Psychological Medicine

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Cortisol and cognition in psychotic disorders: A systematic review and multi-level meta-analysis

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Review Article

Cite this article: Chen, H. Z., Yong, J. X. M., Haussler, S. M., Murray, R. M., Pariante, C. M., Ibrahim, F., & Kravariti, E. (2026). Cortisol and cognition in psychotic disorders: A systematic review and multi-level meta-analysis. *Psychological Medicine*, **56**, e330, 1–12
https://doi.org/10.1017/S0033291726106266

Received: 14 July 2025 UTC
Revised: 23 June 2026 UTC
Accepted: 08 September 2026 UTC

Keywords:
cognitive decline; cortisol; hypothalamic–pituitary–adrenal axis; meta-analysis; psychosis

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H.Z.C. and J.X.M.Y. contributed equally to this study.

Abstract

Emerging evidence suggests that dysregulation of the hypothalamic–pituitary–adrenal (HPA) axis, particularly cortisol, may contribute to the cognitive deficits commonly observed in psychotic disorders. We conducted the first combined systematic review and quantitative synthesis of associations between cortisol and cognition in psychosis. Twelve studies met inclusion criteria (940 participants; 74.68% cases; 39.57% female; mean age = 31.83 years). Of these, nine studies (822 participants; 71.04% cases; 35.96% female; mean age = 32.72 years) contributed data to three-level meta-analyses examining associations between basal cortisol and composite cognition, attention, working memory and processing speed (AWP), executive functioning (EF), and verbal learning and memory (VM). Cortisol sampling time significantly moderated the relationship between cortisol and EF (F = 10.98, p = .004), with a significant negative association emerging between afternoon/evening cortisol and EF (r = −0.27, 95% CI [−0.42, −0.12], p = .01). No other robust cortisol–cognition associations were observed. However, sensitivity analyses revealed a negative association between morning cortisol and AWP following exclusion of an influential study. These findings do not support a general association between basal cortisol and cognitive functioning in psychosis. Instead, they suggest that cortisol–cognition relationships may be both domain- and sampling-time-specific, with the strongest evidence linking elevated afternoon/evening cortisol to poorer executive functioning. Further research using more precise assessments of cortisol dynamics is needed to clarify the role of HPA-axis dysregulation in cognitive impairment across psychotic disorders.

Introduction

Psychosis is increasingly recognised as a multisystem disorder in which the hypothalamic–pituitary–adrenal (HPA) axis plays an important role (Pillinger, D'Ambrosio, McCutcheon, & Howes, 2019). Cortisol, the principal stress hormone of the HPA axis, reflects HPA-axis activity and mediates physiological responses to stress (Chrousos, 2000; McEwen & Stellar, 1993). HPA-axis dysregulation is well documented in psychosis, including elevated cortisol levels, a blunted cortisol awakening response (CAR), and altered stress reactivity (Berger et al., 2016; Borges, Gayer-Anderson, & Mondelli, 2013; Girshkin, Matheson, Shepherd, & Green, 2014; Karanikas, Antoniadis, & Garyfallos, 2014; Zorn et al., 2017). These findings are consistent with the neural diathesis–stress model, which proposes that genetic vulnerability and stress-related HPA-axis abnormalities increase risk for psychosis through effects on dopaminergic and glutamatergic pathways (Cullen et al., 2020; Pruessner, Cullen, Aas, & Walker, 2017; Walker & Diforio, 1997; Walker, Mittal, & Tessner, 2008). Further support comes from evidence linking adverse childhood experiences to increased risk of psychosis (Varese et al., 2012), potentially through HPA-axis sensitisation and heightened stress responsivity (Aas et al., 2014).

Robust evidence indicates that cognitive impairment is a core feature of schizophrenia-spectrum and other psychotic disorders (Bora, Binnur Akdede, & Alptekin, 2017; Bora, Yücel, & Pantelis, 2009, 2010; Lewandowski, Sperry, Cohen, & Öngür, 2014; McCutcheon, Keefe, & McGuire, 2023; Sheffield, Karcher, & Barch, 2018). Deficits span multiple domains, including attention, processing speed, memory, and executive functioning, and are typically associated with large effect sizes (Heinrichs & Zakzanis, 1998; Mesholam-Gately et al., 2009; Schaefer, Giangrande, Weinberger, & Dickinson, 2013). Present from the first episode of psychosis and in drug-naïve patients (Fatouros-Bergman et al., 2014; Mesholam-Gately et al., 2009), these impairments contribute substantially to functional disability (Green, Horan, & Lee, 2019; McCutcheon et al., 2023; Reichenberg & Harvey, 2007).

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Several lines of evidence suggest an interplay between HPA-axis dysfunction and cognitive impairment in psychosis. Prolonged exposure to elevated cortisol may exert neurotoxic effects on the hippocampus and prefrontal cortex, brain regions critical for memory and executive functioning and implicated in psychosis (Giovanoli et al., 2013; Knight et al., 2022; Lupien et al., 1998; Lupien, Juster, Raymond, & Marin, 2018; McEwen, 1999; Mondelli et al., 2010). Owing to their high density of glucocorticoid receptors, these regions are particularly vulnerable to chronic stress, which may lead to dendritic retraction, synaptic loss, and reduced neurogenesis (Arnsten, 2009). Such alterations provide a plausible mechanism linking cortisol dysregulation to cognitive deficits in psychosis.

Two narrative reviews have highlighted a potential link between HPA-axis dysregulation and cognitive impairment in psychosis. Labad (2019) proposed that cognitive deficits may be partly driven by the neurotoxic effects of chronic cortisol elevation, while Aas et al. (2014) reviewed evidence suggesting that cognition in first-episode psychosis may be modulated by cortisol. Together, these reviews support the hypothesis that cortisol dysregulation may contribute to cognitive dysfunction in psychotic disorders.

To our knowledge, no previous study has quantitatively synthesised associations between cortisol and cognition in psychosis. To address this gap, we investigated the relationship between cortisol levels and cognitive performance in psychotic disorders using a combined narrative review and meta-analytic approach. By examining both global cognitive functioning and specific cognitive domains, we aimed to determine whether cortisol–cognition associations differ across distinct aspects of cognition.

Methods

Literature search strategy

The current systematic review and meta-analysis was prospectively registered in PROSPERO (registration number CRD42024564051) and followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines (Page et al., 2021; see Figure 1). The literature searches were conducted using three databases: Web of Science (Core Collection), PsycINFO, and MEDLINE. The publication period ranged from the inception of the database to 15th June 2026. Two researchers (HZC, JXMY)

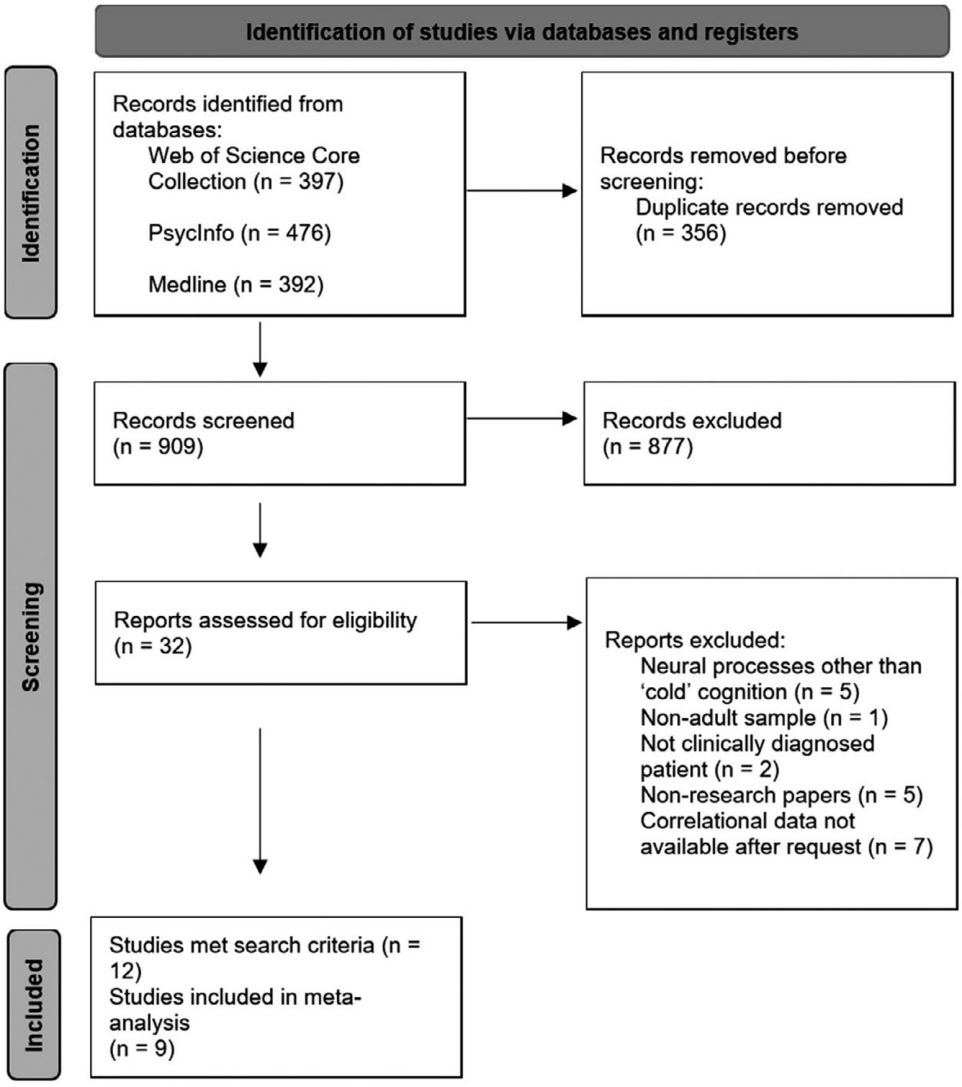


Figure 1. PRISMA flow diagram of the study selection process.

