Psychotic-like experiences and cognitive biases in adolescents: birthweight and sex moderating effects

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1. Introduction

The neurodevelopmental model explains psychosis as the end state of an abnormal neurodevelopmental process in which pathogenesis combines a genetic predisposition with environmental factors such as prenatal and perinatal insults (Davies et al., 2020). Over the last decades, several meta-analyses have found an association between obstetric complications such as abnormal fetal growth (measured as low birth weight -LBW-) and increased later risk in the psychosis continuum spectrum, including schizophrenia (Cannon et al., 2002), psychosis (Davies et al., 2020; Radua et al., 2018) and ultra-high-risk for psychosis subjects (Fusar-Poli et al., 2017). Besides, individual studies have reported associations between early perinatal events and psychotic-like experiences (PLEs) in the general population (Betts et al., 2014; Staines et al., 2024; Zammit et al., 2009).

Early exposure to environmental insults including prematurity and LBW might lead to neurodevelopmental impairments such as cognitive and social function deficits while increasing susceptibility to post-natal challenges, including exposure to childhood trauma, highly perceived stress, bullying, social isolation, and susceptibility for revictimization, accumulating risk factors for the development of psychosis (Amoretti et al., 2022; Lipner et al., 2023; Xenaki et al., 2023). Intrauterine stressful events such as infections and inflammation during pregnancy play an undetermined role in the fetal brain development leading to cognitive and neuropsychiatric deficits implicated in the aetiology of psychosis (Lipner et al., 2023). The effects of early life stressors in increasing the risk of psychosis might be mediated by the oxidative stress and neuroinflammation activation of the immune system (Xenaki et al., 2023). Premorbid cognitive difficulties have been shown in approximately 40-50% of cases in a large group of patients with psychosis (Lipner et al., 2023) and at-risk populations (al-Haddad et al., 2019; Radua et al., 2018). Studies exploring relationships between prenatal infection exposure and premorbid cognition (Amoretti et al., 2022; Lipner et al., 2023) have shown a significant decline in IQ (related with exposure to rubella (Brown et al., 2001), verbal IQ (Influenza B, (Ellman et al., 2009), verbal memory and working memory (related to HSV-2 (Brown et al., 2011), and poorer executive functioning (related to Influenza B and toxoplasma IgG, (Brown et al., 2009) in those who later developed a schizophrenia spectrum disorder. Furthermore, premorbid lower IQ and poorer executive functioning was associated with LBW in individuals with psychosis (Lipner et al., 2023).

Specifically low birth weight (LBW), defined by the World Health Organization as below 2500 grams, has been repeatedly described as a risk factor for the psychosis spectrum (Davies et al., 2020). Although pathophysiological mechanism remains elusive, it has been suggested that early exposure to environmental factors during certain sensitive periods may have an impact on the development of parts of the brain involved in social interaction (Van Os et al., 2009). Interestingly LBW has been related to worse cognitive performance across childhood (van Houdt et al., 2019) with a gradient relationship with IQ (Gu et al., 2017). Studies in adults born preterm at a very LBW showed impaired social functioning compared with term-born adults (Vanes et al., 2022). Indeed, LBW is one of the targeted risk factors to be improved during pregnancy with different psychosocial interventions (Crovetto et al., 2021). Given that LBW has been associated with altered cognitive performance and social functioning, it is plausible that it may also influence specific cognitive processing styles, such as cognitive biases, which are known to play a key role in the development of PLEs (Nosarti et al., 2014; Christians et al., 2023).

Although direct evidence linking LBW to specific cognitive biases remains limited, associated impairments in attention regulation and self-control (two core processes underlying attentional and confirmation biases) suggest a plausible pathway by which LBW could influence susceptibility to distorted cognitive processing (Gu et al., 2017). Neuroimaging studies lend further support to this hypothesis, revealing structural brain changes in LBW individuals in areas involved in executive function and emotion regulation (Peterson et al., 2000), which are also implicated in the formation and maintenance of cognitive biases (Krebs et al., 2009). Altogether, this body of evidence delineates a developmental trajectory wherein LBW serves as both a biological and environmental risk factor that contributes to broad cognitive impairments and potentially to maladaptive cognitive styles, thereby increasing vulnerability to psychosis.

PLEs often present in children, with prevalence of around 17% between ages 9-12 and 7% during adolescence and adulthood (Kelleher et al., 2013; Rimvall et al., 2020). PLEs are usually transitory and not associated with clinical impairment but in some instances may become persistent and developed a clinical psychotic state. Nevertheless, the risk of psychotic disorder during adulthood is higher in adolescents presenting with PLEs (Radua et al., 2018). Among non-help seeking children, 25 % of those presenting with low-grade PLEs at age 11-12, would develop clinical psychotic disorder by the age of 26 years old (Dominguez et al., 2011; Poulton et al., 2000), supporting the phenomenological and temporal continuity between PLEs and psychotic disorder (Linscott and Van Os, 2013). Again, the extent to which genetic factors contribute to PLEs has been shown to be influenced by exposure to environmental risk factors, including LBW (Taylor et al., 2022).

Cognitive biases are recognized as well to play a crucial role in psychosis, particularly in the development and maintenance of delusions (Livet et al., 2020; Moritz et al., 2010; Van Dael et al., 2006). The strongest evidence base relates to the “jumping to conclusions” (JTC) and attributional biases, that were correlated with relapse rates

(Moritz et al., 2010; Van Dael et al., 2006). The JTC bias was defined as “the tendency to collect very little information before reaching a conclusion or making a decision thereby increasing the likelihood of inaccurate beliefs being formed hastily”. It is present in schizotypal, at-risk, symptomatic, and remitted psychotic populations and it has been described as stable over time (Peters et al., 2014). In line with this, recent systematic review and meta-analyses suggest that cognitive biases could be present in the early stages of the illness, as well as potential markers for psychosis (Eisenacher and Zink, 2017; Sauvé et al., 2020). In a recent general population study, it was shown that paranoia-like ideations were the most central in the PLEs network and have found that different dysfunctional cognitive biases are significant mediators in the relationship between exposures to traumatic life events and the risk for psychosis in clinical and non-clinical populations (Gawęda et al., 2021).

In addition, evidence suggests that the neurodevelopmental consequences of LBW, as well as cognitive and emotional processing styles, may differ by sex. Male infants appear to be more vulnerable to adverse perinatal events and neurodevelopmental impairments (Johnson & Breslau, 1999; Christians et al., 2023), whereas female adolescents may show greater susceptibility to certain maladaptive cognitive and emotional patterns, including negative cognitive biases and PLEs (Gluck et al., 2014; Gaweda et al., 2015). Recent large-scale register studies have also highlighted sex differences in the developmental trajectories leading to psychosis, with female sex being associated with an increased risk of early-onset schizophrenia and differential patterns of risk factor impact, including birthweight (Lemvigh et al., 2024). These findings support the inclusion of sex as a moderator in our analyses.

The aim of this study was to investigate the associations between birthweight and cognitive biases, as well as PLEs, in a community sample of adolescents. Specifically, we hypothesized that LBW would be associated with increased cognitive biases and PLEs, and that sex would moderate these associations. In addition, we explored whether the relationship between cognitive biases and PLEs differed between adolescents with low birthweight and those with normal birthweight.

2. Methods

2.1. Sample

The sample consisted of 240 adolescents (147 girls, 93 boys, 1 transgender) born in 2004, aged between 14 and 15 years, who were attending secondary schools in Sabadell, Spain. Prior to participation, all adolescents and their parents provided written informed consent. The exclusion criteria were: (1) lack of parental consent, (2) personal history of psychosis, and (3) missing birth weight information. Recruitment aimed to include adolescents from all secondary schools in Sabadell (n = 33), with schools being contacted via email and introduced to the study through a video summary. Recruitment occurred between April 2019 and February 2020 but was halted due to the COVID-19 pandemic, resulting in 11 secondary schools participating in the study. Given the potential mental health impacts of the pandemic, recruitment was not resumed post-lockdown.

Out of the initial 240 participants, birth weight data was available for 186 adolescents, forming the final sample for statistical analyses. Although all participants completed the questionnaires, only those with birthweight data (n = 186) were included in the present study. Sex was treated as a dichotomous variable in the statistical analysis, meaning that the transgender participant was excluded from these analyses. Participants were recruited from 11 secondary schools. The number of participants per school ranged from 10 to 30: School 1 (30), School 2 (25), School 3 (26), School 4 (12), School 5 (15), School 6 (10), School 7 (22), School 8 (11), School 9 (16), School 10 (13), and School 11 (10).

Ethical approval was granted by the Parc Taulí Drug Research Ethics Committee (CEIm), and permission to conduct the study was obtained from the Education Department of the Generalitat de Catalunya.

2.2. Clinical Assessment

Parents indicated the birthweight of their offspring when providing consent for the study. They were advised to consult the Childhood Booklet, a standardized document that forms part of the National Infant and Adolescent Health Program in Spain, provided to parents or legal guardians upon the initial registration of a newborn at a public health centre. This booklet includes essential perinatal data (such as date of birth, birthweight, length, and Apgar score) and serves as an official record of the child's health trajectory. The document remains in the custody of the parents.

