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Prenatal risk and physical aggression during the first years of life: The gender-specific role of inhibitory control

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Abstract

Prenatal risk and a lack of inhibitory control have consistently been related to the development of physical aggression in older children. This study examined whether inhibitory control mediated the relation between prenatal risk and aggression in infants and toddlers. The role of gender in this mediation model was also examined. The sample consisted of 161 mother–child dyads (83 boys). A prenatal cumulative risk score was created from a number of well-established risk factors including maternal psychopathology, substance use, and social and socioeconomic disadvantages. At 12 months, children performed an inhibitory control task. Physical aggression was assessed through maternal reports at 12 and 20 months of age. Results showed that higher prenatal risk was associated with more physical aggression. Inhibitory control mediated this association at both 12 and 20 months: higher prenatal risk was related to lower inhibitory control, which in turn led to higher aggression. At 20 months, gender moderated the mediation effect: the mediating role of inhibitory control was only found for girls. These results suggest that even before 2 years of age, inhibitory control is an important construct involved in the relation between prenatal risk and physical aggression.

1 | INTRODUCTION

Several maternal risk factors have consistently been related to the development of physical aggression in toddlerhood (Carneiro, Dias, & Soares, 2016). Examples include low socioeconomic status (Garratt, Chandola, Purdam, & Wood, 2017) and substance use during pregnancy (LaGasse et al., 2012). The occurrence of physical aggression is common and appears normative during the first years of life (Hay, 2017; Tremblay, 2010). Whereas for the majority of children a decline of physical aggression occurs after toddlerhood (Mesman, Bongers, & Koot, 2001), some children remain highly aggressive. The search for factors explaining why some children remain highly aggressive is still ongoing.

In addition, much remains unclear about potential mediating mechanisms explaining the associations between maternal risk factors and physical aggression (Evans, Li, & Whipple, 2013). It has been suggested that suboptimal cognitive development might explain associations between risk and physical aggression (Hughes & Ensor, 2008). Of all aspects of cognition that might play a role in such associations, lack of inhibitory control stands out (Raaijmakers et al., 2008; Roman, Ensor, & Hughes, 2016). Whereas evidence for associations between risk, inhibitory control, and physical aggression is relatively consistent for older populations (Carneiro et al., 2016; Utendale & Hastings, 2011), one question that remains is whether these associations can also be observed very early in life. As cognitive development in early childhood may be more easily influenced than most maternal risk factors and subsequent epi-genetic and neurobiological changes (Diamond & Lee, 2011; Dowsett & Livesey, 2000), it is worthwhile to investigate early inhibitory control in the context of risk-aggression associations. Therefore, this study examined whether prenatal risk predicts physical aggression in infancy and toddlerhood and whether inhibitory control mediates the relation between prenatal risk and physical aggression. Because the development of inhibitory control and aggression appears to be influenced by child's gender (Endendijk et al., 2017; Spann & Gagne, 2016), the role of gender in this model is also examined.

1.1 | Risk and aggression

High levels of physical aggression in toddlerhood are predictive of long-term negative developmental outcomes (Campbell, Spieker, Burchinal, & Poe, 2006). In addition to continuing externalizing problem behavior, physical aggression in toddlerhood also predicts internalizing behavior problems, social problems, and poor academic achievement during school age and early adolescence (Brennan, Shaw, Dishion, & Wilson, 2012; Cote, Vaillancourt, LeBlanc, Nagin, & Tremblay, 2006; Mesman et al., 2001; NICHD Early Child Care Research Network, 2004).

Risk factors that have consistently been associated with physical aggression include substance use during pregnancy (Huijbregts, Warren, de Sonneville, & Swaab-Barneveld, 2008; LaGasse et al., 2012), parental psychopathology (de Bruijn, van Bakel, & van Baar, 2009; Velders et al., 2011), low socioeconomic status (Garratt et al., 2017; Tremblay et al., 2004), being a single parent (Cote et al., 2007), and young maternal age (Tremblay et al., 2004; Velders et al., 2011). In the last decade, the importance and advantages of examining a cumulative risk score instead of specific singular risk factors in relation to child's outcomes have been highlighted (Evans et al., 2013; Flouri & Kallis, 2007). First of all, it has consistently been found that multiple risk factors compared with single risk factors are related to poorer developmental outcomes (Evans et al., 2013; Huijbregts, Seguin, Zoccolillo, Boivin, & Tremblay, 2008; Sameroff, Seifer, & McDonough, 2004). In addition, because maternal risk factors often co-occur (Carneiro et al., 2016; Dong et al., 2004), studies may overestimate the impact of single risk factors (Evans et al., 2013). A cumulative risk approach is also more parsimonious, has more statistical power, and has no multicollinearity problems (Evans et al., 2013; Flouri & Kallis, 2007).

Research using a cumulative risk index found that a higher number of risk factors at birth or during early childhood were related to more externalizing problem behavior in young children (Bennett, Marini, Berzenski, Carmody, & Lewis, 2013; Gassman-Pines & Yoshikawa, 2006; Northerner, Trentacosta, & McLear, 2016; Trentacosta et al., 2008). These findings support the importance of examining cumulative risk compared with single risk models in relation to early childhood aggression.

1.2 | Risk and inhibitory control

Inhibitory control is the ability to suppress a dominant response, one of the core components of executive functions (Garon, Bryson, & Smith, 2008; Miyake et al., 2000). The ability to inhibit a prepotent response already starts developing during the first year of life and shows rapid improvements during toddlerhood and the preschool age (Garon et al., 2008; Kochanska, Tjebkes, & Forman, 1998).