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independently screened the titles and abstracts to identify potentially eligible studies, with a third researcher (EK) adjudicating if differences in opinion arose. The search strategy combined search terms related to cortisol, cognition, and psychosis (see Supplementary Appendix A).

Study selection

We selected studies satisfying the following inclusion criteria: (1) primary research study published in a peer-reviewed journal; (2) written in English; (3) studied adult human samples; (4) included participants clinically diagnosed with schizophrenia, other primary psychotic disorders, or mood disorders with psychotic symptoms according to the Diagnostic and Statistical Manual of Mental Disorders (DSM) or the International Classification of Diseases (ICD); (5) measured naturally occurring cortisol; (6) conducted cognitive tests; and (7) reported correlations between cognition and cortisol. Exclusion criteria were: (1) participants in the psychotic group had cortisol-related disorders (e.g., Cushing's disorder); (2) the study reported mental or physical health comorbidities that are associated with cognitive impairment; and (3) the study assessed neural processes other than 'cold' cognition (e.g., social cognition, stress reactivity, emotion or stress perception, and neurophysiological responses). Two researchers (HZC, JXMY) independently conducted full-text screenings, and all decisions on eligibility were based on consensus. When targeted data were missing from an otherwise eligible study, attempts were made to acquire the data before excluding the study from further consideration. Sample overlap was checked among the included studies.

A total of 12 studies met our eligibility criteria. In line with previous studies (Myung, 2023), we set the minimum number of independent studies required to conduct a meta-analysis to five. Nine studies with non-overlapping participant samples examined basal cortisol, enabling a meta-correlation. CAR was examined in two studies, whereas diurnal cortisol slope, daytime cortisol area under the curve, and chronic hair cortisol each were examined in one study, allowing a narrative synthesis.

Data extraction and quality assessment

Two researchers (HZC, JXMY) extracted the following data: (1) authors and year of publication; (2) sample size and gender composition; (3) mean age of sample; (4) range of diagnoses among participants; (5) cortisol specimen type; (6) cortisol collection time; (7) cognitive batteries, tests and variables; (8) correlation coefficients between cortisol and cognitive variables. The study by Cherian, Schatzberg and Keller (2019) reported data from two separate cohorts, a schizophrenia spectrum disorder group and a psychotic major depression group, which represented two separate studies/samples in our meta-analyses. A third researcher (EK) compared the two datasets and confirmed that the data were extracted correctly. Cognitive variables were categorised into one of the following cognitive domains: attention, working memory & processing speed (AWP); executive function (EF); verbal learning and memory (VM); visual–spatial perception, organisation & learning; language function (VS); and general/composite cognitive function (GC). In line with previous work by our group (Millgate et al., 2022), attention, working memory and processing speed were grouped into a single cognitive domain (AWP). This classification was adopted because many neuropsychological measures used in psychosis research tap overlapping attentional, working-memory, and processing-speed processes, making reliable separation of these constructs difficult across studies. Detailed information on the included studies and their characteristics is presented in Table 1.

Two researchers (HZC, JXMY) independently assessed the overall quality of the studies using the NIH Quality Assessment Tool for Observational Cohort and Cross-Sectional Studies (National Heart, Lung, and Blood Institute, NIH, U.S.). The tool contains 14 items, each scored with 1 (yes) or 0 (no, not applicable, not reported, or cannot determine). In instances of score discrepancies, the researchers engaged in discussion to reach a consensus. An overall quality score was calculated by summing all item scores (≥ 7, good; 4 to 6, fair; < 4, poor; Li et al., 2023). All studies were rated as good quality (see Supplementary Appendix B).

Statistical analysis

Multilevel meta-analyses

To generate an overall correlation coefficient between basal cortisol and composite cognitive function among patients with psychotic disorders across eligible studies (n = 9), we first performed a multilevel meta-analysis of correlation coefficients across all studies and cognitive variables. Three further cognitive domains – AWP, EF and VM – met our threshold (5 studies) for performing domain-specific meta-analysis. Study findings relating to the remaining cognitive domains were synthesised narratively.

Several studies reported two or more effect sizes within the same cognitive domain. To account for the dependence arising from multiple effect sizes contributed by individual studies, multilevel meta-analysis was conducted as recommended by López-López, Page, Lipsey, and Higgins (2018). This approach accounts for effect size dependence by estimating variance at multiple levels (Supplementary Figure 1), thereby improving the accuracy of statistical inference (Cheung, 2015, 2019) and avoiding the limitations of averaging effect sizes within studies, which can fail to account for within-study variance and reduce analytic precision. Accordingly, associations between basal cortisol and cognition were synthesised using three-level meta-analysis, with variance partitioned into within-effect-size, within-study, and between-study components (Supplementary Figure 1). Correlation coefficients were converted to Fisher's z prior to analysis and back-transformed to Pearson's r for reporting.

Given the circadian rhythm of cortisol secretion, which may influence cortisol–cognition associations (Gamble, Berry, Frank, & Young, 2014), sampling time was coded as morning (relatively high cortisol levels) or afternoon/evening (relatively low cortisol levels) and included as a moderator in all models. Combining afternoon and evening cortisol measurements was supported by previous studies (e.g., Engert et al., 2011; O'Byrne, Yuen, Butt, & Liu, 2021).

Three-level meta-analyses were first conducted on the full dataset (55 cognitive effect sizes across studies and cognitive domains) and subsequently within the AWP, EF, and VM domains. For each analysis, moderated and unmoderated models were compared using ANOVA, and moderated models were reported only when they provided a significantly better fit. For moderator analyses, a fixed-effect model was used when at least one moderator level contained five or fewer effect sizes (Tufanaru, Munn, Stephenson, & Aromataris, 2015); otherwise, a random-effects model was applied. When dependence among effect sizes remained within significant moderator subgroups, or when unmoderated models were analysed, robust variance estimation (RVE) was used to obtain robust standard errors and valid statistical inference (Hedges, Tipton, & Johnson, 2010; Tipton, 2015; Tipton & Pustejovsky, 2015). Heterogeneity was assessed by τ^2 and I^2, with the caveat that I^2 estimates may be biased when meta-analyses include a small

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Table 1. Characteristics of eligible studies (n = 12)

Study	Country	Sample size (female%)	Mean age	Diagnosis	Cortisol type	Cortisol time	Cortisol measure[b]	Cognitive measurement	Effect sizes (n)	Cognitive domains
Misiak et al. (2021)[a]	Poland	85 (47.1)	37.1	SSD	Blood	Morning	Basal cortisol	RBANS	5	AWP, VM, VS, LA
Cherian et al. (2019)-SSD[a]	US	31 (45.2)	38.48	SSD	Blood	Evening, early morning	Basal cortisol	WAIS-III, TMT, COWA, CLVT-II, WMS III, Stroop Colour Word Test	8	AWP, EF, VM
Cherian et al. (2019)-MD[a]	US	46 (54.3)	36.67	PMD	Blood	Evening, early morning	Basal cortisol	WAIS-III, TMT, CLVT-II, WMS-III, Stroop colour word test	8	AWP, EF, VM
Allott et al. (2018)[a]	Australia	35 (25.7)	20.3	FEP	Blood	Morning	Basal cortisol	WAIS-III, verbal paired associate learning test	5	AWP, EF, VM
Krkovic et al. (2017)[a]	Germany	35 (42)	40.5	SSD	Saliva	Afternoon	Basal cortisol	TMT, D2 test, WAIS, RBMT	7	AWP, EF, VM, GC
Knytl et al. (2019)[a]	Czech Republic	16 (50)	25.81	FEP	Blood	Morning	Basal cortisol	Rey-Osterrieth Complex Figure Test, AVLT, WMS-III, WAIS-III, WCST, Tower of London, continuous performance task, TMT, Stroop colour word test	6	AWP, EF, VM, GC
Havelka et al. (2016)[a]	Czech Republic	23 (0)	23.5	FEP	Blood	Afternoon	Basal cortisol	TMT, AVLT, verbal fluency test, WCST	8	AWP, EF, VM
Walder et al. (2000)[a]	US	18 (44.4)	36.72	SSD	Saliva	Morning	Basal cortisol	CVLT, WMS	3	EF, VM
Inova et al. (2025)[a]	Norway	257 (37.74)	30.75	SSD	Blood	Morning	Basal cortisol	CVLT-II, HVLT-R, WAIS-III, MCCB	4	AWP, EF, VM
Yazici et al. (2025)[a]	Türkiye	38 (0)	37.71	SSD	Blood	Morning	Basal cortisol	WAIS-III	1	VS
Labad et al. (2016)	Spain	60 (35)	24.55	SSD	Saliva	Morning, evening	CAR, DCS	MCCB	–	AWP, EF, VM, VS
Aas et al. (2011)	UK	30 (33.3)	30.1	FEP	Saliva	Morning, evening	CAR, DCAuC	WAIS-III, WMS-III. CANTAB, TMT	–	GC, VM, VS, EF, AWP
Aas et al. (2019)	Norway	28 (50)	33.6	SSD	Hair	–	HCC	MCCB	–	AWP, EF, VM

Note: AWP, attention working memory & processing speed; AVLT, auditory verbal learning test; CANTAB, Cambridge neuropsychological test automated battery; CAR, cortisol awakening response; COWA, controlled oral word association test; CVLT, California verbal learning test; DCAuC, daytime cortisol area under the curve; DCS, diurnal cortisol slope; EF, executive function; FEP, first episode psychosis; GC, general/composite cognitive function; HCC, hair cortisol concentration; HVLT-R, Hopkins verbal learning test; LA, language function; MCCB, matrics consensus cognitive battery; PMD, psychotic major depression; RBANS, repeatable battery for the assessment of neuropsychological status; RBMT, rivermead behavioural memory test; SSD, schizophrenia spectrum disorder; TMT, trail making test; VM, verbal learning and memory; VS, visual–spatial perception organisation and learning; WAIS, Wechsler adult intelligence scale; WCST, Wisconsin card sorting test; WMS, Wechsler memory scale.

