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Investigating the Presence of Autistic Traits and Prevalence of Autism Spectrum Disorder Symptoms in Anorexia Nervosa: A Systematic Review and Meta-Analysis

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ABSTRACT

Objective: The present meta-analysis aims to assess whether individuals with anorexia nervosa (AN) demonstrate elevated autistic traits, to explore potential associations between autistic traits and eating disorder symptoms; as well as to estimate the prevalence of a positive screen for autism spectrum disorder (ASD) assessed via Autism Diagnostic Observation Schedule (ADOS), in AN.

Method: A systematic literature search was conducted in PsycINFO, MEDLINE, and Web of Science in August 2023 and later updated in April 2024 to identify relevant studies. Twenty-two studies with 1172 AN patients and 2747 healthy controls (HCs) met the inclusion criteria.

Results: There was a significant difference between AN and HC groups in autistic traits ($g = 0.88$, CI = 0.65–1.12), and a significant but modest correlation was found between autistic traits and severity of eating disorder symptoms ($r = 0.28$, CI = 0.11–0.44). Proportion meta-analysis indicated that 29% (CI = 0.19–0.38) of children and adults scored above the cut-off for ASD.

Discussion: The current findings suggest that AN frequently overlaps with both autistic traits and autistic symptomatology. Therefore, it is essential to evaluate autism and autistic traits in individuals with AN to tailor individualized treatment plans.

1 | Introduction

Anorexia nervosa (AN), as defined by the American Psychiatric Association, is a severe eating disorder (ED) characterized by low body weight, restricted caloric intake, an obsessive fear of weight gain, and disturbances in body shape perception (APA 2013). With the diagnostic criteria revised for the Fifth Edition of the Diagnostic and Statistical Manual, the lifetime prevalence of AN was reported to have risen from 2.2% to 3.6% (Mustelin et al. 2016), with a lifetime prevalence of 0.1% to 3.6% in females and 0% to 0.3% in males (Galmiche et al. 2019). AN stands to be a significant concern within psychiatry, bearing high morbidity along with functional impairments and high relapse rates (Eddy et al. 2017), as well as the highest mortality in EDs (Arcelus et al. 2011; van Eeden, van Hoeken, and Hoek 2021; van Hoeken and Hoek 2020). AN predominantly

Summary

- The present meta-analysis reveals a significant association between anorexia nervosa and autistic traits, suggesting a potential link between these conditions.
- Individuals with anorexia nervosa exhibit higher levels of autistic traits compared with the general population, and there is an overrepresentation of autism spectrum disorder (ASD) among those with anorexia nervosa.
- There is a mild yet notable correlation between autistic traits and symptom severity of eating disorders.
- These findings highlight the importance of considering the intersection between neurodevelopmental conditions and eating disorders, offering insights that could inform more tailored and effective interventions for those affected.

affects females rather than males and typically emerges during adolescence, although recent literature indicates a decrease in the age at which diagnosis is made (Puckett et al. 2021; van Eeden, van Hoeken, and Hoek 2021).

In contrast, autism spectrum disorder (ASD) is a neurodevelopmental condition characterized by cognitive, social, and behavioral challenges that typically emerge during early childhood. Diagnosis requires the presence of symptoms such as impaired social communication, restricted interests, repetitive behaviors, and sensory abnormalities during the course of neurodevelopment, sometimes as early as infancy (APA 2013). The estimated ASD prevalence was 27.6 per 1000, corresponding to one in 36 children, with prevalence among boys being 3.8 times as high as among girls in a recent surveillance study by the Centers for Disease Control and Prevention (Maenner 2023). Key features of ASD include challenges in social interaction and communication, repetitive behaviors, and narrow interests or activities (APA 2013). Additionally, certain eating behaviors like food selectivity with resultant weight gain and obesity or significant weight loss and nutritional deficiencies are commonly associated symptoms (Baraskewich et al. 2021; Chistol et al. 2018).

In a recent study in the United States, eating difficulties and atypical eating behaviors have been documented in up to 70.4% of children with neurodevelopmental disorders who were referred to a child and adolescent psychiatry clinic, contrasting with 4.8% of children in the general population who were recruited as a standardization sample from various sites in the United States (Mayes and Zickgraf 2019). However, ASD encompasses a diverse diagnostic group, spanning individuals across a wide spectrum of functioning and intellectual abilities. Individuals on the autism spectrum can exhibit extremes across the weight spectrum as well (Li et al. 2020), showing variability from underweight (Kahathuduwa et al. 2022) to overweight (Thom et al. 2022), highlighting the broad range of eating disparities within this population. Conversely, there is an overrepresentation of autistic traits (Westwood et al. 2016) and autistic symptoms in individuals with AN (Westwood et al. 2018) with a longitudinal study including 51 adolescent-onset anorexia patients and matched controls, spanning 18 years, reporting 27.4% of individuals with AN to have comorbid ASD (Anckarsäter et al. 2012). Huke et al. (2013) report a relatively similar rate of 22.9% of comorbid ASD in individuals with EDs.