In order to measure inhibitory control at (very) young ages, the most frequently used tasks involve waiting paradigms. The tasks require children to withhold the tendency to open a gift, eat a snack, or to play with an attractive toy, sometimes compensated by a larger reward at a later time (Kochanska & Aksan, 1995; Kochanska et al., 1998). Also more complex tasks have been used such as those involving an arbitrary rule (e.g., respond "night" to the picture of a sun and vice versa) which causes a conflict between the dominant response and non-dominant response (Garon et al., 2008). It has been shown that 8-month-old children are already able to perform tasks such as the "don't paradigm," where parents request their children to suppress the tendency to play with an attractive toy (Kochanska et al., 1998).

Several individual risk factors, such as low socioeconomic status and maternal psychopathology, have been associated with relatively poor inhibitory control (Comas, Valentino, & Borkowski, 2014; Evans & Rosenbaum, 2008; Mezzacappa, 2004). Cumulative risk, that is, the sum of different socio-economic and socio-demographic disadvantages, has been related to inhibitory control at different ages as well. For example, negative associations were observed between the number of risk factors and executive functioning (including inhibitory control) in 2- (Hughes & Ensor, 2005) and 6-year-old children (Holochwost et al., 2016). Another study showed that children with a low-risk profile assessed during infancy scored higher on an executive functioning task requiring inhibitory control at 36 months compared to children with a high-risk profile (Rhoades, Greenberg, Lanza, & Blair, 2011).

1.3 | Mechanisms underlying the influence of prenatal risk

Several mechanisms can be considered linking specific prenatal risk factors and cumulative risk to children's cognitive and behavioral development. Certain prenatal risk factors, such as tobacco and alcohol use, can have effects on child inhibition and aggressive behavior through direct influences on brain development during pregnancy (Ekblad, Korkeila, & Lehtonen, 2015; Guerri, Bazinet, & Riley, 2009). Other risk factors, such as financial problems, single motherhood, maternal psychopathology, or a limited social network, could induce higher maternal stress (Mulder et al., 2002). Fetal exposure to stress hormones transmitted via the placenta may affect children's cognitive and behavioral development by altering brain development (Bock, Wainstock, Braun, & Segal, 2015; Brunton & Russell, 2011; Mulder et al., 2002). Recent research has suggested that prenatal environmental risk factors could also influence brain structure and brain functioning by modulating expression of genes involved in brain maturation, a process known as epigenetics (Palumbo, Mariotti, Iofrida, & Pellegrini, 2018). These processes may continue postnatally. Risk factors such as financial hardship or parental psychopathology may also have continued consequences for children's cognitive and behavioral development through parenting behavior and limited resources (Holochwost et al., 2016; Lengua et al., 2014). For example, mothers with a psychiatric disorder could be less sensitive in interaction with their children, and financial problems could induce fewer possibilities to provide a cognitively stimulating environment. In addition, a genetic component related to a lack of inhibitory control could have long-term negative consequences for offspring as it could, for example, increase the chances of financial problems, addiction, and teenage pregnancy (Friedman et al., 2008; Gagne, Saudino, & Asherson, 2011).

1.4 | Inhibitory control and aggression

Previous studies consistently showed that impairments in inhibitory control are related to externalizing problem behavior during preschool (Raaijmakers et al., 2008; Spann & Gagne, 2016) and school age (Ellis, Weiss, & Lochman, 2009). In addition, a meta-analysis examining the relation between different aspects of executive functioning and externalizing behavior problems in preschool concluded that executive functioning, and especially inhibition, was indeed related to problem behavior (Schoemaker, Mulder, Dekovic, & Matthys, 2013). Specifically, using maternal reports, Suurland et al. (2016) found that a lack of inhibitory control was predictive of aggressive behavior during preschool, especially in children showing high negative temperamental reactivity. Utendale and Hastings (2011) reported that lower maternally reported inhibitory control was related to more externalizing behavior observed during a play task with other children in 3- to 6-year-olds, and both Raaijmakers et al. (2008) and Spann and Gagne (2016) showed that highly aggressive preschoolers scored relatively poorly on inhibitory control as measured by neurocognitive tasks. In conclusion, support exists for the association between inhibitory control and aggressive behavior during the preschool and early school age, but no research to date has examined the inhibitory control–aggression relation during infancy and toddlerhood.

1.5 | Mediation by inhibitory control in the risk–aggression relation

As prenatal risk, inhibitory control, and physical aggression are interrelated, inhibitory control is proposed as mechanism mediating the effect of prenatal risk on physical aggression. Three studies examined executive functioning, including inhibitory control, as a mediator in the relation between maternal risk and childhood problem behavior. There were strong indications that the relation between cumulative social disadvantage and problem behavior was mediated by executive functioning in 3- and 4-year-old children (Hughes & Ensor, 2008). With an extended sample, it was shown that executive functioning also mediated the relations between maternal depression and maternal education on the one hand and preschool problem behavior on the other (Hughes & Ensor, 2009; Roman et al., 2016). The effects were not only specific to certain risk factors but also specific for executive functioning: verbal ability did not explain the effect of depression and education on children's problem behavior (Roman et al., 2016). These studies suggest an important role of executive functioning explaining the relation between risk factors and externalizing problem behavior in preschool age. However, it remains unclear whether this pathway with inhibitory control as mediator (one of the first developing components of executive functioning) can already be observed during infancy and toddlerhood.

