Temperament and fracture in preschool-aged children

Ryckman, Kandace, MPH (Candidate), Richmond, Sarah A., PhD, MSc, Anderson, Laura N., PhD, MSc, Birken, Catherine S., MD, MSc, FRCPC, Parkin, Patricia C. MD, FRCPC, Macarthur, Colin, MBChB, PhD, Maguire, Jonathon L., MD, MSc, FRCPC, Howard, Andrew W., MD, FRCSC, MSc

Version Post-print/accepted manuscript


Publisher's Statement This is a pre-copyedited, author-produced version of an article accepted for publication in Paediatrics and Child Health following peer review. The version of record Kandace Ryckman, Sarah A. Richmond, Laura N. Anderson, Catherine S. Birken, Patricia C. Parkin, Colin Macarthur, Jonathon L. Maguire, Andrew W. Howard; Temperament and fracture in preschool-aged children, Paediatrics & Child Health, Volume 22, Issue 4, 1 July 2017, Pages 195–198, https://doi.org/10.1093/pch/pxx049 is available online at: https://doi.org/10.1093/pch/pxx049.

How to cite TSpace items

Always cite the published version, so the author(s) will receive recognition through services that track citation counts, e.g. Scopus. If you need to cite the page number of the author manuscript from TSpace because you cannot access the published version, then cite the TSpace version in addition to the published version using the permanent URI (handle) found on the record page.

This article was made openly accessible by U of T Faculty. Please tell us how this access benefits you. Your story matters.
Temperament and fracture in preschool-aged children

Authors
Ryckman, Kandace, MPH (Candidate)¹,²
Richmond, Sarah A., PhD, MSc²
Anderson, Laura N., PhD, MSc³,⁴,⁷
Birken, Catherine S., MD, MSc, FRCPC²,³,⁴,⁵
Parkin, Patricia C. MD, FRCPC²,³,⁴,⁵
Macarthur, Colin, MBChB, PhD³,⁴,⁵,⁶
Maguire, Jonathon L., MD, MSc, FRCPC²,³,⁴,⁵,⁷,⁸
Howard, Andrew W., MD, FRCSC, MSc²,⁴,⁹,¹⁰

¹Dalla Lana School of Public Health, University of Toronto, Toronto, Canada
²Child Health Evaluative Sciences, The Hospital for Sick Children, Toronto, Canada
³Pediatric Outcomes Research Team (PORT), Division of Pediatric Medicine, Department of Pediatrics, Hospital for Sick Children, Toronto, Ontario
⁴Institute of Health, Policy, Management and Evaluation, University of Toronto, Toronto, Canada
⁵Department of Pediatrics, Faculty of Medicine, University of Toronto, Toronto, Canada
⁶Research Institute, The Hospital for Sick Children, Peter Gilgan Centre for Research and Learning (PGCRL)
⁷Department of Pediatrics, St. Michael’s Hospital, Toronto, Canada
⁸Applied Health Research Centre, Keenan Research Centre, Li Ka Shing Knowledge Institute, St Michael’s Hospital, Toronto, Canada
⁹Division of Orthopaedic Surgery, The Hospital for Sick Children, Toronto, Canada
¹⁰Department of Surgery, University of Toronto, Toronto, Canada

Institution where work originated: Child Health Evaluative Sciences, The Hospital for Sick Children

Ethics Board approval: The Hospital for Sick Children

Corresponding author: Kandace Ryckman
The Hospital for Sick Children
Peter Gilgan Centre for Research and Learning
Child Health Evaluative Sciences
686 Bay Street
Toronto, ON M5G 0A4
Tel: 416 813-7654 x308459
kandace.ryckman@sickkids.ca

Word count excluding title, abstract, references and tables: 2,723
ABSTRACT

Objectives: Approximately half of all children will sustain a fracture before adulthood. Understanding the factors that place a child at increased risk of fracture is necessary to inform effective injury prevention strategies. The purpose of this study was to examine the association between temperament and fracture risk in pre-school aged children.