[a]Studies included in meta-analysis.

[b]Only measures with a reported correlation coefficient with a cognitive variable are included in the Table.

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number of studies (von Hippel, 2015). Publication bias was assessed using contour-enhanced funnel plots (visual inspection), Egger's regression test, and Begg's rank correlation test (Harbord, Egger, & Sterne, 2006).

Sensitivity and further analyses

To assess the robustness of our findings to different analytical decisions, biological sample (blood/salivary cortisol), additional potential moderators, and influential studies (studies whose inclusion has a substantial impact on the results of a meta-analysis), we conducted sensitivity analyses by: (1) replacing the multilevel approach with the traditional approach of averaging dependent effect sizes within studies and cognitive domains; (2) excluding the two studies that measured cortisol using saliva samples; (3) examining age and sex as additional potential moderators; and (4) applying study-level influence diagnostics to identify potential outliers.

Influence diagnostics followed established approaches for meta-analytic models (Viechtbauer & Cheung, 2010), including standardised deleted residuals (SDR), Cook's distance (CD), and DFBETAS. We used conservative screening criteria requiring all three indicators (SDR, CD and DFBETAS) to exceed their respective thresholds: (1) a significant study-level SDR test, (2) CD greater than 4/k, and (3) maximum absolute DFBETAS greater than 1. Studies flagged by these screening diagnostics were not removed mechanically but were used to guide sensitivity analyses.

Finally, we compared basal cortisol levels and cognitive performance between patient and control samples across eligible studies using standard meta-analytic models.

Statistical software

Multilevel meta-analyses were conducted in R 4.4.1 using the metafor package (Viechtbauer, 2010). Random-effects models were fitted using restricted maximum likelihood (REML) estimation. Model comparisons were refitted using maximum likelihood estimation because REML is inappropriate for comparing models with different fixed effects (Zuur et al.,2009, p. 122). Robust variance estimation was performed using the robumeta package (Fisher, Tipton, & Zhipeng, 2023), assuming a within-study correlation of 0.8 between dependent effect sizes (package default). Statistical significance was set at $p < .05$.

Results

In all, 12 studies, reporting on 13 independent samples, met eligibility criteria for our systematic review ($n = 12$) and meta-analyses ($n = 9$). The 13 samples comprised 940 participants (39.57% female), including 702 patients with psychotic disorders (36.32% female), with mean ages ranging from 20.3 to 40.5 (mean age across studies = 31.83). The studies were conducted in 9 countries in Europe & Asia ($n = 8$), North America ($n = 3$), and Oceania ($n = 1$). The study characteristics are summarised in Table 1. The subset of studies that were included in the meta-analyses ($n = 9$) comprised 822 participants (39.78% female; mean age = 32.45), including 584 patients (35.96% female, mean age = 32.72).

Multilevel meta-analyses of correlations between basal cortisol level and cognitive function

Composite cognitive function

There was no significant difference between the model fit of moderated and unmoderated models for composite cognitive function ($\chi^2_1 = 3.40$; $p = .07$). Therefore, we report on the unmoderated three-level model with robust variance estimation. The pooled correlation of all the effect sizes was not significant ($r = 0.003$; 95% CI: $-0.15 - 0.15$; $p = .96$). The estimated heterogeneity was high ($\tau^2 = .04$; $I^2 = 65.3\%$; low $I^2 < 25\% \leq$ moderate $I^2 < 50\% \leq$ high I^2; Higgins, Thompson, Deeks, & Altman, 2003). The forest plot is presented in Supplementary Figure 2. For the list of cognitive variables used, see Supplementary Appendix C.

Attention, working memory & processing speed

The moderated model for AWP did not provide a significantly better fit than the unmoderated model ($\chi^2_1 = 1.02$; $p = .31$). Across all sampling times, basal cortisol was not significantly associated with AWP ($r = -0.03$; 95% CI: -0.19 to 0.14; $p = .71$). Total heterogeneity in the all-times AWP model was $\tau^2 = .03$ and $I^2 = 58.3\%$. For the forest plot, see Figure 2.

Executive function

The moderated three-level model for EF showed a significantly better fit than the unmoderated model ($\chi^2_1 = 8.76$; $p = .003$). The random-effects model demonstrated a significant difference between the morning and afternoon/evening cortisol sampling frames ($F_{1,17} = 10.98$; $p = .004$). The pooled correlation was not significant for the morning sampling ($r = 0.08$; 95% CI: -0.07–0.24; $p = .30$) but was significant for the afternoon/evening one ($r = -0.27$; 95% CI: -0.42–0.12; $p = .01$). The forest plot is shown in Figure 3. The within-study ($\tau^2_{level2} = .04$) and between-study ($\tau^2_{level3} = .01$) heterogeneity explained 8.54% and 20.68% of the total variance, respectively. Applying the robust variance estimation model for the afternoon/evening sampling did not substantially alter the level of significance ($r = -0.27$; 95% CI: -0.42–0.11; $p = .01$). The forest plot is shown in Figure 3.

Verbal learning and memory

There was no statistically significant difference in fit between the moderated and unmoderated three-level models ($\chi^2_1 = 1.95$; $p = .16$). In the robust variance estimated random-effect three-level model with small-sample correction, the pooled correlation was non-significant ($r = -0.07$; 95% CI: $-0.24 - 0.10$; $p = .39$; see Figure 4). Heterogeneity was high ($\tau^2 = .03$; $I^2 = 59.0\%$).

Publication bias

An evaluation of publication bias is presented in Supplementary Table 1. All dependent effect sizes were averaged before analysis. Both Egger's and Begg tests were statistically non-significant, suggesting an absence of publication bias. Funnel plots are shown in Supplementary Figure 3.

Sensitivity analyses

Replacing the multilevel analytic strategy with averaging effect sizes within cognitive domains/studies did not alter the pattern of findings (Supplementary Figures 4–6). Likewise, after removing the two studies that measured saliva cortisol, the pattern of findings remained unaltered for all cognitive domains (Supplementary Table 2). Age and gender were not significant moderators of effect sizes in the domain-specific meta-analyses (Supplementary Table 3).

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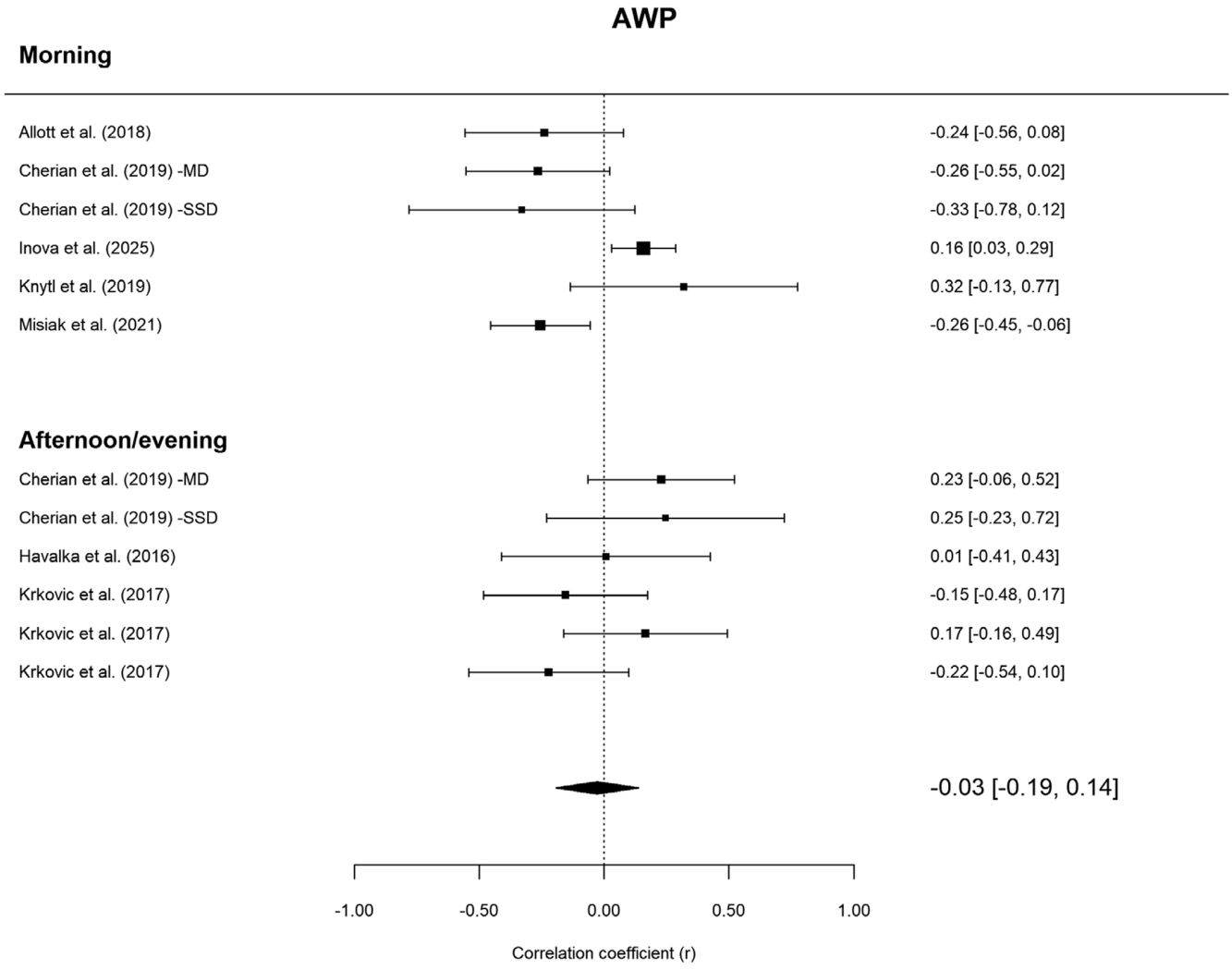