1.6 | Influence of gender

Previous studies indicated that gender is an important factor related to children's inhibitory control and physical aggression. It has consistently been shown that girls have better inhibitory control measured using parent reports (Granero, Louwaars, & Ezpeleta, 2015), as well as neuropsychological tasks during the preschool age (Raaijmakers et al., 2008; Spann & Gagne, 2016). Even in toddlerhood, gender differences are already found: girls were better able to suppress a rewarding response after mothers' request when they were 14, 20 and 33 months old (Kochanska, Coy, & Murray, 2001).

In addition to gender differences in inhibitory control, it has been found that boys show higher levels of aggressive behavior compared with girls during preschool age (Endendijk et al., 2017; Ostrov & Keating, 2004). Studies examining early development of physical aggression have indicated that these gender differences already appear during the second year of life (Alink et al., 2006; Baillargeon et al., 2007; Hay, 2017). Despite these results, there are also studies that did not find significant gender differences during toddlerhood or preschool age (Hay, Castle, & Davies, 2000; Spann & Gagne, 2016).

Although gender differences in inhibitory control and aggression have often been found, it is unclear whether the relations between prenatal risk and inhibitory control, and inhibitory control and aggression are different for boys and girls during toddlerhood. According to most prominent evolutionary perspective, boys and girls use different coping strategies to deal with exposure to risk during pregnancy (Sandman, Glynn, & Davis, 2013; Sutherland & Brunwasser, 2018). Whereas boys continue to invest in their physical development in response to early adversity, and therefore are more susceptible to general developmental delays in cognition and behavior (Dipietro & Voegtline, 2017), girls adapt in more flexible ways to environmental conditions, which results in greater cognitive and behavioral variability (Sandman et al., 2013). Therefore, it could be hypothesized that, whereas boys might "respond" with more aggressive behavior to early (prenatal and postnatal) adversity, girls make more use of adaptive (cognitive) coping strategies, which might include inhibitory control. Consequently, inhibitory control might play a more important role in prenatal risk—postnatal aggression associations for girls than for boys.

While studies specifically examining inhibitory control in relation to prenatal risk are lacking, it seems that prenatal maternal stress is more strongly related to cognitive outcomes for girls than for boys (Sutherland & Brunwasser, 2018). With regard to the relation between inhibitory control or executive functioning and problem behavior, there are indications for stronger associations among girls (Carlson & Wang, 2007; Granvald & Marciszko, 2016; Hughes & Ensor, 2009), although it should be noted that results have not been consistent (Lonigan et al., 2017; Olson et al., 2011; Schoemaker et al., 2013).

Thus, despite the fact that results are not always consistent, the majority of studies find gender influences in inhibitory control and aggressive behavior, thereby underlining the importance of considering gender as a possible moderator when examining mediation effects of inhibitory control in risk–aggression associations (Cabello, Gutierrez-Cobo, & Fernandez-Berrocal, 2017; Granero et al., 2015). Cabello et al. (2017) examined the role of gender in relation to parental educational level, inhibitory control, and aggression in a school age sample. It was found that inhibitory control mediated the negative relation between parental educational level and teacher-rated aggression, but only for boys. Another study examining 3-year-olds found a contrasting result: inhibitory control mediated the relation between socioeconomic status and the number of oppositional defiant disorder symptoms, but only in girls (Granero et al., 2015). The role of gender in a model including prenatal risk, inhibitory control, and physical aggression associations has not yet been examined in children under the age of three.

1.7 | Current study

This study examined the moderated mediation model shown in Figure 1. Based on previous research, it was hypothesized that prenatal cumulative risk would be positively related to child's aggression at 12 and 20 months (hypothesis 1) and that inhibitory control would mediate this association: higher

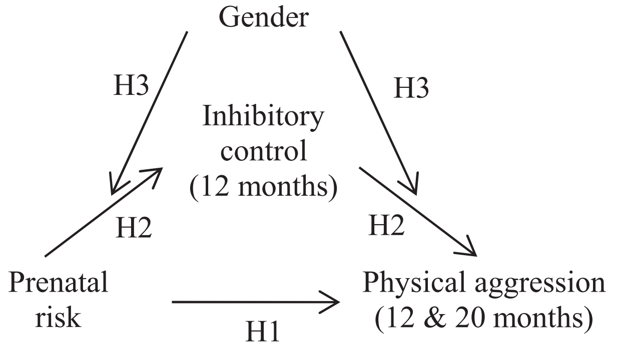

FIGURE 1 The moderated mediation model including prenatal risk, inhibitory control, physical aggression, and gender

prenatal risk would be associated with lower inhibitory control, which would lead to more aggressive behavior (hypothesis 2). Next, it was examined whether gender moderated this mediation model: it was hypothesized that the relation between prenatal risks on aggression via inhibitory control would be different for boys and girls (hypothesis 3). As many contrasting results were reported (in older children), it was difficult to formulate a specific hypothesis about the moderating role of gender. Based on the evolutionary perspective, it might be expected that a role of cognition in risk–aggression associations will be more evident for girls than for boys. However, based on previous findings of lower inhibitory control and increased externalizing behavior problems in boys compared with girls, it cannot be ruled out either that the mediating effects of inhibitory control will be more visible for boys.

2 | METHODS

2.1 | Participants

The present study is part of the Mother–Infant Neurodevelopment Study in Leiden, the Netherlands (MINDS Leiden; Smaling et al., 2015; Suurland et al., 2017). MINDS Leiden is a longitudinal study on neurobiological and neurocognitive predictors of early behavior problems and consists of six data waves (third trimester of pregnancy, and 6, 12, 20, 30, and 45–48 months post-partum). A total of 210 women were recruited during pregnancy via midwifery clinics, hospitals, prenatal classes, and pregnancy fairs. Dutch-speaking, primiparous women between 17 and 25 years old with uncomplicated pregnancies were eligible to participate. Mothers were excluded from the study when they were addicted to drugs, had an intellectual disability (IQ lower than 70), or had severe medical problems or severe psychiatric problems (e.g., psychosis or schizophrenia).