Methods: Children aged 3-6 years who were diagnosed with a fracture were recruited from the Hospital for Sick Children Fracture Clinic. Using a retrospective case-control study design, the 128 cases were frequency-matched by age and sex to 426 controls from the TARGet Kids primary care pediatric. The Childhood Behaviour Questionnaire, a 36-item caregiver response questionnaire was used to assess three temperament factors: surgency (e.g., high activity level); negative affect (e.g., anger, fear, discomfort); and effortful control (e.g., attentional focusing).

Results: Unadjusted logistic models demonstrated no association between children with previous fracture and higher scores of surgency (unadjusted OR=1.06, 95% CI: 0.84, 1.34), negative affect (unadjusted OR=1.15, 95% CI: 0.93, 1.42) or effortful control (unadjusted OR=0.80, 95% CI: 0.63, 1.03). Further, models adjusted for covariates, also demonstrated no significant association with surgency (1.00, 95% CI: 0.78, 1.29), negative affect (1.09, 95% CI: 0.86, 1.37) and effortful control (0.80, 95% CI: 0.61, 1.05).

Conclusion: None of the three main temperament types identified by the Childhood Behaviour Questionnaire were associated with an increase in fracture risk. For children of any temperament, injury prevention efforts should look at ways to make play environments safer.
INTRODUCTION

Despite the overall rate of childhood injuries decreasing, the incidence of paediatric fractures is increasing (1,2). It has long been argued that child temperament and behaviour are important causal factors for unintentional injuries (3-5). Temperament is determined by individual variations in both reactivity and self-regulation (6). Reactivity is the extent to which behavioural or physiological systems within a child are excited, aroused or reactive; whereas self-regulation includes how neural and behavioural processes manage this underlying reactivity (7). As such, temperament is influenced predominantly by the biological makeup of the child but it is also impacted by heredity, maturation and experiences.

The relationship between temperament and fracture has not been well studied, but a recent cross-sectional study demonstrated children aged 3-7 with fractures had higher activity levels and increased distractibility than their peers (8). Furthermore, there is some unintentional injury literature that demonstrates pre-school aged children who are more extroverted (9), impulsive (10) or overactive (11) were more likely to experience unintentional injuries compared to their peers. Children with low inhibitory control were also shown to be at higher risk for injury in a sample of children aged 2-5 years of age (12). Despite these findings, other studies found no significant relationship between temperament in pre-school-aged children and unintentional injuries, particularly those injuries requiring medical attention (13,14). It also has been suggested that other factors, such as parental supervision or safe play environments, could play an important causal role in explaining differences in injury risk among this age group (15).

Given these discrepancies in the literature, the aim of this study is to evaluate the association between child temperament and fracture risk among children aged 3-6 years, using a rigorous case-control study design and an internationally recognized, valid and reliable short-
form tool for measuring child temperament (the Childhood Behaviour Questionnaire – Very Short Form).

METHODS

Study Design

This was a case-control study, designed to examine whether fracture risk among preschool-aged children, 3-6 years was associated with child temperament as measured by the Childhood Behaviour Questionnaire Very Short Form (CBQ- VSF) (7). A flow diagram explaining the study design is provided in Figure 1.

Cases were identified from a database of pre-school aged children referred to the fracture clinic at the Hospital for Sick Children in Toronto from May 2009 to April 2013. Children who had long-bone (e.g. femur, humerus, etc.), wrist, or anklebone abnormality identified on imaging (x-ray or computed tomography), as a fracture by a paediatric radiologist were eligible for study inclusion. Upon consent, caregivers completed a questionnaire similar to the one used in The Applied Research Group for Kids (TARGet Kids!) cohort study(16). Objective measures including height and waist circumference were collected in all participating children.