In each participating secondary school, students first completed anonymous self-administered online questionnaires via Google Forms to collect sociodemographic and clinical information regarding PLEs and cognitive biases. Subsequently, all students in the class, regardless of study participation, attended a psychoeducation session on psychosis risk and early signs of psychosis. This session took place after the completion of all study assessments and therefore could not have influenced participants' responses. The psychoeducation session provided general information about psychosis risk factors, the prevalence and meaning of PLEs in the general population, common cognitive biases, and the importance of early intervention. The session was designed to promote awareness and reduce stigma, and did not involve any form of symptom induction or personal disclosure. The following questionnaires were then administered via Google Forms:

Community Assessment of Psychic Experiences – Positive Scale (CAPE-P15): This 15-item self-report questionnaire assesses PLEs, specifically persecutory ideation (PI), bizarre experiences (BE), and perceptual abnormalities (PA). CAPE-P15 is a shortened version of the original CAPE-42 and is used to identify individuals at risk of psychosis (Capra et al., 2013). Each item is rated on a 4-point Likert scale (1 = never, 2 = sometimes, 3 = often, 4 = nearly always). A total frequency score was computed as the sum of item scores, with higher scores indicating greater frequency of positive PLEs. The

Spanish version of the CAPE-P15 has demonstrated strong psychometric properties, including high internal consistency (Cronbach's α = 0.85–0.86) and a valid bifactor structure (Fonseca-Pedrero et al., 2012).

Cognitive Biases Questionnaire for Psychosis (CBQp): Adapted for adolescents, this self-report questionnaire measures cognitive biases relevant to psychosis, including internalizing (I), catastrophizing (C), dichotomous thinking (DT), jumping to conclusions (JTC), and emotional reasoning (ER) (Peters et al., 2014). Participants rated each item on a three-point scale, with higher scores indicating greater cognitive bias intensity. The total score ranges from 30 to 90 points, and subscale scores range from 5 to 18 points. Three items (4, 9, and 27) were adapted from professional to academic contexts to suit the adolescent population. In the Spanish validation study, the CBQp demonstrated excellent internal consistency (Cronbach's α = 0.87) and strong test–retest reliability (r = 0.94 in the psychosis group), supporting its reliability and validity for assessing cognitive biases relevant to psychosis (Corral et al., 2021).

2.3. Statistical Analyses

All statistical analyses were performed using SPSS version 25.0 (IBM Corp, USA). Log transformation was applied to variables that did not follow a normal distribution, to reduce skewness. Due to positive skewness, the CBQp total score and its subscale scores were log-transformed prior to regression analyses. All other variables, including CAPE-P15 scores and birthweight, were analyzed in their original scales. Chi-square tests were used to compare categorical variables, and t-tests were applied to compare continuous variables. Pearson correlations were calculated to assess the relationships between continuous variables. Correlational analyses stratified by sex are presented for descriptive purposes only, while formal tests of sex differences were conducted using LBW × sex interaction terms in linear regression models.

We also examined the associations between cognitive biases and PLEs separately in adolescents with low and normal birthweight. Partial correlation matrices (adjusted for sex) were computed within each birthweight group, and visualized using heatmaps.

Multiple linear regression analyses were used to explore the association between birth weight and psychometric scores (CAPE-P15 and CBQp), while adjusting for sex and prior mental health history. Sex-birth weight interactions were tested in all models, with only significant interactions retained in the final models. Separate regression analyses were conducted for each psychometric scale. This included 6 regressions for cognitive biases (CBQp total score and 5 subscale scores) and 4 regressions for positive psychotic-like experiences (CAPE-P15 total score and 3 subscale scores). A significance level of $p < 0.05$ (two-sided) was used for all analyses.

Given the exploratory nature of the study and the conceptual and empirical correlations among the outcome variables, no formal correction for multiple comparisons was applied. Results are interpreted with caution, focusing on patterns of association rather than strict significance thresholds.

3. Results

3.1. Descriptive Statistics and Sex Differences

The clinical data of the sample is presented in Table 1. Significant differences in birthweight were found between boys and girls, with girls exhibiting a lower average birthweight (Figure S1). Specifically, the proportion of LBW (defined as <2500 grams) was 4.3% in boys compared to 15.4% in girls ($p = 0.022$).

In terms of PLEs assessed through CAPE-P15, girls reported significantly more paranoid ideation and higher total CAPE scores compared to boys (Table 1). Regarding cognitive biases, girls scored higher in the catastrophizing and JTC subscales of the CBQ, though no significant difference was found in total CBQ scores between boys and girls (Table 1).

3.2. Correlation Analyses: Birth Weight and Psychometric Scores

When exploring the relationships between birthweight and psychometric scores, no significant associations were found between birthweight and total CAPE or CBQ scores for either sex. Similarly, birthweight was not significantly correlated with any of the CAPE subscores (persecutory ideation, bizarre experiences, and perceptual abnormalities).

However, exploratory sex-stratified correlations (Table 2) suggested differential patterns in specific cognitive biases. In boys, higher birthweight was positively correlated with dichotomous thinking, whereas in girls, lower birthweight showed a positive correlation with jumping to conclusions (JTC). These findings are descriptive and should be interpreted with caution, as formal tests of within-group associations were not conducted.

3.3. Correlation analyses: CAPE and CBQ scores. Stratified analyses by birthweight (normal birthweight vs. low birthweight).

In the normal birthweight group, positive partial correlations (adjusted for sex) were observed between CAPE total and subscale scores and CBQ total and subscale scores. The correlations ranged from $r = 0.38$ to $r = 0.64$ (Figure S2). The correlation between CBQ total and CAPE total scores was $r = 0.64$, $p < 0.001$.

In the low birthweight group, correlations between CAPE and CBQ scores were substantially stronger, ranging from $r = 0.29$ to $r = 0.93$ (Figure S3). The correlation between CBQ total and CAPE total scores was particularly high ($r = 0.924$, $p < 0.001$). These exploratory results suggest that low birthweight may be associated with a stronger interrelationship between cognitive biases and PLEs.

3.4. Multiple linear regression analyses

In the multiple linear regression models, female sex emerged as a significant predictor for PLEs, specifically paranoid ideation and total CAPE scores, as well as for three types of cognitive biases: catastrophizing, dichotomous thinking, and JTC (Table 3).

Neither birthweight nor a significant interaction between birthweight and sex was found to predict total CAPE or CBQ scores (Table 3). However, we observed significant interactions between birthweight and sex for two specific CBQ subscales: dichotomous thinking and JTC (Table 3). These interactions are illustrated in Figure 1 (dichotomous thinking) and Figure 2 (JTC).

As shown in Figure 1, regression slopes indicated that lower birthweight was associated with higher dichotomous thinking scores in girls, while boys showed the opposite pattern. Similarly, Figure 2 illustrates an inverse regression pattern for JTC across sexes. These differences reflect the significant sex-by-birthweight interaction terms in the regression models.

No significant interactions between sex and birthweight were found for CAPE subscores (Table 3).

4. Discussion

In our study, we observed significant sex-by-birthweight interaction effects for two cognitive biases: jumping to conclusions (JTC) and dichotomous thinking. These interactions indicate that the association between birthweight and these cognitive biases differed between sexes. However, sex did not moderate the relationship between birthweight and PLEs. Additionally, girls reported more PLEs (particularly paranoid ideation), had lower birthweight, and exhibited higher scores in cognitive biases such as catastrophizing and JTC.

This is, to our knowledge, the first study to investigate the relationship between birthweight and PLEs or cognitive biases in a non-clinical adolescent population. Our findings suggest a sex-specific association between LBW and cognitive biases, contributing to an evolving understanding of how early life factors like birthweight may influence cognitive processing in adolescence. However, it is important to mention that the associations between birthweight and sex were weak, as the variability of the explained variance in linear regression models was low. Previous studies have demonstrated similar sex differences in cognitive biases in adolescents (Gluck et al., 2014) and in the association between LBW and cognitive functioning (Johnson & Breslau, 1999). These studies indicate a greater vulnerability in male children to birth-related complications, though our findings suggest that girls might experience specific cognitive consequences, like increased susceptibility to negative cognitive biases, associated with LBW.

One potential explanation for these findings lies in sex-related structural brain differences, hormonal influences, and differences in maturation rates. Structural brain differences, which become more pronounced during puberty, alongside varying effects of gonadal steroids and hormones like oxytocin and vasopressin, may explain differences in cognitive processing and emotional regulation between boys and girls (Franceschini & Fattore, 2021; Kurth et al., 2021). Additionally, earlier maturation in girls compared to boys could influence how prenatal and perinatal factors, such as LBW, affect neurodevelopmental processes (Laureys et al., 2021). Previous studies have also suggested that intrauterine growth patterns are linked to a heightened risk of schizophrenia, particularly in females (Hsu, in press). Furthermore, sex differences in birthweight are well-documented, with male infants typically being heavier than female infants, and fetal coping strategies in response to adverse intrauterine environments may differ by sex (Clifton, 2010), potentially contributing to sex-specific neurodevelopmental trajectories. In this context, our finding that higher birthweight in boys was associated with increased cognitive biases such as dichotomous thinking is particularly intriguing. This counter-intuitive pattern suggests that higher birthweight may not be uniformly protective, and that different mechanisms may be operating in boys, possibly involving hormonal influences or postnatal environmental interactions. Further research is needed to better understand these associations.