Data for this study were collected during the first (during the third trimester of pregnancy), third (12 months post-partum), and fourth data waves (20 months post-partum). Forty-five mother–child dyads (21%) did not participate in the third wave of the study, due to health problems ($n = 4$), refusal to participate ($n = 24$), inability to contact the mother ($n = 15$), and emigration ($n = 2$). Another four mother–infant dyads did not participate in the fourth wave of the study, because of health problems ($n = 1$) and inability to contact mother ($n = 3$). Dropout was unrelated to background characteristics such as maternal age and income. Dropouts more often had a non-Caucasian background, $p = 0.01$, more often had a single status, $p = 0.03$, and had more prenatal risk factors, $p < 0.01$.

The final sample used in the analyses consisted of 161 mother–child dyads (83 boys and 78 girls) who finished the third and fourth data wave. Mean age of the mothers was 22.94 years ($SD = 2.10$)

during the first wave. The majority of the mothers were Caucasian (88.2%), the remaining mothers were Surinam or Antillean (3.1%), and from other origin (8.7%). Family income ranged from 0 to 5,400 Euros (M = 2,615.07, SD = 1,135.65). Child's age ranged from 11.56 to 15.05 months (M = 12.52, SD = 0.60) at wave 3 and from 18.66 to 24.05 months (M = 20.44, SD = 0.72) at wave 4.

2.2 | Procedures and instruments

The first data wave (during the third trimester of pregnancy) consisted of a home visit, containing interviews and questionnaires. The third data wave (laboratory visit at 12 months post-partum) and fourth data wave (home visit at 20 months post-partum) included several mother–child interaction tasks, a series of tasks measuring the child's cognitive and social development, and behavioral questionnaires. Each appointment lasted approximately 2–2.5 hr and was carried out by two trained female researchers. At the end of each visit, mother received a gift card and a present for her child. The present study was conducted according to guidelines laid down in the Declaration of Helsinki and received approval from the ethics committee of the Department of Education and Child Studies at the Faculty of Social and Behavioral Sciences, Leiden University (ECPW-2011/025), and from the Medical Research Ethics Committee at Leiden University Medical Centre (NL39303.058.12). Informed consent was obtained from all participating woman before data collection.

2.2.1 | Prenatal risk

Prenatal cumulative risk was computed by adding the number of risk factors present during the first data wave (Mejdoubi et al., 2011; World Health Organization, 2005). Risk factors (1 = present, 0 = absent) included (a) maternal psychiatric disorder, measured with the Dutch version of the Mini-International Neuropsychiatric Interview—plus (Sheehan et al., 1997; Van Vliet, Leroy, & Van Megen, 2000), (b) tobacco, (c) alcohol and (d) drug use during pregnancy, (e) teenage pregnancy (< 20 years), (f) no secondary education, (g) unemployment, (h) self-reported financial problems, (i) limited (< 4 persons) social network, measured with the Norbeck Social Support Questionnaire (Norbeck, Lindsey, & Carrieri, 1981, 1983), and (j) being single (see for more detailed information about the criteria: Smaling et al. (2015); Suurland et al. (2017)). The prenatal cumulative risk score ranged from 0 to 3: 59.9% had no risk factors, 21.1% had one risk factor, 14.9% had two risk factors, and 4.3% had three risk factors. Table 1 shows the prevalence of prenatal cumulative risk.

2.2.2 | Inhibitory control

To measure early inhibitory control during the third data wave (12 months), an adapted version of the don't paradigm was carried out (Kochanska & Aksan, 1995; Kochanska et al., 1998). While the infant was sitting on the floor playing with a book, an attractive toy with sounds, colors, and lights was put approximately one meter from the child. While sitting at the table, the mother was instructed to prohibit her child from touching the toy for 2 min, using words and sentences she would also use in daily settings (e.g., "no-no" and "don't do that"). The task was videotaped and coded afterward using the coding manual of Kochanska and Aksan (2005). Infant behavior was coded every 5 s episode using five mutually exclusive codes: 0 = *no attention for the toy*, 1 = *committed compliance* (child looks but does not touch the toy), 2 = *situational or shaky compliance* (the child touches the toy during a part of the episode), 3 = *non-compliance or deviation* (the child touches the toy during the whole episode), and 4 = *defiance* (the child protests, becomes angry or sad). Regarding the reliability of coding infant's behavior, ICC was $\alpha = 0.92$ (based on 27 videos). For the analyses, the percentage of

TABLE 1 Frequency table showing the prevalence of prenatal cumulative risk ($n = 161$)

n risk factors				*n* (%) participants
0				96 (59.9%)
1				34 (21.1%)
	Psychiatric disorder			14
	Tobacco use			4
	Alcohol use			9
	Social risk			7
2				24 (14.9%)
	Psychiatric disorder	Tobacco use		6
	Psychiatric disorder	Alcohol use		1
	Psychiatric disorder	Social risk		8
	Tobacco use	Alcohol use		1
	Tobacco use	Social risk		3
	Social risk	Social risk		5
3				7 (4.3%)
	Psychiatric disorder	Tobacco use	Drug use	1
	Psychiatric disorder	Tobacco use	Social risk	2
	Psychiatric disorder	Social risk	Social risk	3
	Tobacco use	Social risk	Social risk	1

Note: Social risk consists of the following risk factors: teenage pregnancy, no secondary education, unemployment, financial problems, limited social network, and being single.

episodes that the child showed inhibitory control was calculated by dividing the number of episodes the infant showed committed compliance (code 1) by the number of episodes the child had attention for the attractive toy (code 1–4; Kochanska et al., 1998). Six children had missing data for inhibitory control task, because they were not interested in the attractive toy ($n = 2$), became upset during the task ($n = 3$) or because of problems with video recording ($n = 1$).