Although presently, AN and ASD are distinct diagnostic categories, the correlation between autism and anorexia may stem from a shared genetic susceptibility that interacts with environmental influences, contributing to both disordered eating and autistic symptoms. An underlying genetic vulnerability linking the two disorders was initially suggested by Gillberg (1983) based on clinical observations in which he noted that the female cousins of his male patients with ASD were diagnosed with AN. Following this paper, an uncontrolled case study was conducted, concluding that 4 out of 51 adolescents with AN displayed the core diagnostic features of ASD (Gillberg and Råstam 1992), which also incidentally laid the foundations of an 18-year-long longitudinal study (Nielsen et al. 2015).

Over the past decade, research has increasingly highlighted the heightened occurrence of comorbid autistic symptoms among individuals with AN (Huke et al. 2013; Westwood and Tchanturia 2017). Moreover, specific parallels have been observed in terms of neuropsychological profiles, such as executive functions and central coherence (Oldershaw et al. 2011) alongside challenges in attention-switching, perspective-taking, and theory of mind tasks (Courty et al. 2013; Fuglset 2019). In addition to this, affected socioemotional domains such as difficulties in emotion recognition, empathic abilities, and emotional introspection (Hambrook et al. 2008; Kerr-Gaffney, Harrison, and Tchanturia 2020; Kerr-Gaffney et al. 2020; Saure et al. 2022) are postulated to ultimately result in pronounced rigidity in social interactions to facilitate sameness and reduce unpredictability, influenced by underlying genetic factors and triggered by the neurodevelopmental environment (Westwood and Tchanturia 2017; Zhou, McAdam, and Donnelly 2018). Thus, disordered eating patterns might stem from sensory sensitivities, emotional struggles, autistic cognitive patterns, a need for control and predictability, or a combination of these elements (Brede et al. 2020). Consequently, autism and AN may be more intricately linked than initially assumed through the multifaceted interplay of cognitive, social, and emotional functioning, which could impact the initiation and persistence of restricted eating behaviors.

In light of this emerging literature on autistic symptomatology in AN, the objectives of this meta-analysis were: (1) to investigate whether individuals with AN exhibit higher levels of self-reported autistic traits compared with healthy controls (HCs); (2) to explore the correlation between autistic traits and symptoms related to EDs; (3) to assess the prevalence and probability of ASD in individuals with AN; and (4) to identify how other factors such as gender, age, and body mass index (BMI) impact autistic symptomatology in AN.

2 | Methods

2.1 | Study Selection

The "preferred reporting items for systematic reviews and meta-analyses" (PRISMA) (Liberati et al. 2009; Page et al. 2021) and meta-analysis of observational studies in epidemiology

(MOOSE) (Stroup et al. 2000) guidelines were followed for this meta-analysis. The literature search was conducted in August 2023 and updated in April 2024 to include relevant studies from 1980 onwards. This year was chosen to encompass study papers around the time of Gillberg's seminal 1983 paper titled "Are autism and anorexia related," which catalyzed discussions on the presentation of autism and autistic traits in females with anorexia. Following keywords AN ("anorexia" OR AN) and ASD (ASD OR "Autis*") were used to identify articles in PsycINFO, MEDLINE, and Web of Science databases in all available languages. Abstracts written in English that met the eligibility criteria were reviewed for suitability. The reference lists of included studies were assessed to identify additional research not initially found in the electronic database search.

Initially, duplicate articles were eliminated. Researchers (I.I.K. and N.D.) independently conducted the screening process and performed data extraction. Discrepancies were resolved through discussion regarding the inclusion or exclusion of certain manuscripts. If a consensus could not be reached, the article in question was referred to the supervising author (EB).

