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What is This?
Does Gender Matter? Differences in Social-Emotional Behavior Among Infants and Toddlers Before and After Mild Traumatic Brain Injury: A Preliminary Study

Mari-Liis Kaldoja, MSc¹,²,³, and Anneli Kolk, PhD, MD⁴,⁵

Abstract

Traumatic brain injury is a common cause of acquired disability in childhood. While much is known about cognitive sequelae of brain trauma, gender-specific social-emotional problems in children with mild traumatic brain injury is far less understood. The aims of the study were to investigate gender differences in social-emotional behavior before and after mild traumatic brain injury. Thirty-five 3- to 65-month-old children with mild traumatic brain injury and 70 controls were assessed with Ages and Stages Questionnaires: Social-Emotional. Nine months later, 27 of 35 patients and 54 of 70 controls were reassessed. We found that before injury, boys had more self-regulation and autonomy difficulties and girls had problems with adaptive functioning. Nine months after injury, boys continued to struggle with self-regulation and autonomy and new difficulties with interaction had emerged, whereas in girls, problems in interaction had evolved. Even mild traumatic brain injury in early childhood disrupts normal social-emotional development having especially devastating influence on interaction skills.

Keywords

childhood mild traumatic brain injury, social-emotional behavior, gender differences, risk factors, interaction skills.

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their engagement in behaviors that were judged as inappropriate and unacceptable by their mothers.\textsuperscript{8}

Aside from compliance and autonomy, of all the temperamental characteristics, a lack of ability to regulate behavior and emotions, often referred to as self-regulation, inhibitory control, or self-control, is found to be a particularly important contributor to unintentional injuries as well as externalizing behaviors.\textsuperscript{9} Schwebel and Plumert showed that preschool children scoring low on inhibitory control had significantly more lifetime injuries requiring medical attention by the age of 6.\textsuperscript{10} Common risk factors could be identified in externalizing behaviors and minor injuries even as young as 17 months.\textsuperscript{11} Furthermore, several studies of pediatric traumatic brain injury confirm that children suffering from traumatic brain injury are more likely to have a prior history of behavioral and emotional disorder.\textsuperscript{12} For example, among 3- to 6-year-old preschoolers with mild traumatic brain injury, premorbid behavioral factors account for most of the problems recognized in the postacute period.\textsuperscript{13} Research also suggests that infants and toddlers with mild traumatic brain injury display significantly more preinjury social-emotional difficulties in self-regulation and autonomy than their noninjured peers.\textsuperscript{14} Furthermore, 9 months after injury difficulties in self-regulation and autonomy persisted and additional interaction difficulties had accumulated. These results confirm that even mild traumatic brain injury in infants and toddlers have constant negative effects on specific social-emotional skills.\textsuperscript{14}

Few of the studies concerned with gender differences and the outcome of traumatic brain injury in children have mainly focused on the cognitive outcome. These studies have claimed that after traumatic brain injury girls perform better than boys in processing speed and memory tasks.\textsuperscript{15,16} However, while much is now understood about gender differences in cognitive outcome after traumatic brain injury, the preinjury gender differences in social-emotional behavior and gender-specific mild traumatic brain injury outcome in very young children remains less well defined.

The aims of a present study were

1. to specify age-appropriate social-emotional behavior and reveal gender differences in typical social-emotional development in infants and toddlers,
2. to identify any possible gender-specific social-emotional behavioral differences and risk factors for mild traumatic brain injury in infants and toddlers,
3. to evaluate the social-emotional outcome in boys and girls after mild traumatic brain injury to clarify possible hazards in social-emotional development.

\textbf{Methods}

\textbf{Participants}

Thirty-five children (22 boys and 13 girls) between 3 and 65 months of age who were hospitalized at Tartu University Hospital’s Children’s Clinic after mild traumatic brain injury and 70 healthy children, whose age and parents’ education matched controls, participated in the essential study.

Patients’ inclusion criteria were:

1. a diagnosis of mild traumatic brain injury formulated according to the International Classification of Diseases codes S00-S09, which includes all injuries to the head\textsuperscript{17}; in all of the cases, mild traumatic brain injury was caused by a fall (W01-W03, W06-W10, W17, W19) and classified according to criteria proposed by Alexander: loss of consciousness approximately 5 minutes or less, an initial Glasgow Coma Scale of 13 to 15, may have vomited up to 3 times, and/or may have exhibited other signs or symptoms (eg, headache, nausea, lethargy), no abnormal or focal neurologic findings\textsuperscript{18};
2. hospitalization at Tartu University Hospital Children’s Clinic with a diagnosis of mild traumatic brain injury for at least 72 hours; (neuroradiologic findings: all patients were normal);
3. parental fluency in Estonian language; and
4. parental informed consent to participate in the study.