Contrary to prior research linking LBW to neurodevelopmental challenges and psychosis risk (Morley et al., 2004; Davies et al., 2020), we did not find an association between birthweight and PLEs in our sample. This finding may reflect the characteristics of our community sample, where the prevalence of LBW was relatively low, making it more difficult to detect such associations. Moreover, our study only assessed birthweight, without considering gestational age, a limitation that may have affected our ability to fully capture the developmental risks associated with preterm birth. However, exploratory analyses suggested that the associations between cognitive biases and PLEs were stronger in adolescents with low birthweight compared to those with normal birthweight. This finding may point to a pathway whereby early developmental factors influence cognitive-affective processes that in turn shape vulnerability to PLEs, a hypothesis that warrants further investigation.

Despite these challenges, cognitive biases are recognized as key contributors to the development and maintenance of psychosis, particularly delusions (Gaweda et al., 2015; Livet et al., 2020). Jumping to conclusions (JTC), for instance, has been implicated in the formation and persistence of positive psychotic symptoms, particularly delusions, in both early and established psychosis (Ahuir et al., 2021; Henquet et al., 2022). Meta-analyses have consistently linked LBW with cognitive difficulties and later psychosis risk (Christians et al., 2023; Davies et al., 2020). It is believed that early exposure to perinatal stressors during critical neurodevelopmental periods may affect brain regions involved in social and cognitive functions, thereby increasing the cumulative risk for psychosis (Xenaki et al., 2023).

It is important to note that LBW represents a heterogeneous marker of early developmental adversity, encompassing multiple etiological pathways. LBW may result from shorter gestation (i.e., preterm birth) or from intrauterine growth restriction, both of which may be influenced by a range of genetic, epigenetic, and environmental factors. These distinct mechanisms are likely to have differential impacts on neurodevelopmental processes underlying cognitive and emotional functioning (Lemvigh et al., 2024; Christians et al., 2023). The absence of gestational age data in our study limits our ability to disentangle these pathways. Future studies should consider integrating more refined prenatal indicators (e.g., gestational age, fetal growth parameters, placental function) to better characterize the developmental mechanisms linking early adversity to cognitive biases and psychosis risk.

Our study had several limitations. The cross-sectional design precludes any causal inferences. PLEs and cognitive biases were measured using self-report questionnaires, which may introduce various forms of bias. These include social desirability bias (participants responding in a way they perceive as socially acceptable), response style bias (such as tendencies toward extreme or neutral responses), and potential variability in the subjective interpretation of questionnaire items. Although the use of self-report is common and often necessary in adolescent population-based studies, these factors may lead to under- or over-reporting of certain experiences and cognitive styles. Additionally, recruitment was halted due to the COVID-19 pandemic, limiting our sample size and potentially reducing our ability to detect significant associations.

Furthermore, we did not systematically collect gestational age data, as it was not consistently available in the sources used. Birthweight data were reported by parents, who were advised to consult the Childhood Booklet, a standardized official document containing perinatal data, to ensure accuracy when providing this information. However, we did not directly review or systematically collect the full content of the Childhood Booklet, nor did we specifically request gestational age or expected due date data. As a result, we were unable to adjust birthweight for gestational age, which limits the precision of the interpretation of birthweight effects. Finally, given that our sample was community-based, the prevalence of LBW was low, which may explain why we did not find associations between birthweight and PLEs. It is also important to note that the majority of the tested sex by birthweight interactions in our study were not significant. Therefore, the evidence for broad sex-specific effects remains limited and should be interpreted with caution.

5. Conclusions

Our study suggests that the relationship between birthweight, as a proxy for intrauterine conditions, and cognitive biases is moderated by sex, with differential patterns observed in boys and girls in two cognitive biases related to JTC and dichotomous thinking. These findings highlight the importance of considering biological sex when investigating the psychosis continuum spectrum and underscore the need for further research into how early life factors influence cognitive and emotional development differently in boys and girls.

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Figure 1. Scatterplot of the relationship between dichotomous thinking and birth weight, stratified by sex

Insert Figure 1 here

Scatterplots provide a descriptive illustration of the interaction pattern between birthweight and sex on cognitive biases. Formal inferences regarding these associations are based on the adjusted regression models presented in Table 3.

Figure 2. Scatterplot of the relationship between jumping to conclusions and birth weight, stratified by sex

Insert Figure 2 here

Scatterplots provide a descriptive illustration of the interaction pattern between birthweight and sex on cognitive biases. Formal inferences regarding these associations are based on the adjusted regression models presented in Table 3.

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Psychotic-like experiences and cognitive biases in adolescents: birthweight and sex moderating effects

1. *Introduction*

The neurodevelopmental model explains psychosis as the end state of an abnormal neurodevelopmental process in which pathogenesis combines a genetic predisposition with environmental factors such as prenatal and perinatal insults (Davies et al., 2020). Over the last decades, several meta-analyses have found an association between obstetric complications such as abnormal fetal growth (measured as low birth weight -LBW-) and increased later risk in the psychosis continuum spectrum, including schizophrenia (Cannon et al., 2002), psychosis (Davies et al., 2020; Radua et al., 2018) and ultra-high-risk for psychosis subjects (Fusar-Poli et al., 2017). Besides, individual studies have reported associations between early perinatal events and psychotic-like experiences (PLEs) in the general population (Betts et al., 2014; Staines et al., 2024; Zammit et al., 2009).

Early exposure to environmental insults including prematurity and LBW might lead to neurodevelopmental impairments such as cognitive and social function deficits while increasing susceptibility to post-natal challenges, including exposure to childhood trauma, highly perceived stress, bullying, social isolation, and susceptibility for revictimization, accumulating risk factors for the development of psychosis (Amoretti et al., 2022; Lipner et al., 2023; Xenaki et al., 2023). Intrauterine stressful events such as infections and inflammation during pregnancy play an undetermined role in the fetal brain development leading to cognitive and neuropsychiatric deficits implicated in the aetiology of psychosis (Lipner et al., 2023). The effects of early life stressors in increasing the risk of psychosis might be mediated by the oxidative stress and neuroinflammation activation of the immune system (Xenaki et al., 2023). Premorbid cognitive difficulties have been shown in approximately 40-50% of cases in a large group of patients with psychosis (Lipner et al., 2023) and at-risk populations (al-Haddad et al., 2019; Radua et al., 2018). Studies exploring relationships between prenatal infection exposure and premorbid cognition (Amoretti et al., 2022; Lipner et al., 2023) have shown a significant decline in IQ (related with exposure to rubella (Brown et al., 2001), verbal IQ (Influenza B, (Ellman et al., 2009), verbal memory and working memory (related to HSV-2 (Brown et al., 2011), and poorer executive functioning (related to Influenza B and toxoplasma IgG, (Brown et al., 2009) in those who later developed a schizophrenia spectrum disorder. Furthermore, premorbid lower IQ and poorer executive functioning was associated with LBW in individuals with psychosis (Lipner et al., 2023).

Specifically low birth weight (LBW), defined by the World Health Organization as below 2500 grams, has been repeatedly described as a risk factor for the psychosis spectrum (Davies et al., 2020). Although pathophysiological mechanism remains elusive, it has been suggested that early exposure to environmental factors during certain sensitive periods may have an impact on the development of parts of the brain involved in social interaction (Van Os et al., 2009). Interestingly LBW has been related to worse cognitive performance across childhood (van Houdt et al., 2019) with a gradient relationship with IQ (Gu et al., 2017). Studies in adults born preterm at a very LBW showed impaired social functioning compared with term-born adults (Vanes et al., 2022). Indeed, LBW is one of the targeted risk factors to be improved during pregnancy with different psychosocial interventions (Crovetto et al., 2021). Given that LBW has been associated with altered cognitive performance and social functioning, it is plausible that it may also influence specific cognitive processing styles, such as cognitive biases, which are known to play a key role in the development of PLEs (Nosarti et al., 2014; Christians et al., 2023).

Although direct evidence linking LBW to specific cognitive biases remains limited, associated impairments in attention regulation and self-control (two core processes underlying attentional and confirmation biases) suggest a plausible pathway by which LBW could influence susceptibility to distorted cognitive processing (Gu et al., 2017). Neuroimaging studies lend further support to this hypothesis, revealing structural brain changes in LBW individuals in areas involved in executive function and emotion regulation (Peterson et al., 2000), which are also implicated in the formation and maintenance of cognitive biases (Krebs et al., 2009). Altogether, this body of evidence delineates a developmental trajectory wherein LBW serves as both a biological and environmental risk factor that contributes to broad cognitive impairments and potentially to maladaptive cognitive styles, thereby increasing vulnerability to psychosis.

PLEs often present in children, with prevalence of around 17% between ages 9-12 and 7% during adolescence and adulthood (Kelleher et al., 2013; Rimvall et al., 2020). PLEs are usually transitory and not associated with clinical impairment but in some instances may become persistent and developed a clinical psychotic state. Nevertheless, the risk of psychotic disorder during adulthood is higher in adolescents presenting with PLEs (Radua et al., 2018). Among non-help seeking children, 25 % of those presenting with low-grade PLEs at age 11-12, would develop clinical psychotic disorder by the age of 26 years old (Dominguez et al., 2011; Poulton et al., 2000), supporting the phenomenological and temporal continuity between PLEs and psychotic disorder (Linscott and Van Os, 2013). Again, the extent to which genetic factors contribute to PLEs has been shown to be influenced by exposure to environmental risk factors, including LBW (Taylor et al., 2022).