2.2.3 | Physical aggression

Child's physical aggression was measured by the Physical Aggression Scale for Early Childhood during the third (12 months post-partum) and fourth data waves (20 months post-partum). This questionnaire was based on the behavioral questionnaire of Tremblay et al. (1999) and the Childhood Behavior Checklist 1½–5 (Achenbach & Rescorla, 2000) and consists of 11 items (e.g., "physically attacks," "starts fights," "hits"). Mothers rated whether the child had shown these aggressive behaviors during the past two months using a 3-point Likert scale (0 = *not true*, 1 = *somewhat or sometimes true*, and 2 = *very true or often true*). A total score of physical aggression was calculated by summing the item scores (potential range: 0–22). Means reported by Alink et al. (2006) were 1.19 ($SD = 1.71$) at 12 months and 3.20 ($SD = 3.06$) at 24 months for maternal report. Inter-rater reliability, convergent validity, and 1-year stability were substantial in a Dutch sample (Alink et al., 2006; Mesman et al., 2008). Internal consistency (Cronbach's α, calculated for the present sample) was 0.76 at 12 months and 0.73 at 20 months.

2.3 | Data analyses

Preliminary analyses were performed to compute descriptive data and examine outliers. Outliers deviating more than three standard deviations from the mean were winsorized to the value three standard deviations from the mean. Outliers were detected for the total physical aggression score at 12 months (n = 3) and 20 months (n = 3). Bivariate associations between study variables were examined using Pearson's correlations. Differences between boys and girls on the study variables were examined using several t-tests. Since vocabulary has been related to inhibitory control (Wolfe & Bell, 2004), aggression during the early years (Girard et al., 2014), and gender (Eriksson et al., 2012), vocabulary comprehension was tested as potential covariate (measured using the Dutch adaptation of the Communicative Development Inventories: Words and Gestures; Fenson et al., 2000; Zink & Lejaegere, 2003). Age of the children at the data waves was also examined as potential covariate.

The moderated mediation model was tested following the recommendations of Hayes (2015) and Holland, Shore, and Cortina (2017). The first hypothesis was tested using regression analysis to examine whether prenatal risk predicted children's physical aggression. For the second hypothesis, a bootstrap procedure was used to test whether inhibitory control mediated the relation between prenatal risk and physical aggression. The bootstrap method estimates the indirect effect, which is the product of path a (prenatal risk to inhibitory control) and path b (inhibitory control to physical aggression). For the third hypothesis, two steps were carried out to test whether gender moderated the mediation model involving prenatal risk, inhibitory control, and physical aggression. First, it has been recommended by Holland et al. (2017) to examine the specific pathway of the mediation model which would be moderated by gender. Therefore, hierarchical regression analysis was used to test whether gender specifically moderated the effect of prenatal risk on inhibitory control (path a) or the effect of inhibitory control on physical aggression (path b). The independent variables were mean-centered before included as a product in the analysis to prevent multicollinearity and for interpretation purposes. When the interaction effect was significant, simple slopes analyses were performed to test the significance of the slopes for boys and girls. Second, a bootstrap procedure was conducted to estimate the indirect effect from prenatal risk to physical aggression via inhibitory control for boys and girls. The moderated mediation index was used to test whether the indirect effect for boys and girls was significantly different.

All analyses were carried out for physical aggression at 12 months and 20 months separately using the Statistical Package for Social Sciences (SPSS; version 23.0). Bootstrap procedures with 5,000 bootstrap sample draws were conducted using the PROCESS macro (Hayes, 2013). The bootstrap procedure is recommended, because this method does not have distributional requirements such as normality, has lower type I error rates, and has more power because it relies on a single statistical analysis (Edwards & Lambert, 2007; Hayes, 2013). Bias-corrected (BC) percentile bootstrap confidence intervals (95%) were reported for the indirect effects.

3 | RESULTS

3.1 | Descriptive analyses

Descriptive data and correlations between the study variables are displayed in Table 2. Prenatal risk, inhibitory control, and physical aggression were significantly related in the expected directions. In addition, physical aggression at 12 months was positively related to physical aggression at 20 months, $r = 0.28, p < 0.01$. Because vocabulary and age of the children at the data waves were not significantly related to the study variables, these variables were not included in the main analyses.

TABLE 2 Descriptive data and correlation analyses for study variables ($n = 161$)

	1.	2.	3.	4.	*n*	*M*	*SD*	Min	Max
1. Prenatal risk	–				161	0.64	0.89	0.00	3.00
2. Inhibitory control	−0.19*	–			155	0.33	0.32	0.00	1.00
3. Aggression 12 months	0.25**	−0.19*	–		161	2.80	2.10	0.00	11.05
4. Aggression 20 months	0.24**	−0.18*	0.28**	–	161	2.69	2.30	0.00	9.92
5. Vocabulary	−0.13	0.04	0.00	−0.08	155	42.60	21.78	0.00	103.00
6. Age 12-month wave	–	−0.05	−0.02	–	161	12.52	0.60	11.56	15.05
7. Age 20-month wave	–	–	–	0.11	161	20.44	0.72	18.66	24.05

**<0.01.
*<0.05.
† <0.10.

As shown in Table 3, boys and girls did not differ in prenatal risk score and physical aggression at 12 months. A trend was found for physical aggression at 20 months, indicating that boys ($M = 3.01$, $SD = 2.38$) show more physical aggression than girls ($M = 2.36$, $SD = 2.18$), $p = 0.07$. For inhibitory control, girls ($M = 0.40$, $SD = 0.36$) scored higher compared with boys ($M = 0.26$, $SD = 0.27$), $p < 0.01$.