For the present systematic review and meta-analysis, studies that were (1) published in English; (2) examining autistic traits in individuals with AN utilizing the Autism-Spectrum Quotient (AQ); or exploring the AN-ASD comorbidity using gold standard diagnostic measures (Autism Diagnostic Observation Schedule [ADOS] and Autism Diagnostic Observation Schedule, second edition [ADOS-2]); (3) in either a cross-sectional or longitudinal design; (4) including individuals with AN of all age groups; (5) regardless of disease onset or recovery state, were included. Scientific articles regarding comorbidities with other pathologies or evaluating the efficacy of specific treatments were thus excluded. Articles employing alternative measures of autistic traits were also excluded in order to reduce heterogeneity, particularly considering the limited number of studies utilizing these measures. Studies that assessed the same population were not included; among them, one representative article with the highest sample size was included.

3 | Measures

3.1 | Autistic Traits Measures

3.1.1 | AQ

A valid and reliable tool to assess autistic traits, the AQ comprises 50 items, each rated on a 4-point Likert scale spanning from 1 to 4 (ranging from "strongly agree" to "strongly disagree"). It is structured into five subscales: attention to detail, attention switching, imagination, communication, and social skills. Higher scores in each individual subscale point to higher "atypicality" on that subscale, such as remarkable attention to detail, difficulties in attention switching, communication, social skills, and poor imagination. (Baron-Cohen et al. 2001).

3.1.2 | AQ-10

The AQ-10 is a brief questionnaire designed for either a self-report for adults or parents for adolescents to assess autistic traits. Both versions feature identical items and share a common clinical cut-off, as such, the data from both versions can be pooled and analyzed collectively (Allison, Auyeung, and Baron-Cohen 2012). Both the AQ and its abbreviated version, AQ-10, are reliable measures of autistic traits for adolescents and adults, selected to potentially expand the inclusion of studies across a broader age range without introducing heterogeneity through the use of diverse autistic trait measures.

3.1.3 | ADOS and ADOS-2

ADOS-2 (Hus and Lord 2014) and its predecessor ADOS (Lord et al. 1989, 2000) are semi-structured interviews comprising various questions and activities centered on observing communication and behavior in autistic individuals. Both have standardized severity scores for modules tailored to evaluate children, adolescents, and adults and offer metrics to gauge the severity of ASD symptoms with a sensitivity and specificity exceeding 80%. Although ADOS and ADOS-2 are considered the "gold standard" of autism diagnosis, autism remains a clinical diagnosis. In the present study, studies conducted with ADOS and ADOS-2 to screen for autism in the presence of AN were included in the estimation of the prevalence and likelihood of ASD in AN. Autism remains primarily diagnosed through clinical assessment. However, studies that utilize a semi-structured gold-standard tool, rather than relying solely on DSM-5 criteria or clinical judgment, were included to reduce potential bias in autism diagnosis across diverse clinical settings.

3.2 | Clinical Measures for ED Symptoms

3.2.1 | The EDs Evaluation Questionnaire (EDE-Q)

EDE-Q is a self-report questionnaire comprising 33 items, adapted from the EDE, which is widely regarded as the gold standard for assessing EDs (Fairburn, Cooper, and O'Connor 2008; Fairburn and Cooper 1993). The higher global scores indicate greater severity of these ED symptoms.

3.2.2 | The Eating Attitude Test 26 (EAT-26)

The EAT-26 questionnaire and its child counterpart ChEAT-26 comprise 26 items intended to assess attitudes and behaviors linked with EDs. Responses are recorded on a 5-point Likert scale, ranging from "always" to "never," to gauge overall levels of ED psychopathology. Total scores can range from 0 to 78, with higher scores indicating a more significant degree of eating pathology (Garner et al. 1982; Maloney et al. 1989).

3.2.3 | The ED Inventory (EDI)

EDI is a self-report questionnaire designed to evaluate physical, psychological, and behavioral characteristics typically observed in individuals with EDs. Comprising 91 questions, higher scores on the inventory indicate greater severity of pathology. In cases where a total score was not reported The ED Risk Composite

(EDRC) which comprises the Drive for Thinness, Bulimia, and Body Dissatisfaction subscales, was used (Nyman-Carlsson and Garner 2016).

3.2.4 | The Swedish Eating Assessment for ASDs (SWEAA)

Developed and validated to specifically evaluate eating behaviors commonly observed in ASD individuals, SWEAA has been utilized to demonstrate distinctions in eating behaviors, such as difficulties with eating regarding social mealtime environments between ASD adolescents and young adults with normal cognitive abilities and individuals without ASD (Karlsson, Råstam, and Wentz 2013).