Infants and toddlers with inflicted brain injury, previous history of brain trauma, complicated mild traumatic brain injury (compound traumas: broken bones, serious bruises, hematomas on other parts of body), moderate or severe brain traumas, previously diagnosed chronic illness, and genetic or neurologic disorders (eg, moderate or severe developmental delay) were excluded from the present study. A control group of 70 healthy children (44 boys and 26 girls) was recruited from Tartu and Tartu County Family Physician Centers during regular visits to general practitioners. Control group children were selected from a large number of children on the basis of their matching characteristics to the mild traumatic brain injury group in terms of sex, age, and parents’ education. Written informed consents to participate in the present study were obtained from all the parents of study group and control group children.

Twenty-seven of 35 children with mild traumatic brain injury (16 boys and 11 girls) and 54 out of 70 matched controls (32 boys and 22 girls) also participated in the follow-up study. Eight patients with mild traumatic brain injury were unable to present for follow-up: 4 patients were out of the questionnaires’ age range (<65 months), the parents of 3 patients were unresponsive when contacted, and 1 parent refused to participate in the follow-up study. Characteristics of the participants and demographic information of parents completing the questionnaires are presented in Table 1.

\textbf{Procedure}

This prospective case-controlled study used a parental assessment to ascertain preinjury and postinjury social-emotional behavior in infants and toddlers with mild traumatic brain injury. Preinjury assessments of social-emotional behavior were obtained from parents immediately after study enrolment (essential assessment) within 3 days after the mild traumatic brain injury. During essential assessment, parents of children hospitalized with mild traumatic brain injury and the parents of controls who were in general practitioners’ consultation completed the Ages and Stages Questionnaires: Social-Emotional, which is an age-appropriate questionnaire that retrospectively evaluates the child’s behavior within the previous 2 weeks. For patients, the International Classification of Diseases codes in medical files were registered, and neurologic status was assessed by the neurologist treating the child. Medical records of every mild traumatic brain injury patient were reexamined to verify the diagnosis of mild traumatic brain injury.
To our knowledge, this was the first time Questionnaires: Social-Emotional has been used to assess social-emotional behavior in boys and girls with brain injuries.

Statistical Analysis

For consistency, z scores and mean values of subscale scores were computed. These scores were used for statistical analysis. The distributions of all subscale scores and single-item scores were assessed, and because some subscales exhibited nonnormal distribution, nonparametric procedures were used throughout the analysis. The Mann-Whitney U test was used to compare social-emotional behavior between 2 groups. As a measure of the effect size after the Mann-Whitney U test, the correlation coefficient r was computed.

In order to assess long-term effects, the Wilcoxon matched pairs test was applied. Following the Wilcoxon matched pairs test, the matched-pairs rank biserial correlation as a measure of effect size was computed. The score difference was calculated to assess the effect of the change between the mild traumatic brain injury and control groups. This score difference was later assessed with the Mann-Whitney U test. Because of the nondirectional hypotheses, all tests were performed 2-tailed. Exact P values were used instead of asymptotic P values. The overall significance level was set to α = 0.05; still, noteworthy trends at α < 0.1 were also presented. Statistical data analysis was performed with the statistical data analysis package SPSS Statistics 21.

Results

Preinjury Gender Differences in Social-Emotional Behavior

Our results showed no statistically significant differences or noteworthy trends in social-emotional behavior between control group boys and girls.

In the mild traumatic brain injury group, we found that boys showed a slight trend toward more self-regulation problems than girls (z = −1.542, mild traumatic brain injury boys mean = 2.308, standard deviation = 1.233; mild traumatic brain injury girls mean = 1.716 standard deviation = 1.582, P = .063, r = 0.260). Compared to control group boys, mild traumatic brain injury group boys had more overall social-emotional problems (P < .05): significant difficulties occurred in self-regulation and autonomy (P < .05) and slight trend showed more problems in interaction with other people (P = .087). Mild traumatic brain injury group girls did worse than control group girls in adaptive functioning (P < .05) (for more details, see Table 2).