Healthy controls were selected from the TARGet Kids! cohort. This cohort recruits children from the age of birth to 6 years from primary and paediatric care practices in Toronto, Canada(16). TARGet Kids! follows participating children at scheduled well-child visits and collects physical measurements, blood samples, as well as caregiver-completed questionnaires on nutrition, physical activity, and child behaviour. Information is collected at regular intervals during well-child visits with a paediatrician or family physician(16).
Children with health conditions known to affect growth (e.g., failure to thrive, cystic fibrosis) or bone development (e.g. osteogenesis imperfect, Marfan’s syndrome, Ehlers Danlos syndrome, sickle cell disease, congenital heart disease, liver disease, renal disease, malignancy or other chronic systemic disease) were excluded. Furthermore, those with a chronic health condition (except asthma and high functioning autism) or severe developmental delay were excluded. Children whose caregivers were unable to communicate in English were also excluded from this cohort. The Research and Ethics Board at the Hospital for Sick Children and St. Michael’s Hospital approved this study and consent was obtained from the caregiver of all participating children.

Exposure

The CBQ-VSF was used to measure temperament. The CBQ-VSF is a 36-item assessment commonly used for children ages 3-7 years(7). The questionnaire, filled out by the child’s caregiver uses a Likert scale to rate a statement about the child’s behaviour from 1 (extremely untrue) to 7 (extremely true).

The CBQ-VSF assesses child temperament across three factors: surgency, negative affect and effortful control. Surgency is defined as having high scores (i.e., extremely true) for items that measure impulsivity (e.g., often rushes into new situations), high intensity pleasure (e.g., likes to go high and fast when pushed on a swing), and activity level (e.g., is full of energy, even in the evening), as well as strong negative loading for shyness (e.g., never turns away shyly from new acquaintances)(7). Negative affect is characterized by higher scores on questions that measure sadness (e.g., seems to feel depressed when unable to accomplish a task), fear (e.g., is afraid of the dark), anger/frustration (e.g., gets angry when s/he can not find something s/he wants to play with) and discomfort (e.g., is quite upset by a little cut or bruise) and lower scores
on falling reactivity (e.g. has difficulty falling asleep) and soothability (e.g., is very difficult to soothe when s/he has become upset)(7). Effortful control is defined by having higher scores on dimensions for inhibitory control (e.g., approaches places s/he has been told are dangerous slowly and cautiously), attentional focusing (e.g., when drawing or coloring in a book, shows strong concentration), low intensity pleasure (e.g., enjoys gentle rhythmic activities, such as rocking or swaying) and perceptual sensitivity (e.g., comments when a parent has changed his/her appearance)(7). A CBQ-VSF score for each of the three factors was calculated by taking the mean score of the 12 items that correspond to each factor. If no response was given for a question, the mean score of the remaining items was used.

The CBQ-VSF has been validated in a number of studies assessing temperament in children ages 3-7 years(17-19). The CBQ-VSF has demonstrated high internal consistency; Cronbach alpha coefficients for the three factors, surgency, negative affect and effortful control were .75, .72 and .74, respectively(7).

Covariates

A literature review was conducted a priori to identify potential confounders in the relationship between temperament and fracture (i.e. age, sex, waist circumference, maternal education, history of fracture, attendance in daycare, amount of time spent in unstructured playtime outdoors, having been breastfed, daily milk and soda consumption).

Cases and controls were frequency matched on age (in months) and sex. Height and waist circumference was measured directly by a trained research assistant at either the fracture clinic (for cases) or well-child visits (for controls). Waist circumference was then z-standardized by age and sex prior to analysis using the full TARGet Kids! cohort sample of more than 5000 children.
The remainder of the covariates were measured based on caregiver report in the baseline questionnaire. Maternal education (highest level of educational attainment including Post-secondary or Less than Post-Secondary, including High School and Public School) was used as a proxy for socioeconomic status. Previous fracture was assessed by caregiver report of lifetime fracture history (yes/no). Attendance in daycare (yes/no) and history of breastfeeding (yes/no) were measured by asking if the child currently attended a license daycare or preschool program, or had ever been breastfed, respectively. Physical activity was measured as the caregiver’s response to the amount of time, per weekday, spent in unstructured playtime outdoors (in minutes). The average number of cups of milk and soda the child consumed per day was assessed given 7 options (0, ½, 1, 2, 3, 4, 5+ cups per day). For the purposes of the study, milk consumption was categorized as less than 2 cups, 2 cups or more than 2 cups per day. Soda consumption was categorized into a binary variable; children who consumed at least one half cup of soda per day were classified as consuming soda daily and all others were not.