Cognitive biases are recognized as well to play a crucial role in psychosis, particularly in the development and maintenance of delusions (Livet et al., 2020; Moritz et al., 2010; Van Dael et al., 2006). The strongest evidence base relates to the “jumping to conclusions” (JTC) and attributional biases, that were correlated with relapse rates

(Moritz et al., 2010; Van Dael et al., 2006). The JTC bias was defined as "the tendency to collect very little information before reaching a conclusion or making a decision thereby increasing the likelihood of inaccurate beliefs being formed hastily". It is present in schizotypal, at-risk, symptomatic, and remitted psychotic populations and it has been described as stable over time (Peters et al., 2014). In line with this, recent systematic review and meta-analyses suggest that cognitive biases could be present in the early stages of the illness, as well as potential markers for psychosis (Eisenacher and Zink, 2017; Sauvé et al., 2020). In a recent general population study, it was shown that paranoia-like ideations were the most central in the PLEs network and have found that different dysfunctional cognitive biases are significant mediators in the relationship between exposures to traumatic life events and the risk for psychosis in clinical and non-clinical populations (Gawęda et al., 2021).

In addition, evidence suggests that the neurodevelopmental consequences of LBW, as well as cognitive and emotional processing styles, may differ by sex. Male infants appear to be more vulnerable to adverse perinatal events and neurodevelopmental impairments (Johnson & Breslau, 1999; Christians et al., 2023), whereas female adolescents may show greater susceptibility to certain maladaptive cognitive and emotional patterns, including negative cognitive biases and PLEs (Gluck et al., 2014; Gaweda et al., 2015). Recent large-scale register studies have also highlighted sex differences in the developmental trajectories leading to psychosis, with female sex being associated with an increased risk of early-onset schizophrenia and differential patterns of risk factor impact, including birthweight (Lemvigh et al., 2024). These findings support the inclusion of sex as a moderator in our analyses.

The aim of this study was to investigate the associations between birthweight and cognitive biases, as well as PLEs, in a community sample of adolescents. Specifically, we hypothesized that LBW would be associated with increased cognitive biases and PLEs, and that sex would moderate these associations. In addition, we explored whether the relationship between cognitive biases and PLEs differed between adolescents with low birthweight and those with normal birthweight.

2. Methods

2.1. Sample

The sample consisted of 240 adolescents (147 girls, 93 boys, 1 transgender) born in 2004, aged between 14 and 15 years, who were attending secondary schools in Sabadell, Spain. Prior to participation, all adolescents and their parents provided written informed consent. The exclusion criteria were: (1) lack of parental consent, (2) personal history of psychosis, and (3) missing birth weight information. Recruitment aimed to include adolescents from all secondary schools in Sabadell (n = 33), with schools being contacted via email and introduced to the study through a video summary. Recruitment occurred between April 2019 and February 2020 but was halted due to the COVID-19 pandemic, resulting in 11 secondary schools participating in the study. Given the potential mental health impacts of the pandemic, recruitment was not resumed post-lockdown.

Out of the initial 240 participants, birth weight data was available for 186 adolescents, forming the final sample for statistical analyses. Although all participants completed the questionnaires, only those with birthweight data (n = 186) were included in the present study. Sex was treated as a dichotomous variable in the statistical analysis, meaning that the transgender participant was excluded from these analyses. Participants were recruited from 11 secondary schools. The number of participants per school ranged from 10 to 30: School 1 (30), School 2 (25), School 3 (26), School 4 (12), School 5 (15), School 6 (10), School 7 (22), School 8 (11), School 9 (16), School 10 (13), and School 11 (10).

Ethical approval was granted by the Parc Taulí Drug Research Ethics Committee (CEIm), and permission to conduct the study was obtained from the Education Department of the Generalitat de Catalunya.

2.2. Clinical Assessment

Parents indicated the birthweight of their offspring when providing consent for the study. They were advised to consult the Childhood Booklet, a standardized document that forms part of the National Infant and Adolescent Health Program in Spain, provided to parents or legal guardians upon the initial registration of a newborn at a public health centre. This booklet includes essential perinatal data (such as date of birth, birthweight, length, and Apgar score) and serves as an official record of the child's health trajectory. The document remains in the custody of the parents.

In each participating secondary school, students first completed anonymous self-administered online questionnaires via Google Forms to collect sociodemographic and clinical information regarding PLEs and cognitive biases. Subsequently, all students in the class, regardless of study participation, attended a psychoeducation session on psychosis risk and early signs of psychosis. This session took place after the completion of all study assessments and therefore could not have influenced participants' responses. The psychoeducation session provided general information about psychosis risk factors, the prevalence and meaning of PLEs in the general population, common cognitive biases, and the importance of early intervention. The session was designed to promote awareness and reduce stigma, and did not involve any form of symptom induction or personal disclosure. The following questionnaires were then administered via Google Forms:

Community Assessment of Psychic Experiences – Positive Scale (CAPE-P15): This 15-item self-report questionnaire assesses PLEs, specifically persecutory ideation (PI), bizarre experiences (BE), and perceptual abnormalities (PA). CAPE-P15 is a shortened version of the original CAPE-42 and is used to identify individuals at risk of psychosis (Capra et al., 2013). Each item is rated on a 4-point Likert scale (1 = never, 2 = sometimes, 3 = often, 4 = nearly always). A total frequency score was computed as the sum of item scores, with higher scores indicating greater frequency of positive PLEs. The

Spanish version of the CAPE-P15 has demonstrated strong psychometric properties, including high internal consistency (Cronbach's α = 0.85–0.86) and a valid bifactor structure (Fonseca-Pedrero et al., 2012).

Cognitive Biases Questionnaire for Psychosis (CBQp): Adapted for adolescents, this self-report questionnaire measures cognitive biases relevant to psychosis, including internalizing (I), catastrophizing (C), dichotomous thinking (DT), jumping to conclusions (JTC), and emotional reasoning (ER) (Peters et al., 2014). Participants rated each item on a three-point scale, with higher scores indicating greater cognitive bias intensity. The total score ranges from 30 to 90 points, and subscale scores range from 5 to 18 points. Three items (4, 9, and 27) were adapted from professional to academic contexts to suit the adolescent population. In the Spanish validation study, the CBQp demonstrated excellent internal consistency (Cronbach's α = 0.87) and strong test–retest reliability (r = 0.94 in the psychosis group), supporting its reliability and validity for assessing cognitive biases relevant to psychosis (Corral et al., 2021).

2.3. Statistical Analyses

All statistical analyses were performed using SPSS version 25.0 (IBM Corp, USA). Log transformation was applied to variables that did not follow a normal distribution, to reduce skewness. Due to positive skewness, the CBQp total score and its subscale scores were log-transformed prior to regression analyses. All other variables, including CAPE-P15 scores and birthweight, were analyzed in their original scales. Chi-square tests were used to compare categorical variables, and t-tests were applied to compare continuous variables. Pearson correlations were calculated to assess the relationships between continuous variables. Correlational analyses stratified by sex are presented for descriptive purposes only, while formal tests of sex differences were conducted using LBW × sex interaction terms in linear regression models.

We also examined the associations between cognitive biases and PLEs separately in adolescents with low and normal birthweight. Partial correlation matrices (adjusted for sex) were computed within each birthweight group, and visualized using heatmaps.

Multiple linear regression analyses were used to explore the association between birth weight and psychometric scores (CAPE-P15 and CBQp), while adjusting for sex and prior mental health history. Sex-birth weight interactions were tested in all models, with only significant interactions retained in the final models. Separate regression analyses were conducted for each psychometric scale. This included 6 regressions for cognitive biases (CBQp total score and 5 subscale scores) and 4 regressions for positive psychotic-like experiences (CAPE-P15 total score and 3 subscale scores). A significance level of $p < 0.05$ (two-sided) was used for all analyses.

Given the exploratory nature of the study and the conceptual and empirical correlations among the outcome variables, no formal correction for multiple comparisons was applied. Results are interpreted with caution, focusing on patterns of association rather than strict significance thresholds.

3. Results

3.1. Descriptive Statistics and Sex Differences

The clinical data of the sample is presented in Table 1. Significant differences in birthweight were found between boys and girls, with girls exhibiting a lower average birthweight (Figure S1). Specifically, the proportion of LBW (defined as <2500 grams) was 4.3% in boys compared to 15.4% in girls ($p = 0.022$).

In terms of PLEs assessed through CAPE-P15, girls reported significantly more paranoid ideation and higher total CAPE scores compared to boys (Table 1). Regarding cognitive biases, girls scored higher in the catastrophizing and JTC subscales of the CBQ, though no significant difference was found in total CBQ scores between boys and girls (Table 1).

3.2. Correlation Analyses: Birth Weight and Psychometric Scores

When exploring the relationships between birthweight and psychometric scores, no significant associations were found between birthweight and total CAPE or CBQ scores for either sex. Similarly, birthweight was not significantly correlated with any of the CAPE subscores (persecutory ideation, bizarre experiences, and perceptual abnormalities). However, exploratory sex-stratified correlations (Table 2) suggested differential patterns in specific cognitive biases. In boys, higher birthweight was positively correlated with dichotomous thinking, whereas in girls, lower birthweight showed a positive correlation with jumping to conclusions (JTC). These findings are descriptive and should be interpreted with caution, as formal tests of within-group associations were not conducted.

3.3. Correlation analyses: CAPE and CBQ scores. Stratified analyses by birthweight (normal birthweight vs. low birthweight).