Postinjury Social-Emotional Behavior (Follow-Up Outcome)

Nine months after essential assessment, we found that control group girls were reported to have more problems in interacting with other people compared to control group boys (z = −3.213, control group boys mean = 0.481, standard deviation = 0.778; control group girls mean = 1.272, standard deviation = 0.978, P < .05, r = 0.445), whereas no other significant or even noteworthy differences in any examined domains between control group girls and boys were evident.

### Table 1. Demographic Information of Mild Traumatic Brain Injury and Control Group Boys and Girls.

<table>
<thead>
<tr>
<th></th>
<th>Boys</th>
<th>Girls</th>
</tr>
</thead>
<tbody>
<tr>
<td>Essential assessment</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Children with mTBI</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age (mo; M ± SD)</td>
<td>34.09 ± 19.92</td>
<td>31.00 ± 20.57</td>
</tr>
<tr>
<td>No. of children</td>
<td>22</td>
<td>13</td>
</tr>
<tr>
<td>Control group children</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age (mo; M ± SD)</td>
<td>35.77 ± 19.96</td>
<td>30.96 ± 19.99</td>
</tr>
<tr>
<td>No. of children</td>
<td>44</td>
<td>26</td>
</tr>
<tr>
<td>Follow-up assessment</td>
<td></td>
<td></td>
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<tr>
<td>Children with mTBI</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age (mo; M ± SD)</td>
<td>44.30 ± 18.34</td>
<td>34.64 ± 16.75</td>
</tr>
<tr>
<td>No. of children</td>
<td>16</td>
<td>11</td>
</tr>
<tr>
<td>Control group children</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age (mo; M ± SD)</td>
<td>45.63 ± 17.11</td>
<td>34.41 ± 16.34</td>
</tr>
<tr>
<td>No. of children</td>
<td>32</td>
<td>22</td>
</tr>
</tbody>
</table>

Abbreviations: M, mean; mTBI, mild traumatic brain injury; SD, standard deviation.
The follow-up of the mild traumatic brain injury group showed that mild traumatic brain injury group boys had more difficulties in self-regulation compared to mild traumatic brain injury group girls (z = −2.043, mild traumatic brain injury boys mean = 2.378, standard deviation = 1.587; mild traumatic brain injury girls mean = 1.141, standard deviation = 1.358, P < .05, r = 0.403) and a slight trend also confirmed more communication difficulties in mild traumatic brain injury group boys (z = −1.786, mild traumatic brain injury boys mean = 1.250, standard deviation = 1.551; mild traumatic brain injury girls mean = 0.303, standard deviation = 0.674, P = .096, r = 0.344).

Compared to control group boys, mild traumatic brain injury group boys showed significantly worse results in overall social-emotional behavior (P < .05). When these difficulties were thoroughly examined, it appeared that mild traumatic brain injury group boys were worse in self-regulation and in interaction with other people (P < .05). In mild traumatic brain injury group girls, when compared to control group girls, the follow-up outcome 9 months postinjury showed only a slight trend toward worse performance in interacting with other people (P = .060, for more details, see Table 3).

**Changes in Social-Emotional Behavior—A Comparison Between Essential and Follow-Up Assessment**

In control group boys, no significant changes in social-emotional behavior were evident during a 9-month period, still a trend toward improved self-regulation skills was notable (z = −1.598, essential assessment mean = 1.424, standard deviation = 1.288; follow-up assessment mean = 1.111, standard deviation = 0.989, P = .057, r = 0.206). Control group girls showed a slight improvement in self-regulation skills (z = −1.727, essential assessment mean = 1.477, standard deviation = 0.885, P = .043, r = 0.206).
deviation = 1.445; follow-up assessment mean = 1.035, standard deviation = 1.075, \( P = .087, r = 0.260 \) and surprising declines in autonomy skills (\( z = -2.07 \), essential assessment mean = 1.406, standard deviation = 2.230; follow-up assessment mean = 2.656, standard deviation = 2.494, \( P = .063, r = 0.366 \)).

Nine months postinjury, mild traumatic brain injury group boys showed a significant decline in overall social-emotional behavior (\( z = -1.977 \), essential assessment mean = 1.477, standard deviation = 1.068; follow-up assessment mean = 1.764, standard deviation = 1.248, \( P < .05, r = 0.349 \)) and in autonomy (\( z = -2.236 \), essential assessment mean = 2.307, standard deviation = 2.385, follow-up assessment mean = 3.269, standard deviation = 2.137, \( P = .063, r = 0.439 \)). Compared to the preinjury period, mild traumatic brain injury group girls showed a slight improvement in adaptive functions (\( z = -2.088 \), essential assessment mean = 1.629, standard deviation = 1.437; follow-up assessment mean = 0.614, standard deviation = 0.995, \( P < .05, r = 0.445 \)).