**Statistical Analysis**

Data were analyzed using SAS version 9.3. Descriptive statistics for continuous variables included reporting means and standard deviations. In cases where the distribution of the variable was highly skewed (i.e., where skewness was +/-1.5), a geometric mean was produced, using a square-root transformation of the data. For categorical variables, the proportion and percentage with 95% confidence intervals (CIs) were reported. Summary statistics of the primary exposures of interest (i.e., scores for surgency, negative affect and effortful control) were also created for cases, controls and across the total sample population.

Logistic regression was used to model the association between child temperament and fracture outcome. First, three separate univariate analyses were conducted to examine the
association between each CBQ-WSF factor (surgency, negative affect and effortful control) and fracture risk. An unadjusted odds ratio and 95% CI was produced for each CBQ-WSF factor. Statistical effect modification between the primary exposures of interest (i.e., surgency, negative affect and effortful control) with age and sex were examined against an a priori significance level of $\alpha=0.05$. Further analyses were performed to check for confounding by each of the covariates.

Odds ratios and 95% CI were then calculated for each CBQ-WSF factor adjusting for age, sex, standardized waist circumference, maternal education, history of fracture, daily unstructured playtime, attendance in daycare, daily breastfeeding and milk and soda consumption. Among covariates, missing data ranged from 0% to 13.24% (Table 1). Multivariate imputation by fully conditional specification methods was used to address missing data(20). Based on an analysis of convergence amongst imputed distributions, 5 imputations with 10 burn-in iterations were completed(20).

RESULTS

During the study period, 275 children completed study data collection at the fracture clinic. Of these, 148 children met inclusion criteria; 95 children were outside of age range and 32 were missing the CBQ. The controls were randomly selected to frequency match cases for both age and sex in an approximate 3:1 ratio, resulting in a control population of 426 children. Descriptive summaries for both cases and controls are provided in Table 1. There appeared to be no differences between cases and controls in age, sex or any of the other covariates.

[Insert Table 1]

The unadjusted logistic regression model examining the association suggested no difference between cases and controls. Odds of experiencing a fracture were not increased by
having a higher score for surgency (unadjusted OR=1.06, 95% CI: 0.84, 1.34) or negative affect (unadjusted OR=1.15, 95% CI: 0.93, 1.42). The effect estimate for effortful control demonstrated a slightly protective effect; (unadjusted OR=0.80, 95% CI: 0.63, 1.03) however, none of these results (Table 2) were statistically significant.

[Insert Table 2]

The adjusted model, controlling for age, sex, history of fracture, waist circumference, maternal education, daily-unstructured playtime, attendance in daycare, breastfeeding, average daily milk and carbonated beverage consumption also demonstrated a null relationship between temperament factors and fracture risk. The adjusted odds ratio for surgency was 1.00 (95% CI: 0.78, 1.29), for negative affect was 1.09 (95% CI: 0.86, 1.37) and effortful control was 0.80 (95% CI: 0.61, 1.05). Analyses of effect modification of exposures by age and sex found no significant results with $\alpha=0.05$. There was no evidence of confounding by covariates.

**DISCUSSION**

This study assessed whether principal child temperament factors (i.e., surgency, negative affect and effortful control) assessed by the 36-item CBQ were associated with fracture risk in preschool-aged children. High scores for surgency and negative affect had a null effect, while the effect estimate for effortful control demonstrated a possible protective effect (OR=0.80, 95%CI: 0.61, 1.05); however, none of these associations were statistically significant.

Previous research has suggested that children who are more extroverted, impulsive and overactive were more likely to experience unintentional injuries compared to their peers(8-11,15,21,22). It has also been suggested that children with low inhibitory control were at higher risk for injury(12). Previous studies; however, were limited by their cross-sectional nature(9-12,15,22), small sample sizes of less than 100(8-10,12,22), and the use of parental report to
measure fractures as the outcome(9-12,15). Some studies also examined the role of temperament in predicting injury in samples that contained slightly older children ranging from 3-14 years(15,21,22).