In the normal birthweight group, positive partial correlations (adjusted for sex) were observed between CAPE total and subscale scores and CBQ total and subscale scores. The correlations ranged from $r= 0.38$ to $r= 0.64$ (Figure S2). The correlation between CBQ total and CAPE total scores was $r= 0.64$, $p < 0.001$.

In the low birthweight group, correlations between CAPE and CBQ scores were substantially stronger, ranging from $r= 0.29$ to $r= 0.93$ (Figure S3). The correlation between CBQ total and CAPE total scores was particularly high ($r= 0.924$, $p< 0.001$). These exploratory results suggest that low birthweight may be associated with a stronger interrelationship between cognitive biases and PLEs.

3.4. Multiple linear regression analyses

In the multiple linear regression models, female sex emerged as a significant predictor for PLEs, specifically paranoid ideation and total CAPE scores, as well as for three types of cognitive biases: catastrophizing, dichotomous thinking, and JTC (Table 3).

Neither birthweight nor a significant interaction between birthweight and sex was found to predict total CAPE or CBQ scores (Table 3). However, we observed significant interactions between birthweight and sex for two specific CBQ subscales: dichotomous thinking and JTC (Table 3). These interactions are illustrated in Figure 1 (dichotomous thinking) and Figure 2 (JTC).

As shown in Figure 1, regression slopes indicated that lower birthweight was associated with higher dichotomous thinking scores in girls, while boys showed the opposite pattern. Similarly, Figure 2 illustrates an inverse regression pattern for JTC across sexes. These differences reflect the significant sex-by-birthweight interaction terms in the regression models.

No significant interactions between sex and birthweight were found for CAPE subscores (Table 3).

4. Discussion

In our study, we observed significant sex-by-birthweight interaction effects for two cognitive biases: jumping to conclusions (JTC) and dichotomous thinking. These interactions indicate that the association between birthweight and these cognitive biases differed between sexes. However, sex did not moderate the relationship between birthweight and PLEs. Additionally, girls reported more PLEs (particularly paranoid ideation), had lower birthweight, and exhibited higher scores in cognitive biases such as catastrophizing and JTC.

This is, to our knowledge, the first study to investigate the relationship between birthweight and PLEs or cognitive biases in a non-clinical adolescent population. Our findings suggest a sex-specific association between LBW and cognitive biases, contributing to an evolving understanding of how early life factors like birthweight may influence cognitive processing in adolescence. However, it is important to mention that the associations between birthweight and sex were weak, as the variability of the explained variance in linear regression models was low. Previous studies have demonstrated similar sex differences in cognitive biases in adolescents (Gluck et al., 2014) and in the association between LBW and cognitive functioning (Johnson & Breslau, 1999). These studies indicate a greater vulnerability in male children to birth-related complications, though our findings suggest that girls might experience specific cognitive consequences, like increased susceptibility to negative cognitive biases, associated with LBW.

One potential explanation for these findings lies in sex-related structural brain differences, hormonal influences, and differences in maturation rates. Structural brain differences, which become more pronounced during puberty, alongside varying effects of gonadal steroids and hormones like oxytocin and vasopressin, may explain differences in cognitive processing and emotional regulation between boys and girls (Franceschini & Fattore, 2021; Kurth et al., 2021). Additionally, earlier maturation in girls compared to boys could influence how prenatal and perinatal factors, such as LBW, affect neurodevelopmental processes (Laureys et al., 2021). Previous studies have also suggested that intrauterine growth patterns are linked to a heightened risk of schizophrenia, particularly in females (Hsu, in press). Furthermore, sex differences in birthweight are well-documented, with male infants typically being heavier than female infants, and fetal coping strategies in response to adverse intrauterine environments may differ by sex (Clifton, 2010), potentially contributing to sex-specific neurodevelopmental trajectories. In this context, our finding that higher birthweight in boys was associated with increased cognitive biases such as dichotomous thinking is particularly intriguing. This counter-intuitive pattern suggests that higher birthweight may not be uniformly protective, and that different mechanisms may be operating in boys, possibly involving hormonal influences or postnatal environmental interactions. Further research is needed to better understand these associations.

Contrary to prior research linking LBW to neurodevelopmental challenges and psychosis risk (Morley et al., 2004; Davies et al., 2020), we did not find an association between birthweight and PLEs in our sample. This finding may reflect the characteristics of our community sample, where the prevalence of LBW was relatively low, making it more difficult to detect such associations. Moreover, our study only assessed birthweight, without considering gestational age, a limitation that may have affected our ability to fully capture the developmental risks associated with preterm birth. However, exploratory analyses suggested that the associations between cognitive biases and PLEs were stronger in adolescents with low birthweight compared to those with normal birthweight. This finding may point to a pathway whereby early developmental factors influence cognitive-affective processes that in turn shape vulnerability to PLEs, a hypothesis that warrants further investigation.

Despite these challenges, cognitive biases are recognized as key contributors to the development and maintenance of psychosis, particularly delusions (Gaweda et al., 2015; Livet et al., 2020). Jumping to conclusions (JTC), for instance, has been implicated in the formation and persistence of positive psychotic symptoms, particularly delusions, in both early and established psychosis (Ahuir et al., 2021; Henquet et al., 2022). Meta-analyses have consistently linked LBW with cognitive difficulties and later psychosis risk (Christians et al., 2023; Davies et al., 2020). It is believed that early exposure to perinatal stressors during critical neurodevelopmental periods may affect brain regions involved in social and cognitive functions, thereby increasing the cumulative risk for psychosis (Xenaki et al., 2023).

It is important to note that LBW represents a heterogeneous marker of early developmental adversity, encompassing multiple etiological pathways. LBW may result from shorter gestation (i.e., preterm birth) or from intrauterine growth restriction, both of which may be influenced by a range of genetic, epigenetic, and environmental factors. These distinct mechanisms are likely to have differential impacts on neurodevelopmental processes underlying cognitive and emotional functioning (Lemvigh et al., 2024; Christians et al., 2023). The absence of gestational age data in our study limits our ability to disentangle these pathways. Future studies should consider integrating more refined prenatal indicators (e.g., gestational age, fetal growth parameters, placental function) to better characterize the developmental mechanisms linking early adversity to cognitive biases and psychosis risk.

Our study had several limitations. The cross-sectional design precludes any causal inferences. PLEs and cognitive biases were measured using self-report questionnaires, which may introduce various forms of bias. These include social desirability bias (participants responding in a way they perceive as socially acceptable), response style bias (such as tendencies toward extreme or neutral responses), and potential variability in the subjective interpretation of questionnaire items. Although the use of self-report is common and often necessary in adolescent population-based studies, these factors may lead to under- or over-reporting of certain experiences and cognitive styles. Additionally, recruitment was halted due to the COVID-19 pandemic, limiting our sample size and potentially reducing our ability to detect significant associations.

Furthermore, we did not systematically collect gestational age data, as it was not consistently available in the sources used. Birthweight data were reported by parents, who were advised to consult the Childhood Booklet, a standardized official document containing perinatal data, to ensure accuracy when providing this information. However, we did not directly review or systematically collect the full content of the Childhood Booklet, nor did we specifically request gestational age or expected due date data. As a result, we were unable to adjust birthweight for gestational age, which limits the precision of the interpretation of birthweight effects. Finally, given that our sample was community-based, the prevalence of LBW was low, which may explain why we did not find associations between birthweight and PLEs. It is also important to note that the majority of the tested sex by birthweight interactions in our study were not significant. Therefore, the evidence for broad sex-specific effects remains limited and should be interpreted with caution.

5. Conclusions

Our study suggests that the relationship between birthweight, as a proxy for intrauterine conditions, and cognitive biases is moderated by sex, with differential patterns observed in boys and girls in two cognitive biases related to JTC and dichotomous thinking. These findings highlight the importance of considering biological sex when investigating the psychosis continuum spectrum and underscore the need for further research into how early life factors influence cognitive and emotional development differently in boys and girls.

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Figure 1. Scatterplot of the relationship between dichotomous thinking and birth weight, stratified by sex

Insert Figure 1 here

Scatterplots provide a descriptive illustration of the interaction pattern between birthweight and sex on cognitive biases. Formal inferences regarding these associations are based on the adjusted regression models presented in Table 3.

Figure 2. Scatterplot of the relationship between jumping to conclusions and birth weight, stratified by sex

Insert Figure 2 here

Scatterplots provide a descriptive illustration of the interaction pattern between birthweight and sex on cognitive biases. Formal inferences regarding these associations are based on the adjusted regression models presented in Table 3.

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Author Contributions Statement

Here's the updated CRediT statement with **Investigation** added to all authors who contributed to **Data Curation**:

- **Estefania Gago:** Data Curation, Formal Analysis, Investigation, Writing – Original Draft Preparation, Visualization, Writing – Review & Editing.
- **Itziar Montalvo:** Conceptualization, Methodology, Data Curation, Formal Analysis, Investigation, Supervision, Project Administration, Funding Acquisition, Writing – Review & Editing.
- **Meritxell Tost:** Data Curation, Investigation, Writing – Review & Editing.
- **Sara Pérez:** Data Curation, Investigation, Writing – Review & Editing.
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- **Diego Palao:** Writing – Review & Editing.
- **Roser Nadal:** Conceptualization, Methodology, Writing – Review & Editing.
- **Montse Pàmias:** Conceptualization, Methodology, Writing – Review & Editing.
- **Virginia Soria:** Supervision, Writing – Review & Editing.
- **Clemente García-Rizo:** Formal Analysis, Visualization, Supervision, Writing – Review & Editing.
- **Javier Labad:** Conceptualization, Methodology, Formal Analysis, Visualization, Supervision, Project Administration, Funding Acquisition, Writing – Review & Editing.

