperament and food security.. Our study may have also been limited by a relatively low nutritional risk profile, and our demographic data revealed high parental education. The results may therefore not be generalizable to other populations.

Results from this study contribute to the growing recognition of temperament as an important early childhood behavioral risk factor in child nutritional outcomes. This study used a longitudinal design and although causation cannot be directly inferred, it represents a stronger design than previous studies. Results from this study suggests that early childhood temperament impacts later nutritional risk providing evidence that preventive strategies for decreasing nutritional risk factors in preschool children might consider approaches to address temperament. While temperament of individuals tend to be relatively stable over time, there is evidence that links between early temperament and child outcomes are malleable and that self-regulation can be improved with interventions promoting sensitive, responsive parenting (9). Future research should explore parenting style as a mediating factor in relationship between temperament and nutritional risk in preschool children.

In summary, this study demonstrated a concurrent and longitudinal protective effect of high effortful control on nutritional risk factors in preschool children. New nutritional risk prevention strategies might consider programming to increase effortful control as opposed to decreasing negative affectivity in preschool children (9,30).

Conflict of Interest Statement

All authors declare that they have no competing interests

1

2 **Acknowledgements**

3 MH and CB were involved in the study design. All authors critically reviewed the study
4 design. YC analyzed all data. MH and CB wrote the first draft of the manuscript and
5 each author listed has revised and approved the submission of this manuscript and
6 takes full responsibility for the manuscript.

7 This work was supported by CIHR, SickKids Foundation, SMH foundation, Physician
8 Services Incorporated. Funding agencies had no role in the design and conduct of the
9 study, collection, management, analyses or interpretation of the results of this study or in
10 the preparation, review, or approval of the manuscript.

11 We would like to thank Dr. S.A. Reijneveld for critically reviewing the manuscript.
12 Additionally, the authors thank all participating families for their time and involvement in
13 TARGet Kids! and are grateful to all practitioners who are currently involved in the
14 TARGet Kids! research network. Steering Committee: Tony Barazzino, Brian
15 Chisamore, Mark Feldman, Moshe Ipp. Research Team: Kathleen Abreo, Tarandeep
16 Malhi, Antonietta Pugliese, Megan Smith, Laurie Thompson. Applied Health Research
17 Centre: Gerald Lebovic, Magda Melo, Patricia Nguyen. Mount Sinai Services Laboratory:
18 Azar Azad.

19

20

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Table 1 Baseline characteristics

	All children	Children with 2 clinic visits	Children with 3 clinic visits
<i>Child characteristics</i>			
Number of children	678	543	135
Boys (n,%)	336 (49.6)	270 (49.7)	66 (48.9)
Age, months (SD)	38.1 ± 2.3	37.7 ± 2.9	37.3 ± 1.9
z-BMI (SD) (kg/m ²) ¹	0.27 ± 1.0	0.22 ± 0.98	0.48 ± 1.0
Negative Affectivity	3.7 ± 0.8	3.7 ± 0.8	3.6 ± 0.8
Effortful Control	5.4 ± 0.7	5.4 ± 0.7	5.4 ± 0.7
Surgency	4.5 ± 0.8	4.5 ± 0.8	4.6 ± 0.8
Total NutriSTEP ® score	13.7 ± 6.2 ³	13.9 ± 6.4	13.1 ± 5.3
Dietary Intake domain score	6.7 ± 3.2 ⁴	6.7 ± 3.2	6.7 ± 3.0
<i>Parent & Household characteristics</i>			
Age of mother, years (SD)	36.1 ± 4.4	33.0 ± 4.5	32.7 ± 3.7
Parent BMI (SD) (kg/m ²) ^{1,2}	25.0 ± 4.5	25.0 ± 4.4	24.8 ± 4.9
Neighborhood income (SD) (1000 CAD)	63.6 ± 30.5	62.8 ± 30.9	66.3 ± 28.9
Maternal education (n, %)			
Public school	4 (0.6)	4 (0.8)	0
High school	40 (5.9)	32 (6.1)	8 (6.2)
College / University	615 (90.7)	493 (93.2)	122 (93.9)

¹ Using WHO Child Growth Standards (20)

² Parent BMI refers to the BMI of the parent who attended the clinic visit.

³ Percentiles of the Total NutriSTEP ® score at baseline: 5th percentile 5; 25th percentile 9, 75th percentile 17, 95th percentile 25

⁴ Percentiles of the Dietary Intake domain score at baseline: 5th percentile 2; 25th percentile 4; 75th percentile 9, 95th percentile 12

Abbreviations: BMI = Body Mass Index, CAD= Canadian Dollar. Missing data z-BMI n = 8, age of mother n=39, parent BMI n = 82, neighborhood income n = 56, maternal education n=17

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Figure 1 Schematic representation of statistical analysis

- Legend:
- A: Cross-sectional mixed effect model to test the overall associations of temperament on nutritional risk at all three time points simultaneously.
- B: Longitudinal multivariate linear regression model to test the effect of the previous temperament domains on changes in nutritional risk (Total NutriSTEP® score) at follow-up visits
- T1 = baseline well-child clinic visit, T2 = follow-up well-child clinic visit, T3 = follow-up well-child clinic visit