This study may have elucidated the true association between the three main constructs of temperament and fracture risk in children. This can be attributed to the strength in study design, in addition to the large sample size (n=574) and the ability to objectively measure fracture through medically confirmed diagnosis. This study was also able to collect and adjust for potential confounders in the relationship between temperament and fracture, such as amount of physical activity, attendance in daycare and dietary consumption.

Limitations of this study is that because we used the CBQ-VSF, a 36-item scale, we could only measure the major dimensions of temperament (surgency, negative affect, and effortful control) and not their subscales which have been used in previous studies on injuries. Although extroversion and impulsivity contribute to items in the surgency scale, the aggregate nature of the CBQ-VSF does not let us measure these subscale constructs directly. Similarly, inhibitory control contributes to the effortful control construct, but can not be measured directly by the CBQ-VSF. Other limitations of our study include the potential for recall bias if caregivers of cases were more likely to have increased awareness of their child’s activity level or risk-taking personality, post injury, which could lead to an overestimation of the true association between temperament and fracture. The fact that this study found a null association and that parents were blinded to the study hypothesis indicates that recall bias is not a major concern. Additionally, this study is limited by the accuracy of caregiver-report on child temperament which has been suggested could reflect more about parent personalities and biases, rather than child temperament(23). There is also some discrepancy in parental agreement between mothers
and fathers when scoring children in the CBQ-VSF(24). However, direct observation to obtain behavioral measures, the gold standard in child development studies, was not feasible for this study design. Finally, although this study evaluated many possible confounders, we were unable to control for parenting style.

The results of this study give way to two implications for future work in this area. Firstly, there might not be a true association between temperament and fracture. Data from this study suggested that none of the three main temperament types identified by the CBQ-VSF were associated with greater odds of experiencing a fracture. As such, practitioners should not discourage risky play amongst children of certain temperaments as a way to prevent injury. Risky play has been demonstrated as an important part of healthy child development(25).

Secondly, injury prevention interventions should emphasize changes to the built environment that can make play spaces safer for children. There is evidence to support the effectiveness of implementing playground safety standards as a means to reduce injuries(26-28). For example, it has been reported that the replacement of hazardous outdoor playground equipment in playgrounds reduced the rate of injury from 2.61 to 1.68 per 1000 students per month (RR=0.70, 95% CI: 0.62, 0.78)(28).

**CONCLUSION**

This study found that temperament, as measured by the CBQ-VSF, was not associated with risk of fracture in preschool aged children. For children of any temperament, injury prevention efforts should look at ways to make play environments safer which may include a focus on changes to the built environment to reduce the risk of fracture in this age group.
ACKNOWLEDGEMENTS

The authors would like to thank Yang Chen, from TARGet Kids, for his help in assembling the data.
REFERENCES