Figure 2. Forest plot of meta-correlations between cortisol and attention/working memory/processing speed via a three-level model. Note that Cherian et al. (2019) included two different cohorts, and they were treated as two independent studies in the analyses.

Applying study-level influence diagnostics to identify studies that may exert undue influence on model estimates or exhibit outlying effect sizes flagged Inova et al. (2025) as an influential and outlier study in relation to the AWP sampling-time moderator model (SDR $\chi^2_1 p$ = .009; CD = 1.19, $CD_{threshold}$ = 0.50 |; $DFBETA|_{max}$ = 1.57). After excluding Inova et al. (2025), the AWP sampling-time moderator became statistically significant ($F_{1,9} p$ = .03) and a significant negative correlation emerged between morning cortisol and AWP (r = −0.21; 95% CI: −0.34–0.08; p = .002), while the afternoon/evening correlation was not significant (r = 0.04; 95% CI: −0.11–0.18; p = .63) (Supplementary Figure 7).

Further analyses: Case–control comparisons

Among the nine meta-correlated studies, seven (excluding Havelka, Prikrylova-Kucerova, Prikryl, & Ceskova, 2016; and Yazici et al., 2025) included a control group, and five (excluding Krkovic, Moritz, & Lincoln, 2017; and Walder, Walker, and Lewine, 2000) compared cortisol levels between patients and controls. The five studies all measured morning cortisol, but only Cherian et al. (2019) measured afternoon/evening cortisol. A random-effects meta-analysis demonstrated that the difference in morning cortisol between the patient and control groups was not significant (d = 0.11; 95% CI: −0.06–0.28; p = .22). Patients with psychosis demonstrated significantly poorer cognitive performance in all the domains (Supplementary Table 4). Due to the exploratory nature of these analyses, we relaxed our requirement of minimum study number (n = 5) to conduct meta-analyses.

Other cognitive domains and outcomes: A narrative synthesis

The following eligible studies examined cognitive domains that did not meet the threshold for domain-specific meta-analysis. For visual–spatial perception, organisation and learning, Misiak et al. (2021) reported a marginal negative correlation with morning cortisol (r = −0.24; p = .06), whereas Yazici et al. (2025) reported a significant positive correlation (r = 0.42; p = .008). Misiak et al. (2021) found no association with semantic verbal fluency. Several effects could not be assigned to a single cognitive domain, including positive associations with general cognition (Knytl et al., 2019) and negative associations with delayed verbal/visual memory (Misiak

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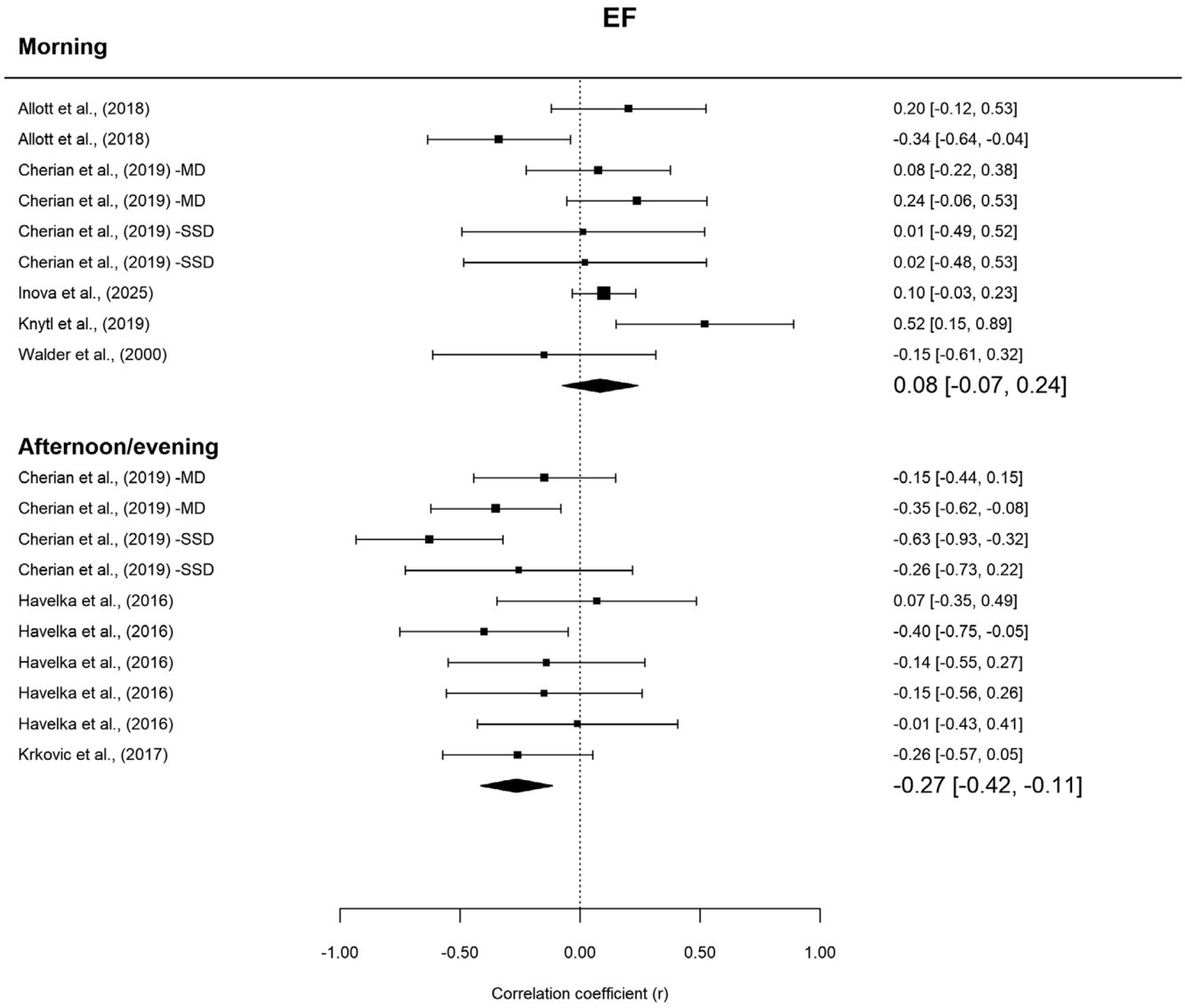


Figure 3. Forest plots of meta-correlations between cortisol and executive function via a three-level model.

et al., 2021); these were included only in the composite multilevel model.

Three studies examined cortisol measures other than basal cortisol. Aas et al. (2011) and Labad et al. (2016) reported associations between cortisol awakening response (CAR) and poorer cognitive performance, particularly in verbal learning, memory, and processing speed, whereas Aas et al. (2011) found no associations with daytime cortisol area-under-the-curve measures. Labad et al. (2016) also linked a flatter diurnal cortisol slope to poorer spatial working memory in women with early psychosis. Finally, Aas et al. (2019) found that higher hair cortisol concentrations were associated with poorer working memory.

Discussion

The present study systematically reviewed and meta-analysed associations between cortisol levels and cognitive functioning in psychosis, examining both global cognition and the domains of attention, working memory and processing speed, executive function, and verbal learning and memory. To our knowledge, this is the first quantitative synthesis of cortisol–cognition associations in psychosis.

Negative correlations between cortisol levels and cognitive function

Our meta-analysis suggests that cortisol–cognition associations in psychosis are both domain- and sampling-time-specific. The strongest and most consistent finding was a negative association between afternoon/evening cortisol levels and executive functioning, which remained significant across multiple analytical approaches despite stringent controls for effect-size dependence. A negative association between morning cortisol and attention, working memory and processing speed also emerged following exclusion of the influential study by Inova et al. (2025), although this effect was not observed in the primary analysis. Together, these findings indicate that cortisol–cognition relationships may be more apparent within specific cognitive domains than at the level of global cognitive functioning.