3.2 | Main analyses

Main analyses were performed for participants with complete data ($n = 155$). A linear regression analysis was used to test whether prenatal risk predicted child's physical aggression (hypothesis 1). A significant regression model was found for the prediction of physical aggression at 12 months, $F(1, 153) = 10.02$, $p < 0.01$, and at 20 months, $F(1, 153) = 10.16$, $p < 0.01$. Results indicated that higher prenatal risk predicted more physical aggression at 12 months, $\beta = 0.25$, $t(153) = 3.17$, $p < 0.01$, and at 20 months, $\beta = 0.25$, $t(153) = 3.19$, $p < 0.01$.

Regarding the second hypothesis, the analyses showed that the unstandardized indirect effect of prenatal risk on physical aggression through inhibitory control was significant for both physical aggression at 12 months, $ab = 0.06$, $SE = 0.03$, 95% BC CI [0.01, 0.15], and at 20 months, $ab = 0.07$, $SE = 0.04$, 95% BC CI [0.00, 0.19]. As shown in Figure 2, the standardized path coefficients were in the expected directions: higher prenatal risk was related to lower inhibitory control, which in turn

TABLE 3 Results of the *t*-tests comparing boys and girls on study variables

	Boys ($n = 83$)				Girls ($n = 78$)				
	M	*SD*	Min	Max	*M*	*SD*	Min	Max	*t*
Prenatal risk	0.63	0.96	0.00	3.00	0.65	0.82	0.00	3.00	−0.19
Inhibitory control	0.26	0.27	0.00	1.00	0.40	0.36	0.00	1.00	−2.81**
Aggression 12 months	3.00	2.37	0.00	11.05	2.59	1.75	0.00	11.05	1.26
Aggression 20 months	3.01	2.38	0.00	9.92	2.36	2.18	0.00	9.92	1.81†

** < 0.01.
* < 0.05.
† < 0.10.

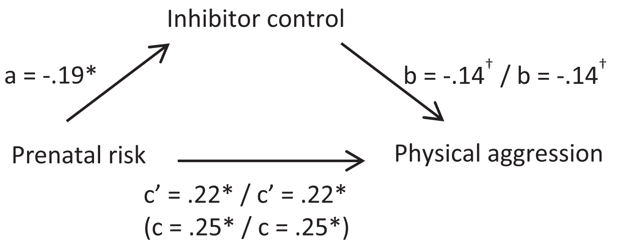

FIGURE 2 Mediation model of prenatal risk on physical aggression through inhibitory control. Standardized regression coefficients for 12 and 20 months were shown before and after the slash, respectively. ** < 0.01, * < 0.05, † < 0.10

predicted more physical aggression. Inhibitory control accounted for approximately 10% of the total effect in both 12-month physical aggression (10.86%) and 20-month physical aggression (10.52%).

For the third hypothesis, two steps were carried out to test whether gender moderated the mediation model involving prenatal risk, inhibitory control, and physical aggression. First, hierarchical regression analysis was used to test whether gender moderated the effect of prenatal risk on inhibitory control (path a) or the effect of inhibitory control on physical aggression (path b). The first hierarchical regression analysis showed that the interaction between prenatal risk and gender on inhibitory control was not significant, $\beta = -0.03$, $p = 0.67$. Table 4 shows the results of the second hierarchical regression analysis examining the interaction between inhibitory control and gender on physical aggression at 12 and 20 months. For physical aggression at 12 months, the interaction between inhibitory control and gender was not significant, $\beta = 0.02$, $p = 0.81$. For 20 months, the final model was significant, $F(4, 150) = 5.28$, $p < 0.01$, and adding the interaction improved the model significantly, $\Delta R^2 = 0.03$, $p = 0.02$. The interaction between inhibitory control and gender was significant, $\beta = -0.19$, $p = 0.02$. Figure 3 shows the regression lines for boys and girls. Post hoc analyses examining the simple slopes

TABLE 4 Hierarchical regression analyses predicting physical aggression at 12 and 20 months ($n = 155$)

	Physical aggression 12 months				Physical aggression 20 months			
	β	t	R^2	ΔR^2	β	t	R^2	ΔR^2
Model 1			0.06	0.06**			0.06	0.06**
Prenatal risk	0.25	3.17**			0.25	3.19**		
Model 2			0.09	0.03			0.09	0.03†
Prenatal risk	0.23	2.84**			0.23	2.89**		
Inhibitory control	−0.12	−1.53			−0.12	−1.41		
Gender	−0.08	−1.03			−0.11	−1.34		
Model 3			0.09	0.00			0.12	0.03*
Prenatal risk	0.23	2.84**			0.24	3.06**		
Inhibitory control	−0.12	−1.38			−0.06	−0.70		
Gender	−0.08	−1.04			−0.12	−1.50		
Inhibitory control × Gender	−0.02	−0.25			−0.19	−2.33*		

Note: Prenatal risk, inhibitory control, and gender are mean-centered.
** < 0.01.
* < 0.05.
† < 0.10.

revealed that girls showed a significant negative association between inhibitory control and physical aggression, $p = 0.01$, while for boys there was no significant effect, $p = 0.33$.