### Table 1: Descriptive statistics for cases and controls (n=574)

<table>
<thead>
<tr>
<th></th>
<th>Cases (n=148)</th>
<th>Control (n=426)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Age (months)</strong></td>
<td>55.7 (36.0, 76.9)</td>
<td>53.2 (36.0, 73.4)</td>
</tr>
<tr>
<td><strong>Height (cm)</strong></td>
<td>109.4 (92.3, 126.4)</td>
<td>105.8 (91.0, 120.6)</td>
</tr>
<tr>
<td><strong>Waist circumference (cm)</strong></td>
<td>52.5 (38.5, 66.5)</td>
<td>53.2 (44.7, 61.8)</td>
</tr>
<tr>
<td><strong>Unstructured playtime outside of daycare or pre-school (min/weekday)</strong></td>
<td>57 (38.6, 75.4)</td>
<td>54 (34.5, 73.5)</td>
</tr>
<tr>
<td><strong>Sex</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>79 (53.3%)</td>
<td>228 (53.5%)</td>
</tr>
<tr>
<td>Female</td>
<td>69 (46.6%)</td>
<td>198 (46.5%)</td>
</tr>
<tr>
<td><strong>Maternal Education</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Post-Secondary</td>
<td>119 (80.4%)</td>
<td>382 (89.7%)</td>
</tr>
<tr>
<td>Less than Post-Secondary</td>
<td>27 (18.2%)</td>
<td>32 (7.5%)</td>
</tr>
<tr>
<td><strong>History of Past Fracture</strong></td>
<td>2 (1.4%)</td>
<td>12 (2.8%)</td>
</tr>
<tr>
<td>Yes</td>
<td>15 (10.1%)</td>
<td>17 (4.0%)</td>
</tr>
<tr>
<td>No</td>
<td>112 (75.7%)</td>
<td>366 (85.9%)</td>
</tr>
<tr>
<td><strong>Attend Licensed Daycare</strong></td>
<td>72 (48.7%)</td>
<td>229 (53.8%)</td>
</tr>
<tr>
<td>Yes</td>
<td>72 (48.7%)</td>
<td>229 (53.8%)</td>
</tr>
<tr>
<td>No</td>
<td>75 (50.7%)</td>
<td>190 (44.6%)</td>
</tr>
<tr>
<td><strong>Daily Milk Consumption</strong></td>
<td>1 (0.7%)</td>
<td>7 (1.6%)</td>
</tr>
<tr>
<td>Less than 2 cups</td>
<td>40 (27.0%)</td>
<td>161 (37.8%)</td>
</tr>
<tr>
<td>2 cups</td>
<td>59 (39.9%)</td>
<td>166 (39.0%)</td>
</tr>
<tr>
<td>More than 2 cups</td>
<td>42 (28.4%)</td>
<td>89 (21.0%)</td>
</tr>
<tr>
<td><strong>Consume Soda Daily</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>17 (11.5%)</td>
<td>21 (4.9%)</td>
</tr>
<tr>
<td></td>
<td>No</td>
<td>102 (68.9%)</td>
</tr>
<tr>
<td>------------------</td>
<td>---------------</td>
<td>-------------</td>
</tr>
<tr>
<td>No Response – n (%)</td>
<td>29 (19.6%)</td>
<td>47 (11.0%)</td>
</tr>
<tr>
<td><em>Breastfed</em></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>124 (83.8%)</td>
<td>395 (92.7%)</td>
</tr>
<tr>
<td>No</td>
<td>24 (16.2%)</td>
<td>25 (5.9%)</td>
</tr>
<tr>
<td>No Response – n (%)</td>
<td>0 (0%)</td>
<td>6 (1.41%)</td>
</tr>
</tbody>
</table>

*Confidence interval; **Square root transformation to produce a geometric mean that satisfies normality assumption.*
**Table 2**: Unadjusted and adjusted logistic regression model of the relationship between fracture and temperament, measured by CBQ-VSF* factors

<table>
<thead>
<tr>
<th>Temperament Factor</th>
<th>Unadjusted OR**</th>
<th>95%CI***</th>
<th>Adjusted+ OR</th>
<th>95%CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Surgency</td>
<td>1.06</td>
<td>(0.84, 1.34)</td>
<td>1.00</td>
<td>(0.78, 1.29)</td>
</tr>
<tr>
<td>Negative Affect</td>
<td>1.15</td>
<td>(0.93, 1.42)</td>
<td>1.09</td>
<td>(0.86, 1.37)</td>
</tr>
<tr>
<td>Effortful Control</td>
<td>0.80</td>
<td>(0.63, 1.03)</td>
<td>0.80</td>
<td>(0.61, 1.05)</td>
</tr>
</tbody>
</table>

*Childhood Behaviour Questionnaire – Very Short Form; **Odds ratio; ***Confidence interval; +Adjusted for age, sex, history of fracture, age and sex standardized waist circumference, maternal education, daily unstructured playtime, attendance in daycare, breastfeeding, average daily milk and carbonated beverage consumption.