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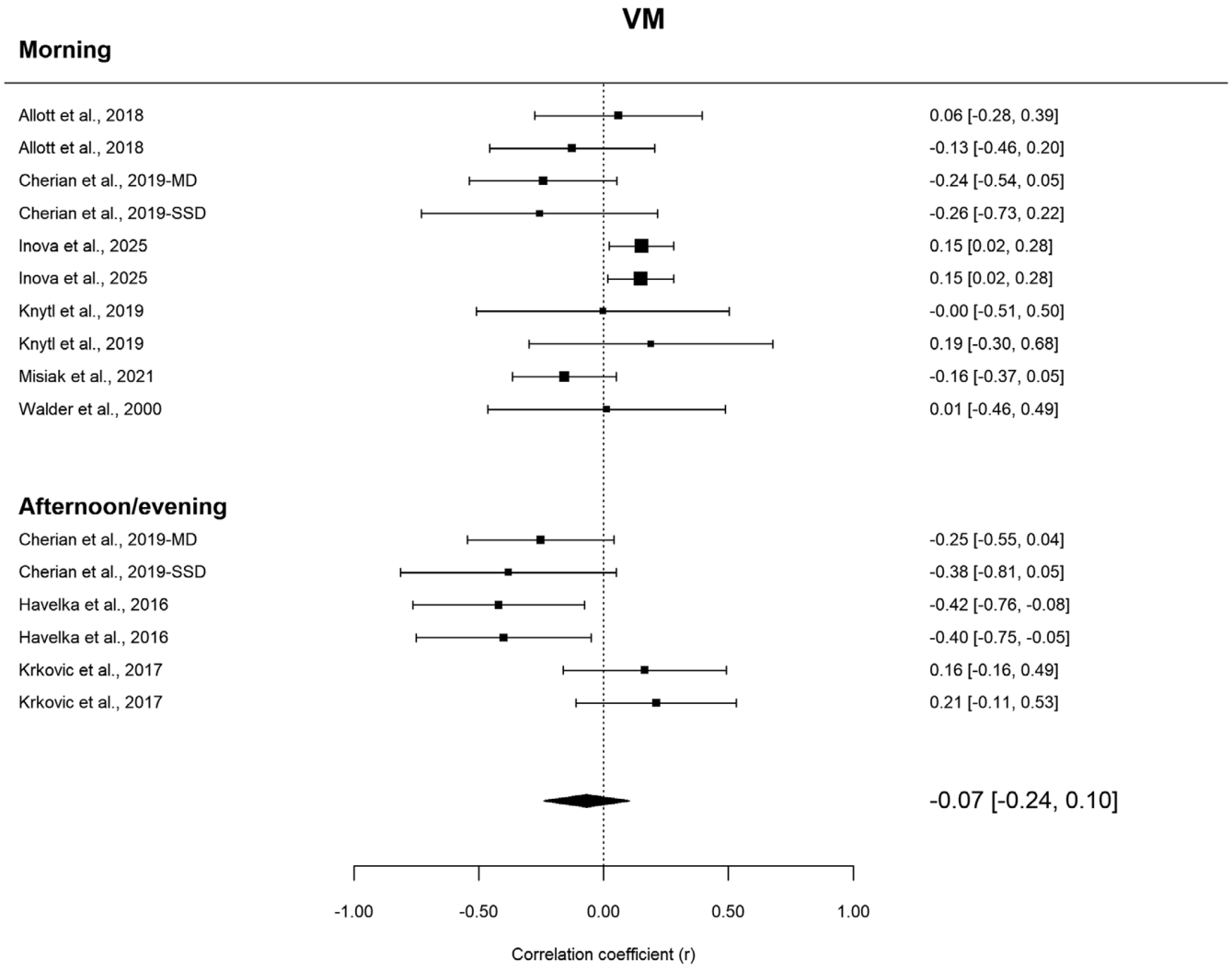


Figure 4. Forest plot of three-level meta-correlation between cortisol and verbal learning and memory.

Previous research in healthy populations has shown that higher daytime cortisol levels are associated with poorer performance across several cognitive domains, including attention, executive functioning, and verbal learning and memory (Evans et al., 2011; Lee et al., 2007). The present findings suggest that a similar relationship may be evident in psychosis, particularly for executive functioning. One potential explanation is that prolonged cortisol exposure affects glucocorticoid-sensitive brain regions involved in cognition, especially the prefrontal cortex (Pruessner et al., 2017). Experimental and animal studies indicate that HPA-axis overactivation can disrupt prefrontal cortical pathways through mechanisms such as dendritic atrophy (Radley et al., 2004) and impaired synaptic plasticity (Cerqueira et al., 2007, 2008). Cortisol-related hippocampal alterations have also been reported in psychosis (Mondelli et al., 2010), although the absence of a significant association between basal cortisol and verbal learning and memory in the present meta-analysis suggests that hippocampal mechanisms provide broader neurobiological context rather than a direct explanation for our findings. More generally, alterations in prefrontal–hippocampal networks may represent one pathway linking HPA-axis dysregulation to cognitive dysfunction in psychosis.

Variations in cognitive measurement and cortisol timing

The cortisol–cognition associations observed in our meta-analysis appeared to be sampling-time-specific. Afternoon/evening cortisol showed the most consistent negative association with executive functioning, whereas associations involving attention, working memory, and processing speed were less stable across sensitivity analyses. One possible explanation is that broad categories such as "morning cortisol" may obscure biologically distinct phases of cortisol secretion. Cortisol levels change rapidly after awakening, and evidence of a blunted cortisol awakening response in psychosis (Aas et al., 2011) does not necessarily imply uniformly altered cortisol concentrations throughout the morning. Consequently, associations with cognition may differ depending on when samples are collected relative to the post-awakening peak. This issue was also highlighted by Inova et al. (2025), who noted the difficulty of interpreting single morning cortisol measurements without precise timing information. Together, these findings underscore the importance of sampling time when investigating cortisol–cognition relationships in psychosis.

Differences between cognitive domains may also contribute to the observed pattern of findings. Tasks assessing attention, working memory and processing speed are generally less complex than

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executive function tasks and may be more sensitive to sleep-related fatigue and fluctuations in arousal (Jarraya, Jarraya, Chtourou, & Souissi, 2014; Munnilari et al., 2024). Given the high prevalence of sleep disturbance in psychosis (Reeve, Sheaves, & Freeman, 2015), variability in sleep and morning sampling procedures may therefore be particularly relevant when examining these domains. By contrast, executive function tasks place greater demands on higher-order cognitive control and may be less susceptible to transient fluctuations in arousal, allowing associations with cortisol to emerge more clearly. These findings highlight the importance of precise cortisol sampling protocols, including reporting clock time, time since awakening, and, where feasible, repeated morning measurements.

Cortisol and HPA dysregulation in psychosis: How much is stress involved?

Cortisol is commonly viewed as a biomarker of stress and HPA-axis activity, yet the extent to which psychosocial stress directly contributes to cognitive impairment in psychosis remains unclear. Although stress exposure features prominently in models of psychosis, evidence linking HPA-axis abnormalities to perceived or chronic stress has been inconsistent (Aas et al., 2011; Cullen et al., 2020). Nevertheless, diathesis–stress models propose that stress-related neurobiological processes may influence cognition through alterations in dopaminergic, inflammatory, and hippocampal–prefrontal pathways (Howes & McCutcheon, 2017; Niwa et al., 2013; Pruessner et al., 2017).

The present findings do not permit conclusions about the role of stress per se, as cortisol may reflect biological processes beyond psychosocial stress. Moreover, HPA-axis dysregulation may arise from factors intrinsic to psychosis, including genetic vulnerability, neurodevelopmental alterations, medication effects, and chronic illness burden. Accordingly, the observed cortisol–cognition associations should not be interpreted as evidence that stress directly causes cognitive impairment. Rather, they suggest that HPA-axis dysregulation may represent one component of a broader neurobiological network associated with cognitive dysfunction in psychosis. Future studies combining cortisol measures with direct assessments of stress exposure and stress reactivity may help clarify the contribution of stress-related processes to cognitive impairment in this population.

Limitations and future research

The present systematic review and meta-analysis provides the first quantitative synthesis of associations between basal cortisol and cognitive functioning in psychosis, while also examining the potential moderating role of cortisol sampling time across specific cognitive domains. Several strengths enhance confidence in the findings. First, we used three-level meta-analytic models to account for the dependence arising from multiple effect sizes contributed by individual studies, thereby avoiding the loss of information associated with conventional averaging approaches. Second, the principal findings remained robust across multiple sensitivity analyses, including alternative analytic strategies, exclusion of saliva-based cortisol studies, and adjustment for potentially influential studies. Third, the convergence between the quantitative meta-analytic findings and the broader narrative synthesis strengthens the overall interpretation of the evidence base.

Nevertheless, several limitations should be acknowledged. Although we adhered to recommended methodological guidance regarding the minimum number of studies required for meta-analysis (Cheung, 2019; Myung, 2023), the relatively small evidence base limited statistical power and contributed to wide confidence intervals, particularly in moderator and domain-specific analyses. The observed effect sizes were also modest. However, this is not unexpected given the multifactorial nature of psychosis and its substantial clinical and etiological heterogeneity, where any single biological factor is unlikely to account for a large proportion of variance in cognitive functioning. In addition, substantial heterogeneity was observed in several models, reflecting the methodological and clinical diversity of the available literature. The small number of studies also limited the ability to evaluate publication bias and prevented a systematic examination of cortisol measures beyond basal cortisol, such as the cortisol awakening response and diurnal cortisol slope, both of which may be relevant to cognitive functioning in psychosis (Haussler et al., 2025).