Second, a bootstrap procedure was used to examine whether the indirect effect from prenatal risk to aggression via inhibitory control was different for boys and girls. Because the two pathways (prenatal risk on inhibitory control and inhibitory control on aggression) in the model including aggressive behavior at 12 months were both not significantly moderated by gender, the moderated mediation index was only tested for aggression at 20 months. The index of moderated mediation was significant, coefficient = 0.20, $SE = 0.11$, 95% BC CI [0.03, 0.45], which implied that the conditional indirect effect was significantly different for boys and girls. For boys, the unstandardized conditional indirect effect was not significant, $ab = -0.05$, $SE = 0.07$, 95% BC CI [−0.25, 0.04], while for girls the unstandardized indirect effect was significant, $ab = 0.15$, $SE = 0.08$, 95% BC CI [0.01, 0.36]. Thus, higher prenatal risk was related to lower inhibitory control, which in turn predicted more aggression at 20 months, but only for girls. In addition, the effects of the missing data were examined. Although the indirect effect analyses could not be performed after multiple imputation (Hayes, 2013), additional correlation and regression analyses indicated that the pattern of results remained similar when multiple imputation was conducted as a procedure to handle missing data.

As exploratory post hoc analyses, it was examined whether the mediation by inhibitory control would be evident for specific prenatal risk factors (maternal psychiatric disorder, substance use during pregnancy, or social risk). Bootstrap analyses indicated that the indirect effect via inhibitory control was significant for the mediation model including social risk as predictor for physical aggression at 12 months, $ab = 0.18$, $SE = 0.08$, 95% BC CI [0.05, 0.38], and 20 months, $ab = 0.16$, $SE = 0.10$, 95% BC CI [0.01, 0.40]. For maternal psychiatric problems and substance use during pregnancy as predictors, inhibitory control did not significantly mediate the risk–aggression relation.

4 | DISCUSSION

The aim of this study was to examine inhibitory control as a potential mediator in the prenatal risk–physical aggression relation. The influence of gender in this mediation model was also examined. Results showed that higher prenatal risk was related to higher levels of physical aggression in 12- and 20-month-old children, and this relation was indeed mediated by inhibitory control at both 12 and

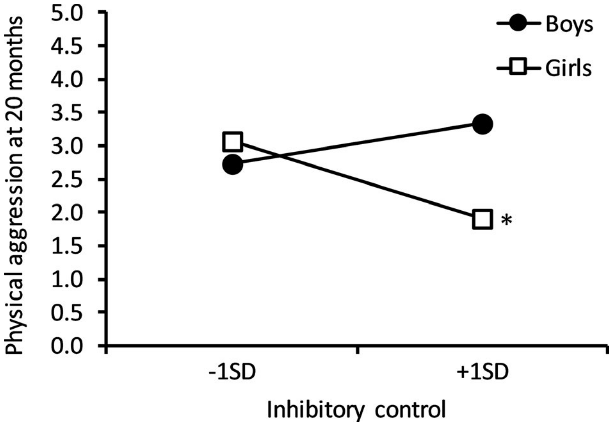

FIGURE 3 Moderation of gender on the relation between inhibitory control and aggression at 20 months. ** < 0.01, * < 0.05, † < 0.10

20 months: higher prenatal risk was related to lower inhibitory control, which in turn led to higher levels of physical aggression. At 20 months, gender moderated this mediation effect: the mediating role of inhibitory control in the risk–aggression relation was only found for girls, but not for boys.

4.1 | Prenatal risk, physical aggression, and the role of inhibitory control

Consistent with previous research, an association was found between prenatal risk and physical aggression in 12- and 20-month-old children. Results indicated that a higher number of risk factors during pregnancy, such as maternal psychiatric disorder, substance use during pregnancy, unemployment, and financial problems, predicted higher maternally reported physical aggression. These results replicated studies examining this relation in preschool and childhood age (Gassman-Pines & Yoshikawa, 2006; Trentacosta et al., 2008), and showed that the effects of maternal risk are already visible at 12 months of age.

Previous research also has consistently shown associations between risk and a lack of inhibitory control (Holochwost et al., 2016; Hughes & Ensor, 2005; Rhoades et al., 2011) and between a lack of inhibitory control and physical aggression (Spann & Gagne, 2016; Utendale & Hastings, 2011). As expected, in this study it was found that inhibitory control mediated the relation between prenatal risk and physical aggression: a higher number of prenatal risk factors were related to lower inhibitory control, which was related to higher levels of physical aggression. Similar mediating effects were found for executive functioning (including inhibitory control; Hughes & Ensor, 2008, 2009; Roman et al., 2016), in studies focusing on either singular risk factors or cumulative risk in relation to (more general) problem behavior. This study showed that one of the executive functions, inhibitory control, is a specifically important construct that is already affected at a very young age by maternal risk and is important for regulation of behavior in everyday life during infancy and toddlerhood.