CONFLICT OF INTEREST

The authors declare that they have no conflicts of interest related to the content of this article.

Table 1. Clinical data of the sample.

	Boys N=69		Girls N=117		
	Mean or N	SD or %	Mean or N	SD or %	p value
Age	14.6	0.6	14.6	0.5	0.552
Ethnicity					0.090
Caucasian	61	88.4%	107	91.5%	
Gypsy	2	2.9%	0	0%	
Maghreb	0	0%	1	0.9%	
Latin-American	6	8.7%	3	2.6%	
Asian	0	0%	1	0.9%	
Mixed race	0	0%	3	2.6%	
Other	0	0%	2	1.7%	
Tobacco use					0.633
Daily	0	0%	1	0.9%	
Occasional	7	10.1%	15	12.8%	
Never	62	89.9%	101	86.3%	
Cannabis use					0.846
Daily	0	0%	0	0%	
Occasional	2	2.9%	4	3.4%	
Never	67	97.1%	113	96.6%	
Alcohol use					0.090
Daily	0	0%	0	0%	
Occasional	16	23.2%	41	35.0%	
Never	53	76.8%	76	65.0%	
Mental health follow-up history					0.339
Never	50	72.5%	79	67.5%	
Previously	13	18.8%	19	16.2%	
Currently	6	8.7%	19	16.2%	
Current psychopharmacological treatment	10	14.5%	15	12.8%	0.747
Birthweight (grams)	3353.8	458.2	3144.2	558.1	0.009
Low birthweight (<2500 g)	3	4.3%	18	15.4%	0.022
Psychometric scales					
CAPE P15					
CAPE Paranoid ideation	7.9	2.3	9.1	2.5	0.001
CAPE Bizarre experiences	9.2	2.9	9.6	2.8	0.314
CAPE Perceptual abnormalities	3.7	1.4	3.6	1.0	0.819
CAPE Total score	20.8	5.3	22.4	5.2	0.039
CBQ					
CBQ Intentionalizing	7.6	2.1	7.5	1.3	0.970
CBQ Catastrophizing	8.8	1.7	9.6	1.9	0.003
CBQ Dichotomous thinking	9.1	2.3	9.5	2.4	0.212
CBQ Jumping to conclusions	9.6	1.9	10.3	1.9	0.013
CBQ Emotional reasoning	8.0	2.2	8.1	2.2	0.067
CBQ Total score	44.4	8.2	46.3	7.8	0.067

Abbreviations: CAPE= Community Assessment of Psychotic Experiences; CBQ= Cognitive Biases Questionnaire

Raw data (untransformed) is shown for CAPE-P15 and CBQ scores. However, p values for CBQ scores were calculated with a T-test using log transformed measures.

Table 2. Pearson correlation analyses between birthweight and psychometric scales. Stratified analysis by sex.

	Birthweight	
	Boys	**Girls**
CBQ Intentionalizing	0.008	-0.029
CBQ Catastrophizing	0.109	-0.029
CBQ Dichotomous thinking	**0.265***	-0.104
CBQ Jumping to conclusions	0.209	**-0.209***
CBQ Emotional reasoning	0.046	-0.038
CBQ Total score	0.157	-0.110
CAPE Paranoid ideation	0.217	-0.028
CAPE Bizarre experiences	0.100	-0.036
CAPE Perceptual abnormalities	-0.064	-0.073
CAPE Total score	0.133	-0.046

Abbreviations: CAPE= Community Assessment of Psychotic Experiences; CBQ= Cognitive Biases Questionnaire

CBQp scores were log-transformed (natural logarithm, ln).

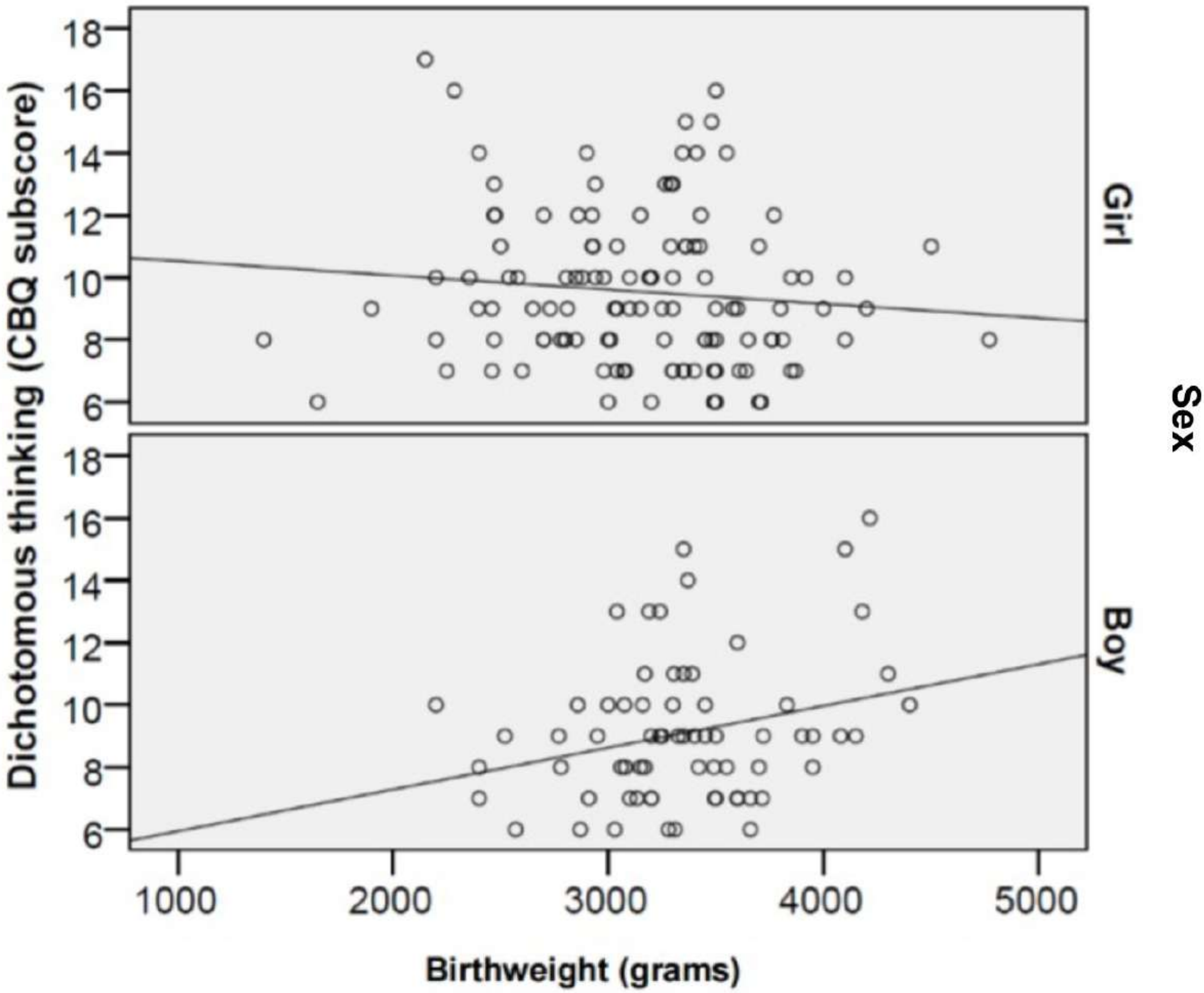
*$p<0.05$

Table 3. Results of the multiple linear regression analyses exploring associations between birthweight and psychometric scales.

		Birthweight		Female sex		Mental health follow-up history		Interaction female sex by birthweight	
	R^2	Beta	p	Beta	p	Beta	p	Beta	p
CBQ Intentionalizing	0.002	-0.016	0.831	-0.002	0.977	0.036	0.623	NS	NS
CBQ Catastrophizing	0.046	0.008	0.914	0.215	0.004	0.013	0.853	NS	NS
CBQ Dichotomous thinking	0.041	0.302	0.032	1.283	0.011	0.060	0.415	-1.183	0.017
CBQ Jumping to conclusions	0.076	0.240	0.082	1.460	0.003	0.053	0.464	-1.283	0.009
CBQ Emotional reasoning	0.011	-0.016	0.828	0.029	0.697	-0.101	0.175	NS	NS
CBQ Total score	0.019	-0.019	0.797	1.742	0.083	0.144	0.885	NS	NS
CAPE Paranoid ideation	0.064	0.049	0.500	0.252	0.001	0.044	0.541	NS	NS
CAPE Bizarre experiences	0.025	0.013	0.857	0.070	0.352	0.138	0.061	NS	NS
CAPE Perceptual abnormalities	0.012	-0.066	0.380	-0.034	0.651	0.087	0.240	NS	NS
CAPE Total score	0.036	0.016	0.829	0.149	0.047	0.114	0.120	NS	NS

Standardized regression coefficients are shown (Beta). CBQ scores were log-transformed (natural logarithm, ln) prior to conducting multiple linear regression analyses. Sex × birthweight interactions were tested in all models. Only significant interactions were retained in the final models presented here. 'NS' indicates that the interaction term was not retained due to non-significance.