An additional limitation concerns the grouping of attention, working memory, and processing speed into a single AWP domain. Although these constructs are theoretically distinct and this approach may have obscured more specific associations with cortisol, many neuropsychological measures used in psychosis research draw on overlapping attentional, working-memory, and processing-speed processes and cannot be readily assigned to a single domain. As such, the broader AWP classification may provide a more ecologically valid representation of the cognitive constructs assessed across studies while facilitating meaningful quantitative synthesis.

Finally, we did not formally adjust for multiple comparisons because the domain-specific and sampling-time analyses were not conceptualised as tests of a single omnibus null hypothesis (García-Pérez, 2023). Moreover, given the modest evidence base, strict multiplicity correction would have increased the risk of Type II errors and potentially obscured meaningful associations. Nevertheless, given the number of cognitive endpoints and stratified analyses performed, statistically significant findings should be interpreted cautiously and viewed as hypothesis-generating pending replication.

Future research should investigate cortisol–cognition associations across different stages of psychosis, from the premorbid and prodromal phases to chronic illness (Kristensen et al., 2024). Longitudinal studies may help clarify the temporal relationship between HPA-axis dysregulation and cognitive impairment, while identifying opportunities for early intervention.

Further work should incorporate more precise assessments of cortisol dynamics, including repeated morning sampling, the cortisol awakening response, and diurnal cortisol slopes. Given the domain- and sampling-time-specific associations observed in the present review, future studies should also examine whether different cognitive domains are differentially sensitive to distinct aspects of HPA-axis functioning. Larger, methodologically rigorous studies will be essential to establish the robustness and clinical relevance of cortisol–cognition associations in psychosis.

Conclusion

Overall, this review provides the first quantitative synthesis of cortisol–cognition associations in psychosis and suggests that these relationships may be both domain- and sampling-time-specific. The most robust finding was a negative association between afternoon/evening cortisol and executive functioning, supporting a potential role for HPA-axis dysregulation in cognitive impairment. Sensitivity analyses also identified a negative association between morning cortisol and attention, working memory and processing

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speed, although this finding requires replication. Future studies using more precise cortisol assessments will be important for clarifying how cortisol dynamics relate to cognitive functioning across psychotic disorders.

Supplementary material. The supplementary material for this article can be found at http://doi.org/10.1017/S0033291726106266.

Author contribution. Conceptualisation: E.K.; Data curation: E.K., H.Z.C., J.X.M.Y.; Formal analysis: E.K., H.Z.C., J.X.M.Y.; Investigation: E.K., H.Z.C., J.X.M.Y.; Methodology: E.K., H.Z.C., J.X.M.Y., S.M.H.; Software: F.I., H.Z.C., J.X.M.Y.; Supervision: E.K.; Validation: C.M.P., R.M.M., S.M.H.; Visualisation: H.Z.C., J.X.M.Y.; Writing – original draft preparation: E.K., H.Z.C., J.X.M.Y.; Writing – review & editing: C.M.P., E.K., F.I., H.Z.C., J.X.M.Y., R.M.M., S.M.H.

Funding statement. E.K. and R.M.M. are supported by the NIHR Maudsley Biomedical Research Centre at South London and Maudsley National Health Service (NHS) Foundation Trust and King's College London.

Competing interests. The authors declare no potential conflict of interest.

References

Aas, M., Dazzan, P., Mondelli, V., Melle, I., Murray, R. M., & Pariante, C. M. (2014). A systematic review of cognitive function in first-episode psychosis, including a discussion on childhood trauma, stress, and inflammation. *Frontiers in Psychiatry*, **4**. https://doi.org/10.3389/fpsyt.2013.00182

Aas, M., Dazzan, P., Mondelli, V., Toulopoulou, T., Reichenberg, A., Di Forti, M., Fisher, H. L., Handley, R., Hepgul, N., Marques, T., Miorelli, A., Taylor, H., Russo, M., Wiffen, B., Papadopoulos, A., Aitchison, K. J., Morgan, C., Murray, R. M., & Pariante, C. M. (2011). Abnormal cortisol awakening response predicts worse cognitive function in patients with first-episode psychosis. *Psychological Medicine*, **41**(3), 463–476. https://doi.org/10.1017/S0033291710001170

Aas, M., Pizzagalli, D. A., Laskemoen, J. F., Reponen, E. J., Ueland, T., Melle, I., Agartz, I., Steen, N. E., & Andreassen, O. A. (2019). Elevated hair cortisol is associated with childhood maltreatment and cognitive impairment in schizophrenia and in bipolar disorders. *Schizophrenia Research*, **213**, 65–71. https://doi.org/10.1016/j.schres.2019.01.011

Allott, K. A., Yuen, H. P., Bartholomeusz, C. F., Rapado-Castro, M., Phassouliotis, C., Butselaar, F., Wood, S. J., Proffitt, T.-M., Savage, G., Phillips, L. J., Bendall, S., Markulev, C., Reniers, R. L. E. P., Pantelis, C., Baldwin, L., McGorry, P. D., & Garner, B. (2018). Stress hormones and verbal memory in young people over the first 12 weeks of treatment for psychosis. *Psychiatry Research*, **260**, 60–66. https://doi.org/10.1016/j.psychres.2017.11.044

Arnsten, A. F. T. (2009). Stress signalling pathways that impair prefrontal cortex structure and function. *Nature Reviews Neuroscience*, **10**(6), 410–422. https://doi.org/10.1038/nrn2648

Berger, M., Kraeuter, A. K., Romanik, D., Malouf, P., Amminger, G. P., & Sarnyai, Z. (2016). Cortisol awakening response in patients with psychosis: Systematic review and meta-analysis. *Neuroscience & Biobehavioral Reviews*, **68**, 157–166. https://doi.org/10.1016/j.neubiorev.2016.05.027

Bora, E., Binnur Akdede, B., & Alptekin, K. (2017). Neurocognitive impairment in deficit and non-deficit schizophrenia: A meta-analysis. *Psychological Medicine*, **47**(14), 2401–2413. https://doi.org/10.1017/S0033291717000952

Bora, E., Yücel, M., & Pantelis, C. (2009). Cognitive functioning in schizophrenia, schizoaffective disorder and affective psychoses: Meta-analytic study. *British Journal of Psychiatry*, **195**(6), 475–482. https://doi.org/10.1192/bjp.bp.108.055731

Bora, E., Yücel, M., & Pantelis, C. (2010). Cognitive impairment in affective psychoses: A meta-analysis. *Schizophrenia Bulletin*, **36**(1), 112–125. https://doi.org/10.1093/schbul/sbp093

Borges, S., Gayer-Anderson, C., & Mondelli, V. (2013). A systematic review of the activity of the hypothalamic–pituitary–adrenal axis in first episode psychosis. *Psychoneuroendocrinology*, **38**(5), 603–611. https://doi.org/10.1016/j.psyneuen.2012.12.025

Cerqueira, J. J., Almeida, O. F. X., & Sousa, N. (2008). The stressed prefrontal cortex. Left? Right! *Brain, Behavior, and Immunity*, **22**(5), 630–638. https://doi.org/10.1016/j.bbi.2008.01.005

Cerqueira, J. J., Mailliet, F., Almeida, O. F. X., Jay, T. M., & Sousa, N. (2007). The prefrontal cortex as a key target of the maladaptive response to stress. *The Journal of Neuroscience*, **27**(11), 2781–2787. https://doi.org/10.1523/jneurosci.4372-06.2007

Cherian, K., Schatzberg, A. F., & Keller, J. (2019). HPA axis in psychotic major depression and schizophrenia spectrum disorders: Cortisol, clinical symptomatology, and cognition. *Schizophrenia Research*, **213**, 72–79. https://doi.org/10.1016/j.schres.2019.07.003

Cheung, M. W. L. (2015). metaSEM: An R package for meta-analysis using structural equation modeling. *Frontiers in Psychology*, **5**. https://doi.org/10.3389/fpsyg.2014.01521

Cheung, M. W. L. (2019). A guide to conducting a meta-analysis with non-independent effect sizes. *Neuropsychology Review*, **29**(4), 387–396. https://doi.org/10.1007/s11065-019-09415-6

Chrousos, G. P. (2000). Stress, chronic inflammation, and emotional and physical well-being: Concurrent effects and chronic sequelae. *Journal of Allergy and Clinical Immunology*, **106**(5), S275–S291. https://doi.org/10.1067/mai.2000.110163

Cullen, A. E., Rai, S., Vaghani, M. S., Mondelli, V., & McGuire, P. (2020). Cortisol responses to naturally occurring psychosocial stressors across the psychosis Spectrum: A systematic review and meta-analysis. *Frontiers in Psychiatry*, **11**. https://doi.org/10.3389/fpsyt.2020.00513

Engert, V., Efanov, S. I., Dedovic, K., Dagher, A., & Pruessner, J. C. (2011). Increased cortisol awakening response and afternoon/evening cortisol output in healthy young adults with low early life parental care. *Psychopharmacology*, **214**(1), 261–268. https://doi.org/10.1007/s00213-010-1918-4

Evans, P. D., Fredhoi, C., Loveday, C., Hucklebridge, F., Aitchison, E., Forte, D., & Clow, A. (2011). The diurnal cortisol cycle and cognitive performance in the healthy old. *International Journal of Psychophysiology*, **79**(3), 371–377. https://doi.org/10.1016/j.ijpsycho.2010.12.006

Fatouros-Bergman, H., Cervenka, S., Flyckt, L., Edman, G., & Farde, L. (2014). Meta-analysis of cognitive performance in drug-naïve patients with schizophrenia. *Schizophrenia Research*, **158**(1-3), 156–162. https://doi.org/10.1016/j.schres.2014.06.034