**Differences in Social-Emotional Behavior—A Comparison Between Mild Traumatic Brain Injury and Control Group Children: Preinjury and 9 Months Postinjury**

When the Mann-Whitney \( U \) test was used to evaluate the differences in dynamics between mild traumatic brain injury and control group boys, negative dynamics were seen in mild traumatic brain injury boys, whose parents had stated an increase in overall social-emotional problems (\( z = -1.615, P = .054, r = 0.233 \)). A decline in interaction skills with other people (\( z = -2.339, P < .05, r = 0.338 \)) and increasing autonomy difficulties (\( z = -2.157, P < .05, r = 0.318 \)) were the most evident.

Compared to control group girls, in mild traumatic brain injury girls no significant changes in any social-emotional behavior subdomains in dynamics were revealed while a trend toward worsening of interaction with other people was still detectable (\( z = -1.860, P = .064, r = 0.324 \)).

**Discussion**

To our knowledge, this is the first study to address preinjury gender differences in social-emotional behavior in children with mild traumatic brain injury as young as 3 to 65 months. Mostly because of methodological difficulties, this age group has been unfoundedly neglected in previous research even though the incidence rate for traumatic brain injury in children younger than 4 years is almost twice as high as in older age groups (for more details, see Ventsel et al.,2 Langlois et al.,2 etc).

Our findings suggest that there are different risk factors for mild traumatic brain injury in male and female babies and toddlers. Boys, who have more self-regulation, interaction and autonomy difficulties and girls, who have worse adaptive functioning, are more likely to incur a mild traumatic brain injury. These findings are at least partially concordant with the work of Morrongiello, Ondejko, and Littlejohn, who argued that young boys with compliance issues are in higher risk of in-home injuries (including falls causing mild traumatic brain injury).8

Furthermore, our results show that, preinjury, self-regulation and autonomy difficulties are actually more common and notable in male infants and toddlers compared to females. Similar results in infants and toddlers suffering from traumatic brain injury or other accidental injuries have previously been described by Gartstein and Fagot9 and Aken et al.11

The results of the current study improve our knowledge of the mechanisms that explain gender differences in children with mild traumatic brain injury. They confirm that these differences are not only innate tendencies but are also due to gender role development. This knowledge has practical implications. Thus, faced with these gender differences, knowledge about gender-specific social-emotional risky behaviors, which makes infants and toddlers more vulnerable to mild traumatic brain injury, should be incorporated into programs concerned with traumatic brain injury as well as other accidental injuries prevention programs.

Granie22 has suggested that gender differences in children’s risky behaviors can be detected at least as early as the preschool period, but our results show that some gender-specific, risky behaviors are even notable in infants as young as 3 months.

Contrary to Morrongiello and Dawber,7 whose findings indicate that young boys are more autonomous and independent, our results do not confirm that assumption. We did not find any significant differences in social-emotional behavioral problems in the autonomy skills of control group boys or girls.

However, our follow-up study revealed intriguing results, namely, that parents of the 12- to 65-month-old control group children tended to report more interaction difficulties in girls compared to boys. It is noteworthy that this gender difference in control group children was not detectable 9 months earlier during our essential study. This discrepancy could be explained at least partially by parents’ gradually growing expectations for girls. It generally thought that little girls develop socially and cognitively more quickly than little boys and, therefore, it could be that the demands parents make to their daughters’ interaction skills are already higher in comparison to their sons.

Our results also showed that after 9 months, both control group boys and girls were doing remarkably better in self-regulation, whereas a similar trend was not notable in the mild traumatic brain injury group. This confirms the findings of Rothbart et al, who have shown a remarkable improvement in self-regulation skills due to a shift in control from the brain’s orienting network in infancy to the executive network by the age of 3–4 years in typically developing children. However, when the development of these network connections is disrupted as a result of a diffuse brain injury (or injury of the frontotemporal and parietal areas that is most common to early childhood traumatic brain injury) the normal development of self-regulation may be affected.23