When considering how maternal prenatal risk factors influence child's inhibitory control, and subsequently child's physical aggression, several pathways can be considered. One of the ways prenatal risk may exert influence on child's development can be through affecting structural and functional brain development, due to substance use during pregnancy (Ekblad et al., 2015) or due to increased levels of stress hormones associated with risk factors, such as financial problems or being a single mother, transported to the fetus (Mulder et al., 2002). Our exploratory analyses did not indicate mediating effects of inhibitory control when substance use or maternal psychopathology was included as singular risk factors in the model, possibly because they operate in interaction with each other, or with other factors in the prediction of physical aggression (Huijbregts et al., 2008; O'Brien, Mustanski, Skol, Cook, & Wakschlag, 2013). There was a significant mediation effect for having social risk, including a limited social network, financial problems, and teenage pregnancy, which might all elicit increased stress levels with potential neurobiological effects on the brain in children (Bock et al., 2015; Brunton & Russell, 2011; Mulder et al., 2002). There could also be an influence of a genetic component related to a lack of inhibitory control, which could lead to financial problems and teenage pregnancy in woman, and physical aggression in children (Friedman et al., 2008; Gagne et al., 2011). Another pathway that can be considered is through parenting practices and quality of mother–child interactions. Due to environmental risk that may continue after pregnancy, parents may be less able to have sensitive and supportive interactions with their child and have less financial possibilities to satisfy the child's material needs for cognitive stimulation (Holochwost et al., 2016; Lengua et al., 2014).

Results indicated that at 20 months of age, the mediating effect of inhibitory control in the prenatal risk–aggression relation was only found for girls, but not for boys. This moderating role of gender did not appear at 12 months, probably because gender differences in physical aggression develop during the second year of life (Alink et al., 2006; Baillargeon et al., 2007). Alink et al. (2006) found that boys were more aggressive than girls at 24 and 36 months, but not at 12 months. This study found comparable effects: gender differences in physical aggression were not found at 12 months, but a trend was found at 20 months of age. In 20-month-old children, boys tend to show more physical aggression than girls.

The mediating role of inhibitory control was especially important for girls, acting as mechanism through which higher prenatal cumulative risk was related to more physical aggression. In line with the evolutionary perspective, girls try to flexibly adapt to adverse environmental conditions resulting in greater variability of cognitive and behavioral coping strategies (Sandman et al., 2013; Sutherland & Brunwasser, 2018). Therefore, inhibitory control may be particularly important for girls in relation to aggression during toddlerhood.

4.2 | Strengths and limitations

A strength of this study was the longitudinal research design and different measurement instruments. Prenatal risk was measured using a sum score of different risk factors during pregnancy, inhibitory control was measured by a laboratory task at 12 months, and physical aggression was rated by the mother at 12 and 20 months. Another strength was that the effects of gender were examined and that mediation was tested using bootstrapping instead of parametric methods. The bootstrap procedure has the advantage that it does not have distributional requirements and has lower type I error rates and more statistical power (Edwards & Lambert, 2007; Hayes, 2013). The results in this study should however also be interpreted considering several limitations. First, the prenatal risk score ranged only from zero to three, with 4.3% of the mothers having three risk factors, which might imply that the results of this study are not easily applicable to mother–child dyads experiencing very high levels of risk. Second, physical aggression was measured using maternal reports. Future studies should include multiple informants and behavioral observations to get a more objective measure of physical aggression. Third, the risk factors in this study were only examined during pregnancy, and whereas there appears to be a relatively high stability of risk from prenatal to postnatal life stages (Bennett et al., 2013), changes in risk status may have occurred. It would have been preferable to take stability of risk factors into account for the analyses presented here. Next, the inhibitory control task also required maternal involvement (i.e., it was a co-regulatory measure), since mothers had to try and prevent that their children touched the toy. A higher number of attempts or a more strict tone of voice may have induced more inhibitory behavior of the child. In addition to addressing the limitations of this study, future studies should also include assessments of aggressive behavior later in childhood. With assessments during preschool and middle childhood, trajectory analyses can reveal insights into the possible associations between risk factors, inhibitory control, and high persistent aggressive behavior after toddlerhood. Next, previous research in preschoolers has shown that attention distraction could be a useful strategy to inhibit responses (Peake, Mischel, & Hebl, 2002). Although the results of this study remained similar when having no attention for the toy was also operationalized as inhibitory control, future studies should examine the role of attention distraction in inhibitory control in infants. In addition, future studies should use direct assessment of maternal stress in relation to risk factors during pregnancy, for example, by including autonomic nervous system (ANS) or hypothalamic–pituitary–adrenal (HPA) axis measurements.

4.3 | Implications

In sum, the present study indicates that inhibitory control is an important mechanism in the relation between maternal prenatal risk and child's physical aggression already during infancy and toddlerhood. Results underline the importance of taking gender into account, since the mediating effect of inhibitory control on physical aggression at 20 months was only found for girls. The results of this study implicate that interventions aimed to reduce aggressive behavior should focus on both maternal factors, as well as children's inhibitory control, since both are important constructs related to physical aggression. At maternal level, the results underscore the importance that pregnant woman experiencing several risk factors should be identified already during pregnancy to start intervention early (Tremblay, 2010). At child level, the results implicate that interventions focusing on improving inhibitory control in very young children could help regulating behavior and reduce physical aggression. Whereas an intervention involving inhibitory control could be specifically useful for girls, because inhibitory control may already be part of their adaptive coping strategies and was shown to be associated with aggression already at a very young age, boys could also benefit from early inhibitory control training, as this might help them develop alternatives for aggressive behavior in response to adversity. Previous research showed promising results of interventions to improve inhibitory control or other aspects of executive functioning already in infancy and preschool age (Diamond & Lee, 2011; Dowsett & Livesey, 2000; Kovacs & Mehler, 2009; Wass, Porayska-Pomsta, & Johnson, 2011), whereas further transfer effects with respect to reduction of externalizing problem behavior through EF-training have also been observed in (very) young children (Volckaert & Noel, 2015).

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CONFLICTS OF INTEREST

The authors declare no conflicts of interest with regard to the funding source for this study.

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