Fisher, Z., Tipton, E., & Zhipeng, H. (2023). *robumeta: Robust Variance Meta-Regression*. In (Version 2.1) https://cran.r-project.org/web/packages/robumeta/index.html

Gamble, K. L., Berry, R., Frank, S. J., & Young, M. E. (2014). Circadian clock control of endocrine factors. *Nature Reviews Endocrinology*, **10**(8), 466–475. https://doi.org/10.1038/nrendo.2014.78

García-Pérez, M. A. (2023). Use and misuse of corrections for multiple testing. *Methods in Psychology*, **8**, 100120. https://doi.org/10.1016/j.metip.2023.100120

Giovanoli, S., Engler, H., Engler, A., Richetto, J., Voget, M., Willi, R., Winter, C., Riva, M. A., Mortensen, P. B., Feldon, J., Schedlowski, M., & Meyer, U. (2013). Stress in puberty unmasks latent neuropathological consequences of prenatal immune activation in mice. *Science*, **339**(6123), 1095–1099. https://doi.org/10.1126/science.1228261

Girshkin, L., Matheson, S. L., Shepherd, A. M., & Green, M. J. (2014). Morning cortisol levels in schizophrenia and bipolar disorder: A meta-analysis. *Psychoneuroendocrinology*, **49**, 187–206. https://doi.org/10.1016/j.psyneuen.2014.07.013

Green, M. F., Horan, W. P., & Lee, J. (2019). Nonsocial and social cognition in schizophrenia: Current evidence and future directions. *World Psychiatry*, **18**(2), 146–161. https://doi.org/10.1002/wps.20624

Harbord, R. M., Egger, M., & Sterne, J. A. C. (2006). A modified test for small-study effects in meta-analyses of controlled trials with binary endpoints. *Statistics in Medicine*, **25**(20), 3443–3457. https://doi.org/10.1002/sim.2380

Haussler, S. M., Zahid, U., Day, F., Ciufolini, S., Petros, N., Gifford, G., Alameda, L., Quattrone, D., Dazzan, P., Pariante, C., Fisher, H. L., Laurens, K. R., Di Forti, M., Wood, S. J., Murray, R. M., McGuire, P., Mondelli, V., & Cullen, A. E. (2025). Salivary cortisol measures across the clinical stages of psychosis: An individual participant data (IPD) meta-analysis. *Psychoneuroendocrinology*, **173**, 107283. https://doi.org/10.1016/j.psyneuen.2025.107283

Havelka, D., Prikrylova-Kucerova, H., Prikryl, R., & Ceskova, E. (2016). Cognitive impairment and cortisol levels in first-episode schizophrenia patients. *Stress*, **19**(4), 383–389. https://doi.org/10.1080/10253890.2016.1193146

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Hedges, L. V., Tipton, E., & Johnson, M. C. (2010). Robust variance estimation in meta-regression with dependent effect size estimates. *Research Synthesis Methods*, **1**(1), 39–65. https://doi.org/10.1002/jrsm.5

Heinrichs, R. W., & Zakzanis, K. K. (1998). Neurocognitive deficit in schizophrenia: A quantitative review of the evidence. *Neuropsychology*, **12**(3), 426–445. https://doi.org/10.1037/0894-4105.12.3.426

Higgins, J. P., Thompson, S. G., Deeks, J. J., & Altman, D. G. (2003). Measuring inconsistency in meta-analyses. *BMJ*, **327**(7414), 557–560. https://doi.org/10.1136/bmj.327.7414.557

Howes, O. D., & McCutcheon, R. (2017). Inflammation and the neural diathesis-stress hypothesis of schizophrenia: A reconceptualization. *Translational Psychiatry*, **7**(2), e1024–e1024. https://doi.org/10.1038/tp.2016.278

Inova, A., Birkenæs, V., Quintana, D. S., Ormerod, M. B. E. G., Ueland, T., Ueland, T., Djurovic, S., Andreassen, O., Steen, N. E., & Aas, M. (2025). Cortisol and C-reactive protein (CRP) regulation in severe mental disorders. *Psychoneuroendocrinology*, **172**, 107272. https://doi.org/10.1016/j.psyneuen.2024.107272

Jarraya, S., Jarraya, M., Chtourou, H., & Souissi, N. (2014). Diurnal variations on cognitive performances in handball goalkeepers. *Biological Rhythm Research*, **45**(1), 93–101. https://doi.org/10.1080/09291016.2013.811032

Karanikas, E., Antoniadis, D., & Garyfallos, G. D. (2014). The role of cortisol in first episode of psychosis: A systematic review. *Current Psychiatry Reports*, **16**(11), 503. https://doi.org/10.1007/s11920-014-0503-7

Knight, S., McCutcheon, R., Dwir, D., Grace, A. A., O'Daly, O., McGuire, P., & Modinos, G. (2022). Hippocampal circuit dysfunction in psychosis. *Translational Psychiatry*, **12**(1), 344. https://doi.org/10.1038/s41398-022-02115-5

Knytl, P., Voráčková, V., Dorazilová, A., Rodriguez, M., Cvrčková, A., Kofroňová, E., Kuchař, M., Kratochvílová, Z., Šustová, P., Čerešňáková, S., & Mohr, P. (2019). Neuroactive steroids and cognitive functions in first-episode psychosis patients and their healthy siblings. *Frontiers in Psychiatry*, **10**. https://doi.org/10.3389/fpsyt.2019.00390

Kristensen, T. D., Mager, F. M., Ambrosen, K. S., Barber, A. D., Lemvigh, C. K., Bojesen, K. B., Nielsen, M. Ø., Fagerlund, B., Glenthøj, B. Y., Syeda, W. T., Glenthøj, L. B., & Ebdrup, B. H. (2024). Cognitive profiles across the psychosis continuum. *Psychiatry Research*, **342**, 116168. https://doi.org/10.1016/j.psychres.2024.116168

Krkovic, K., Moritz, S., & Lincoln, T. M. (2017). Neurocognitive deficits or stress overload: Why do individuals with schizophrenia show poor performance in neurocognitive tests? *Schizophrenia Research*, **183**, 151–156. https://doi.org/10.1016/j.schres.2016.11.002

Labad, J. (2019). The role of cortisol and prolactin in the pathogenesis and clinical expression of psychotic disorders. *Psychoneuroendocrinology*, **102**, 24–36. https://doi.org/10.1016/j.psyneuen.2018.11.028

Labad, J., Gutiérrez-Zotes, A., Creus, M., Montalvo, I., Cabezas, Á., Solé, M., Ortega, L., Algora, M. J., Sánchez-Gistau, V., & Vilella, E. (2016). Hypothalamic-pituitary-adrenal axis measures and cognitive abilities in early psychosis: Are there sex differences? *Psychoneuroendocrinology*, **72**, 54–62. https://doi.org/10.1016/j.psyneuen.2016.06.006

Lee, B. K., Glass, T. A., McAtee, M. J., Wand, G. S., Bandeen-Roche, K., Bolla, K. I., & Schwartz, B. S. (2007). Associations of salivary cortisol with cognitive function in the Baltimore memory study. *Archives of General Psychiatry*, **64**(7), 810–818. https://doi.org/10.1001/archpsyc.64.7.810

Lewandowski, K. E., Sperry, S. H., Cohen, B. M., & Öngür, D. (2014). Cognitive variability in psychotic disorders: A cross-diagnostic cluster analysis. *Psychological Medicine*, **44**(15), 3239–3248. https://doi.org/10.1017/S0033291714000774

Li, Y., Jia, W., Yan, N., Hua, Y., Han, T., Yang, J., Ma, L., & Ma, L. (2023). Associations between chronic stress and hair cortisol in children: A systematic review and meta-analysis. *Journal of Affective Disorders*, **329**, 438–447. https://doi.org/10.1016/j.jad.2023.02.123

López-López, J. A., Page, M. J., Lipsey, M. W., & Higgins, J. P. T. (2018). Dealing with effect size multiplicity in systematic reviews and meta-analyses. *Research Synthesis Methods*, **9**(3), 336–351. https://doi.org/10.1002/jrsm.1310

Lupien, S. J., de Leon, M., de Santi, S., Convit, A., Tarshish, C., Nair, N. P. V., Thakur, M., McEwen, B. S., Hauger, R. L., & Meaney, M. J. (1998). Cortisol levels during human aging predict hippocampal atrophy and memory deficits. *Nature Neuroscience*, **1**(1), 69–73. https://doi.org/10.1038/271

Lupien, S. J., Juster, R.-P., Raymond, C., & Marin, M.-F. (2018). The effects of chronic stress on the human brain: From neurotoxicity, to vulnerability, to opportunity. *Frontiers in Neuroendocrinology*, **49**, 91–105. https://doi.org/10.1016/j.yfrne.2018.02.001

McCutcheon, R. A., Keefe, R. S. E., & McGuire, P. K. (2023). Cognitive impairment in schizophrenia: Aetiology, pathophysiology, and treatment. *Molecular Psychiatry*, **28**(5), 1902–1918. https://doi.org/10.1038/s41380-023-01949-9

McEwen, B. S. (1999). Stress and hippocampal plasticity. *Annual Review of Neuroscience*, **22**(1), 105–122. https://doi.org/10.1146/annurev.neuro.22.1.105

McEwen, B. S., & Stellar, E. (1993). Stress and the individual: Mechanisms leading to disease. *Archives of Internal Medicine*, **153**(18), 2093–2101. https://doi.org/10.1001/archinte.1993.00410180039004