In children with mild traumatic brain injury, the follow-up assessment confirmed declines in social-emotional behavior after the injury. Our results affirm the viewpoints of Brown et al,24 Janusz et al,25 and Kirkwood et al,26 who have also
shown behavioral impairments occurring after childhood traumatic brain injury. This was in contrast to the findings of Anderson et al.,27 and Fay et al.,28 Fletcher et al.,29 Kinsella et al.,30 and Wetherington et al.,31 who have all stated average behavioral ratings after childhood traumatic brain injury. While Wetherington et al.31 failed to show behavioral impairments after childhood traumatic brain injury in 3-year-old children, they did conclude that it may be premature to infer that preschoolers do not evidence behavioral dysfunction after early traumatic brain injury as most of the behavioral dysfunctions may be notable later in life. Because of the huge benefit of early intervention, it is crucial to use more sensitive screening and evaluation methods to detect even slight aberrations from normal social-emotional development as early as possible. The Ages and Stages Questionnaires: Social-Emotional used in the present study seemed to be one of the possible cost-effective methods that could help to identify young children at risk for social-emotional behavioral problems.

An important strength of our study is that even though we used a relatively small sample size, especially in the follow-up period, the methodology employed in our study made it possible to detect noteworthy gender- and age-specific social-emotional behavioral difficulties that occur after mild traumatic brain injury. We found that even a mild traumatic brain injury has a negative effect on ongoing social-emotional development and, overall, social-emotional outcomes after mild traumatic brain injury are somewhat worse for boys than for girls. More precisely, we found that 9 months after the injury, boys were continuing to do more poorly in self-regulation than girls. They were also doing worse in self-regulation than control group boys. Moreover, boys with mild traumatic brain injury were showing worse interaction and autonomy skills compared with their noninjured controls, whereas little girls who had suffered mild traumatic brain injury only showed worse interaction skills compared to their noninjured same-gender peers. These results give reason to presume that interaction skills are most vulnerable to the negative effect of mild traumatic brain injury in social-emotional development both in boys and girls and confirm the previous findings of Ganeshalingam et al.,32 Anderson et al.,33 and Ryan et al.,34 who have shown remarkable declines in social competence and especially in social interaction, communication, and social contact in children after early traumatic brain injury.

In light of these findings, it is especially important to state that in the postinjury period, although parents of children with mild traumatic brain injury are especially worried about the decline in their child’s cognitive skills, worsening of academic performance, and accumulating health problems, children themselves are reporting social interaction difficulties and worsening peer relationships as their main concern and insuperable obstacle after their injury.

**Limitations of the Study**

Some methodologic limitations in the present study need to be addressed. First, the relatively small sample size (22 boys and 13 girls in the mild traumatic brain injury group and 44 boys and 26 girls in the control group for the baseline study, and 17 boys and 9 girls in the mild traumatic brain injury group and 34 boys and 18 girls in the control group for the follow-up study) used here and the limited number, sophistication, and power of the analysis that we were able conduct affect the confidence with which we can draw conclusions and implications. Therefore, the results here would benefit from replication with larger samples.

Additionally, the use of only a single measure (Ages and Stages Questionnaires: Social-Emotional) to assess social-emotional behavior and development may not be enough. Notwithstanding, more precise estimates of early childhood mild traumatic brain injury’s influence on a child’s social-emotional development would be beneficial in future research, in addition to parent-completed questionnaires, and suitable behavioral observations or experimental testing with a follow-up period of at least 3 years for a more thorough insight.

And finally, the retrospective collection of data for preinjury could bias the results as the parents of mild traumatic brain injury children could be affected in the aftermath of their child’s injury.

**Conclusion**

Our findings suggest that there are gender-specific risk signs for mild traumatic brain injury even in children as young as 3 to 65 months of age. Little boys who struggle with self-regulation and autonomy issues and little girls who have difficulties with adaptive functioning may be at elevated risk. Nine months after their injury, boys continue to have more social-emotional difficulties with self-regulation and autonomy. New problems with interaction with other people emerged for both boys and girls. Nevertheless, boys seem to be more vulnerable to the negative effects of mild traumatic brain injury. Our results also suggest that the further development of interaction skills is significantly affected by mild traumatic brain injury.

In conclusion, it is important to stress that parents, if informed of different gender-specific social-emotional risk signs, could prevent brain traumas by modifying the child’s environment, applying extra care and early intervention.

**Acknowledgments**

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**Author Contributions**

MLK was responsible for the patient selection, data collection, and statistical analysis of the data. She also wrote the first and final draft of the article. AK was responsible for the design of the project and
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