Abbreviations: CAPE= Community Assessment of Psychotic Experiences; CBQ= Cognitive Biases Questionnaire; NS= Non-significant.


Dichotomous thinking (CBQ subscore)
18
16
14
12
10
8
6
Girl
Boy
Sex
1000
2000
3000
4000
5000
Birthweight (grams)

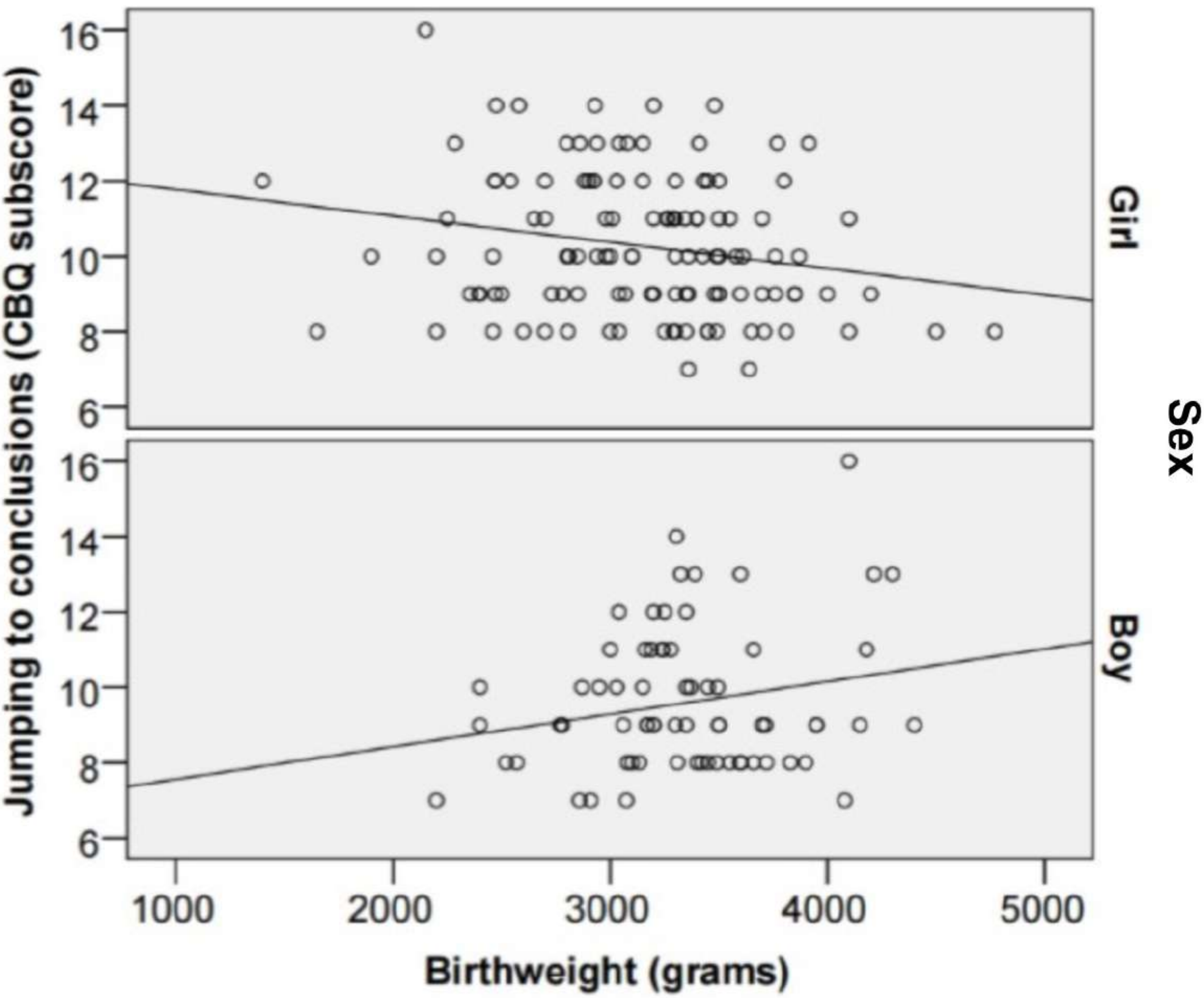
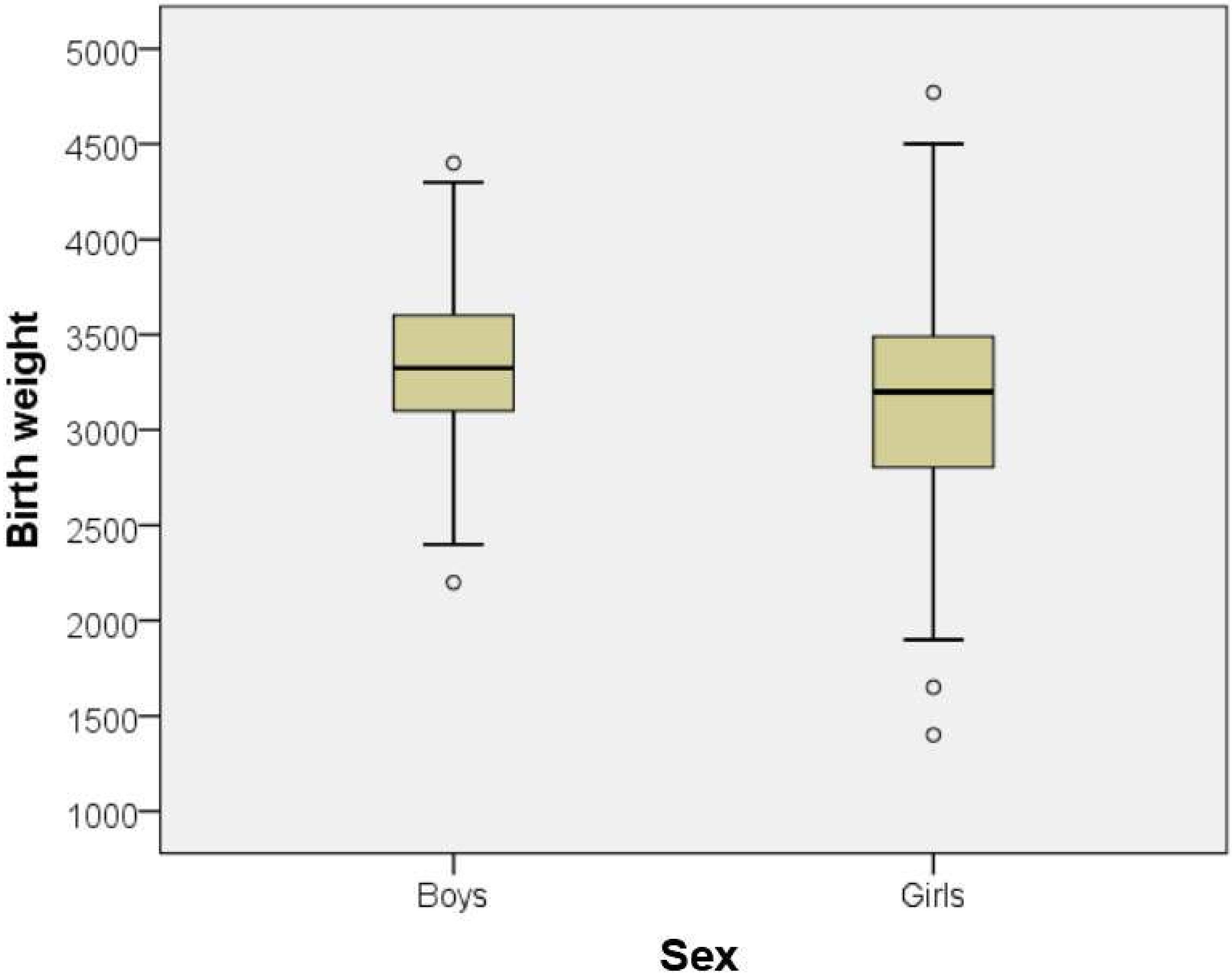
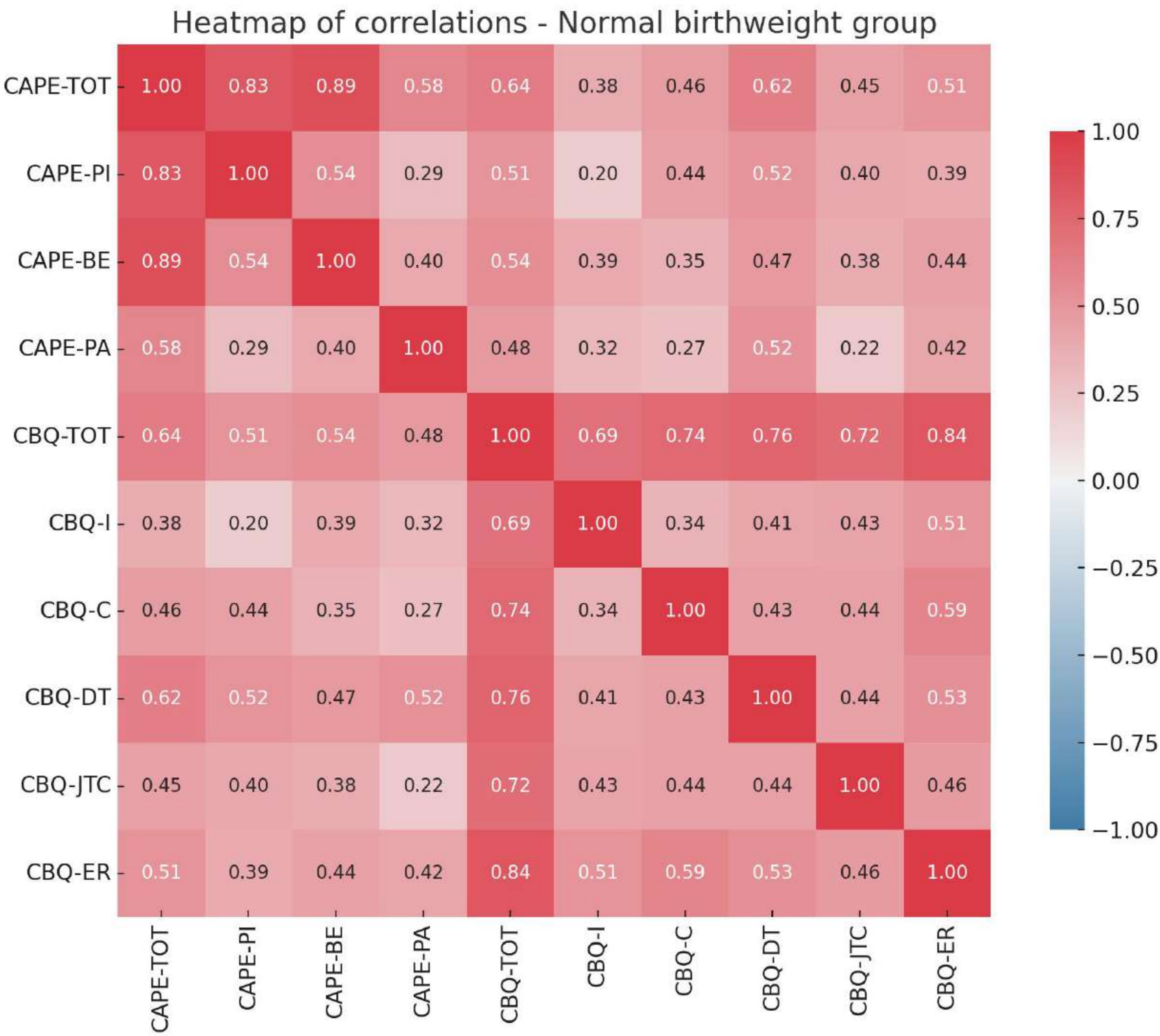