Mesholam-Gately, R. I., Giuliano, A. J., Goff, K. P., Faraone, S. V., & Seidman, L. J. (2009). Neurocognition in first-episode schizophrenia: A meta-analytic review. *Journal of Neuropsychology*, **23**(3), 315–336. https://doi.org/10.1037/a0014708

Millgate, E., Hide, O., Lawrie, S. M., Murray, R. M., MacCabe, J. H., & Kravariti, E. (2022). Neuropsychological differences between treatment-resistant and treatment-responsive schizophrenia: A meta-analysis. *Psychological Medicine*, **52**(1), 1–13. https://doi.org/10.1017/S0033291721004128

Misiak, B., Piotrowski, P., Chęć, M., & Samochowiec, J. (2021). Cortisol and dehydroepiandrosterone sulfate in patients with schizophrenia spectrum disorders with respect to cognitive performance. *Comprehensive Psychoneuroendocrinology*, **6**, 100041. https://doi.org/10.1016/j.cpnec.2021.100041

Mondelli, V., Pariante, C. M., Navari, S., Aas, M., D'Albenzio, A., Di Forti, M., Handley, R., Hepgul, N., Marques, T. R., Taylor, H., Papadopoulos, A. S., Aitchison, K. J., Murray, R. M., & Dazzan, P. (2010). Higher cortisol levels are associated with smaller left hippocampal volume in first-episode psychosis. *Schizophrenia Research*, **119**(1-3), 75–78. https://doi.org/10.1016/j.schres.2009.12.021

Munnilari, M., Bommasamudram, T., Easow, J., Tod, D., Varamenti, E., Edwards, B. J., Ravindrakumar, A., Gallagher, C., & Pullinger, S. A. (2024). Diurnal variation in variables related to cognitive performance: A systematic review. *Sleep and Breathing*, **28**(1), 495–510. https://doi.org/10.1007/s11325-023-02895-0

Myung, S.-K. (2023). How to review and assess a systematic review and meta-analysis article: A methodological study (secondary publication). *Journal of Educational Evaluation for Health Professions*, **20**(24). https://doi.org/10.3352/jeehp.2023.20.24

Niwa, M., Jaaro-Peled, H., Tankou, S., Seshadri, S., Hikida, T., Matsumoto, Y., Cascella, N. G., Kano, S.-i., Ozaki, N., Nabeshima, T., & Sawa, A. (2013). Adolescent stress–induced epigenetic control of dopaminergic neurons via glucocorticoids. *Science*, **339**(6117), 335–339. https://doi.org/10.1126/science.1226931

O'Byrne, N. A., Yuen, F., Butt, W. Z., & Liu, P. Y. (2021). Sleep and circadian regulation of cortisol: A short review. *Current Opinion in Endocrine and Metabolic Research*, **18**, 178–186. https://doi.org/10.1016/j.coemr.2021.03.011

Page, M. J., McKenzie, J. E., Bossuyt, P. M., Boutron, I., Hoffmann, T. C., Mulrow, C. D., Shamseer, L., Tetzlaff, J. M., Akl, E. A., Brennan, S. E., Chou, R., Glanville, J., Grimshaw, J. M., Hróbjartsson, A., Lalu, M. M., Li, T., Loder, E. W., Mayo-Wilson, E., McDonald, S., … Moher, D. (2021). The PRISMA 2020 statement: An updated guideline for reporting systematic reviews. *BMJ*, **372**, n71. https://doi.org/10.1136/bmj.n71

Pillinger, T., D'Ambrosio, E., McCutcheon, R., & Howes, O. D. (2019). Is psychosis a multisystem disorder? A meta-review of central nervous system, immune, cardiometabolic, and endocrine alterations in first-episode psychosis and perspective on potential models. *Molecular Psychiatry*, **24**(6), 776–794. https://doi.org/10.1038/s41380-018-0058-9

Pruessner, M., Cullen, A. E., Aas, M., & Walker, E. F. (2017). The neural diathesis-stress model of schizophrenia revisited: An update on recent findings considering illness stage and neurobiological and methodological complexities. *Neuroscience & Biobehavioral Reviews*, **73**, 191–218. https://doi.org/10.1016/j.neubiorev.2016.12.013

Radley, J. J., Sisti, H. M., Hao, J., Rocher, A. B., McCall, T., Hof, P. R., McEwen, B. S., & Morrison, J. H. (2004). Chronic behavioral stress induces apical dendritic reorganization in pyramidal neurons of the medial prefrontal cortex. *Neuroscience*, **125**(1), 1–6. https://doi.org/10.1016/j.neuroscience.2004.01.006

Reeve, S., Sheaves, B., & Freeman, D. (2015). The role of sleep dysfunction in the occurrence of delusions and hallucinations: A systematic review. *Clinical Psychology Review*, **42**, 96–115. https://doi.org/10.1016/j.cpr.2015.09.001

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Reichenberg, A., & Harvey, P. D. (2007). Neuropsychological impairments in schizophrenia: Integration of performance-based and brain imaging findings. *Psychological Bulletin.*, **133**(5), 833–858. https://doi.org/10.1037/0033-2909.133.5.833

Schaefer, J., Giangrande, E., Weinberger, D. R., & Dickinson, D. (2013). The global cognitive impairment in schizophrenia: Consistent over decades and around the world. *Schizophrenia Research*, **150**(1), 42–50. https://doi.org/10.1016/j.schres.2013.07.009

Sheffield, J. M., Karcher, N. R., & Barch, D. M. (2018). Cognitive deficits in psychotic disorders: A lifespan perspective. *Neuropsychology Review*, **28**(4), 509–533. https://doi.org/10.1007/s11065-018-9388-2

Tipton, E. (2015). Small sample adjustments for robust variance estimation with meta-regression. *Psychological Methods*, **20**(3), 375–393. https://doi.org/10.1037/met0000011

Tipton, E., & Pustejovsky, J. E. (2015). Small-sample adjustments for tests of moderators and model fit using robust variance estimation in meta-regression. *Journal of Educational and Behavioral Statistics*, **40**(6), 604–634. https://doi.org/10.3102/1076998615606099

Tufanaru, C., Munn, Z., Stephenson, M., & Aromataris, E. (2015). Fixed or random effects meta-analysis? Common methodological issues in systematic reviews of effectiveness. *JBI Evidence Implementation*, **13**(3), 196–207. https://doi.org/10.1097/xeb.0000000000000065

Varese, F., Smeets, F., Drukker, M., Lieverse, R., Lataster, T., Viechtbauer, W., Read, J., van Os, J., & Bentall, R. P. (2012). Childhood adversities increase the risk of psychosis: A meta-analysis of patient-control, prospective- and cross-sectional cohort studies. *Schizophrenia Bulletin*, **38**(4), 661–671. https://doi.org/10.1093/schbul/sbs050

Viechtbauer, W. (2010). Conducting meta-analyses R with the metafor package. *Journal of Statistical Software*, **36**(3), 1–48. https://doi.org/10.18637/jss.v036.i03

Viechtbauer, W., & Cheung, M. W.-L. (2010). Outlier and influence diagnostics for meta-analysis. *Research Synthesis Methods*, **1**(2), 112–125. https://doi.org/10.1002/jrsm.11

von Hippel, P. T. (2015). The heterogeneity statistic I2 can be biased in small meta-analyses. *BMC Medical Research Methodology*, **15**(1), 35. https://doi.org/10.1186/s12874-015-0024-z

Walder, D. J., Walker, E. F., & Lewine, R. J. (2000). Cognitive functioning, cortisol release, and symptom severity in patients with schizophrenia. *Biological Psychiatry*, **48**(12), 1121–1132. https://doi.org/10.1016/S0006-3223(00)01052-0

Walker, E. F., & Diforio, D. (1997). Schizophrenia: A neural diathesis-stress model. *Psychological Review*, **104**(4), 667–685. https://doi.org/10.1037/0033-295x.104.4.667

Walker, E. F., Mittal, V., & Tessner, K. (2008). Stress and the hypothalamic pituitary adrenal Axis in the developmental course of schizophrenia. *Annual Review of Clinical Psychology*, **4**(1), 189–216. https://doi.org/10.1146/annurev.clinpsy.4.022007.141248

Yazici, E., Ogur, Y. S., Erdogan, D. G., Turkmen, B. A., & Yazici, A. B. (2025). Evaluation of CRH, ACTH, cortisol, and chromogranin levels in the acute stage of schizophrenia. *Clinical Medicine & Research*, **23**(1), 11–20. https://doi.org/10.3121/cmr.2025.1930

Zorn, J. V., Schür, R. R., Boks, M. P., Kahn, R. S., Joëls, M., & Vinkers, C. H. (2017). Cortisol stress reactivity across psychiatric disorders: A systematic review and meta-analysis. *Psychoneuroendocrinology*, **77**, 25–36. https://doi.org/10.1016/j.psyneuen.2016.11.036

Zuur, A. F., Ieno, E. N., Walker, N. J., Saveliev, A. A., Smith, G. M., Zuur, A. F., Ieno, E. N., Walker, N. J., Saveliev, A. A., & Smith, G. M. (2009). Mixed effects modelling for nested data. In A. F. Zuur, E. N. Ieno, N. Walker, A. A. Saveliev, & G. M. Smith (Eds.), *Mixed effects models and extensions in ecology with R* (pp. 101–142). Springer. https://doi.org/10.1007/978-0-387-87458-6_5

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