Jumping to conclusions (CBQ subscore)
16
14
12
10
8
6
Girl
Boy
Sex
1000
2000
3000
4000
5000
Birthweight (grams)

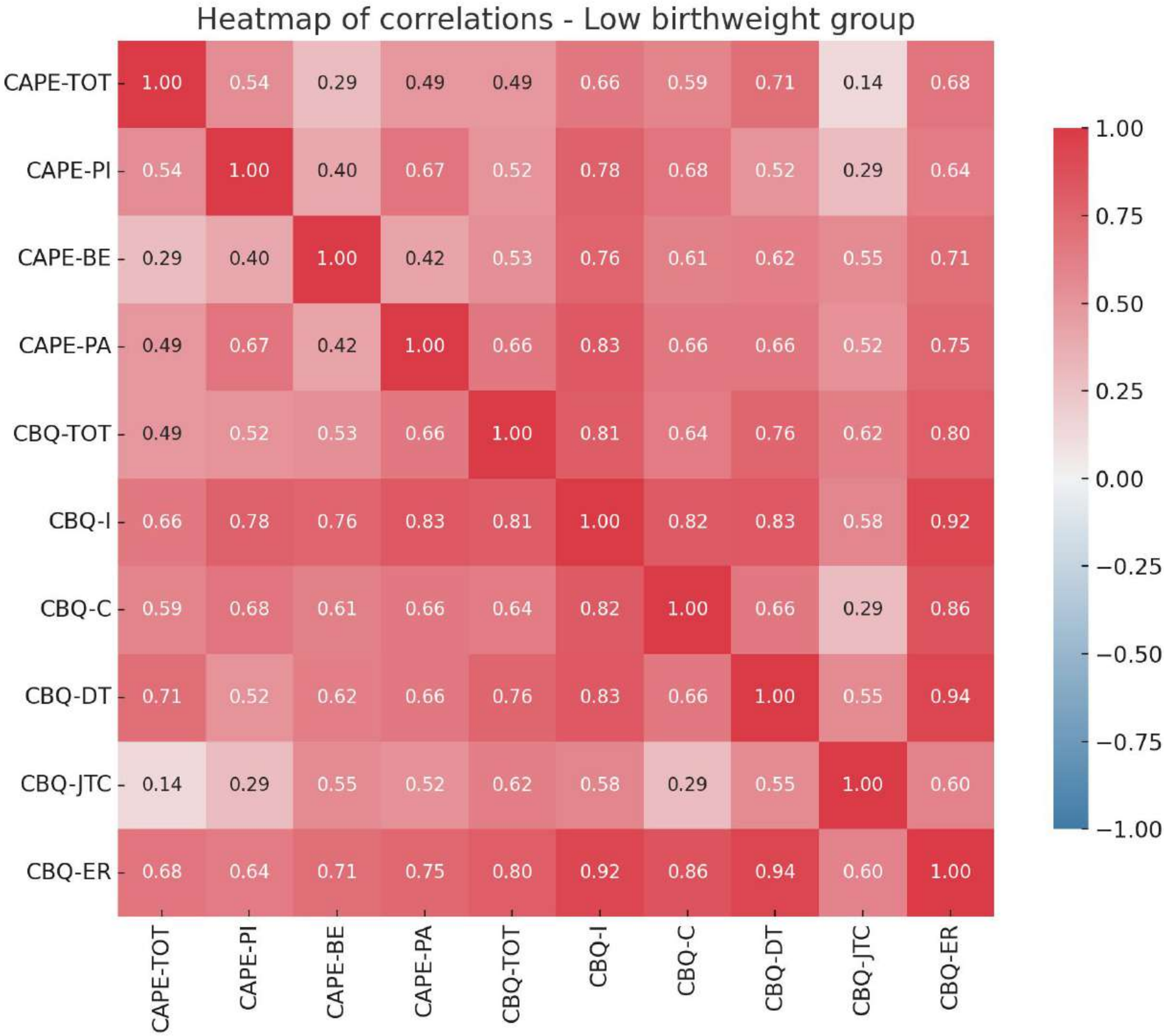
Figure S1. Box-plot graph comparing birthweigh by sex.



Outliers are represented as empty dots.



Heatmap of correlations - Normal birthweight group
CAPE-TOT
CAPE-PI
CAPE-BE
CAPE-PA
CBQ-TOT
CBQ-I
CBQ-C
CBQ-DT
CBQ-JTC
CBQ-ER
1.00 0.83 0.89 0.58 0.64 0.38 0.46 0.62 0.45 0.51
0.83 1.00 0.54 0.29 0.51 0.20 0.44 0.52 0.40 0.39
0.89 0.54 1.00 0.40 0.54 0.39 0.35 0.47 0.38 0.44
0.58 0.29 0.40 1.00 0.48 0.32 0.27 0.52 0.22 0.42
0.64 0.51 0.54 0.48 1.00 0.69 0.74 0.76 0.72 0.84
0.38 0.20 0.39 0.32 0.69 1.00 0.34 0.41 0.43 0.51
0.46 0.44 0.35 0.27 0.74 0.34 1.00 0.43 0.44 0.59
0.62 0.52 0.47 0.52 0.76 0.41 0.43 1.00 0.44 0.53
0.45 0.40 0.38 0.22 0.72 0.43 0.44 0.44 1.00 0.46
0.51 0.39 0.44 0.42 0.84 0.51 0.59 0.53 0.46 1.00
1.00
0.75
0.50
0.25
0.00
−0.25
−0.50
−0.75
−1.00



Heatmap of correlations - Low birthweight group
CAPE-TOT
CAPE-PI
CAPE-BE
CAPE-PA
CBQ-TOT
CBQ-I
CBQ-C
CBQ-DT
CBQ-JTC
CBQ-ER
1.00 0.54 0.29 0.49 0.49 0.66 0.59 0.71 0.14 0.68
0.54 1.00 0.40 0.67 0.52 0.78 0.68 0.52 0.29 0.64
0.29 0.40 1.00 0.42 0.53 0.76 0.61 0.62 0.55 0.71
0.49 0.67 0.42 1.00 0.66 0.83 0.66 0.66 0.52 0.75
0.49 0.52 0.53 0.66 1.00 0.81 0.64 0.76 0.62 0.80
0.66 0.78 0.76 0.83 0.81 1.00 0.82 0.83 0.58 0.92
0.59 0.68 0.61 0.66 0.64 0.82 1.00 0.66 0.29 0.86
0.71 0.52 0.62 0.66 0.76 0.83 0.66 1.00 0.55 0.94
0.14 0.29 0.55 0.52 0.62 0.58 0.29 0.55 1.00 0.60
0.68 0.64 0.71 0.75 0.80 0.92 0.86 0.94 0.60 1.00
1.00
0.75
0.50
0.25
0.00
−0.25
−0.50
−0.75
−1.00