3.3 | Statistical Analyses

Data including effect size measures and demographic and clinical information were extracted from included articles by one of the reviewers (I.I.K. and N.D.) and subsequently cross-checked by the other. In the case of a study (Iwasaki et al. 2013), reporting data for subtypes of AN (restricting and binging-purging), data regarding each subtype were considered independent studies, and the HC count was halved for each entry. In another study (Postorino et al. 2017), two different AQ total scores measured by different AQ scales developed for children (AN = 7, HC = 7) and adults and adolescents (AN = 23, HC = 28) were reported. Only the effect size of AQ adult/adolescent version was extracted due to the low sample size for the children's version. Two studies assessed individuals with AN at multiple time points using AQ10 (Halls et al. 2023; Leppanen et al. 2022). For these studies, the measurements at the T1 point were extracted to ensure the highest possible sample size in the meta-analysis. A meta-analysis for the relevant data was conducted only if effect size measures were available for at least five studies. In other cases, only a qualitative review was conducted.

Mean difference and correlational meta-analyses were performed with ".metafor" package using the langtest.jp developed by (Mizumoto 2015), an R-based web application, to account for differences in effect sizes of autistic traits as measured by AQ and to assess the relationship between autistic traits and ED symptoms as measured by a variety of validated scales, respectively. Considering that AQ10 is a brief assessment instrument, varying performance in capturing autistic traits compared to the AQ is a possibility. A recent study indicates that AQ10 has lower retest reliability and performs worse than AQ in an online setting, particularly in the general population (Cheung et al. 2023). Therefore, we opted to conduct two separate analyses regarding the AQ: one combining AQ10 and AQ, and another using AQ alone. The proportional meta-analysis was performed using JAMOVI 2.4.12 with the MAJOR module (The Jamovi Project 2024) to estimate the rate of AN patients scoring above the cut-off in ADOS across multiple studies. A LogOR meta-analysis was planned, which involves applying the natural logarithm of the odds ratio from studies reporting both patients and controls scoring above the ADOS cutoff to estimate the odds ratio for a positive ASD screen. However, due to the limited number of studies available ($n = 3$), the analysis was not feasible. A qualitative review of these findings was conducted instead. A meta-regression was conducted to examine whether moderators of age, gender, and BMI explained heterogeneity in autistic trait effect sizes among studies with ".metafor" package R version 4.2.0 with the guide provided by (Harrer et al. 2021).

A random-effects model (DerSimonian–Laird estimate) was used and effect sizes (Hedges' g) were weighted using the inverse variance method. Homogeneity of the distribution of weighted effect sizes was tested with the Q and I^2 tests (I^2 values $< 50\%$ indicate low, $I^2 > 50\%$ indicate moderate, and $I^2 > 75\%$ indicate large heterogeneity; reflecting higher variability in effect sizes across the included studies). Publication bias was assessed by both the visual inspection of funnel plots and Egger's test, which is based on the premise that studies with significant findings in studies with small sample sizes are more likely to be reported, while large-scale studies are more likely to be published regardless of significance.

4 | Results

Thirty-four articles were reviewed in full, and 12 studies were excluded from the current meta-analysis (see Figure 1 for the study selection process), As a result, the present meta-analysis included 22 studies with 1172 patients and 2747 controls (Table 1). The lowest percentage of females reported in any study was 87%, while the majority of studies included were overwhelmingly female, with 19 studies reporting a female participant rate of 100%. Although only three studies provided data on participants' race and ethnicity, the majority of those reported were Caucasian/White European, ranging from 83% to 96.9%. This finding aligns with the fact that, apart from two studies conducted in Japan, all other studies included in the meta-analysis were conducted in European countries.

4.1 | Autistic Traits in AN

Among the studies included, 12 featured AQ total scores, involving 450 patients and 2437 controls, while an additional 4 studies reported AQ10 scores. In combination, a total of 16 studies, encompassing 817 patients and 2706 controls, were included in the pooled mean difference meta-analysis for autistic traits. Additionally, 8 studies examined AQ subscales.

4.1.1 | AQ and AQ10

There was a significant difference between AN and HC groups in pooled AQ total and AQ10 scores ($g = 0.88$, CI = 0.65–1.12, $k = 17$); (Figure 2; Table 2). The pooled AQ scores were significantly larger in the AN group compared with the HC group ($p < 0.001$). There was significant heterogeneity in the distribution of effect sizes for pooled AQ scores ($I^2 = 81.12\%$). There was no evidence of publication bias ($p = 0.18$) (Table 2; Figure S1).

4.1.2 | AQ Total

There was a significant difference between AN and HC groups in AQ total scores ($g = 0.90$, CI = 0.60–1.20, $k = 13$; Figure 3;

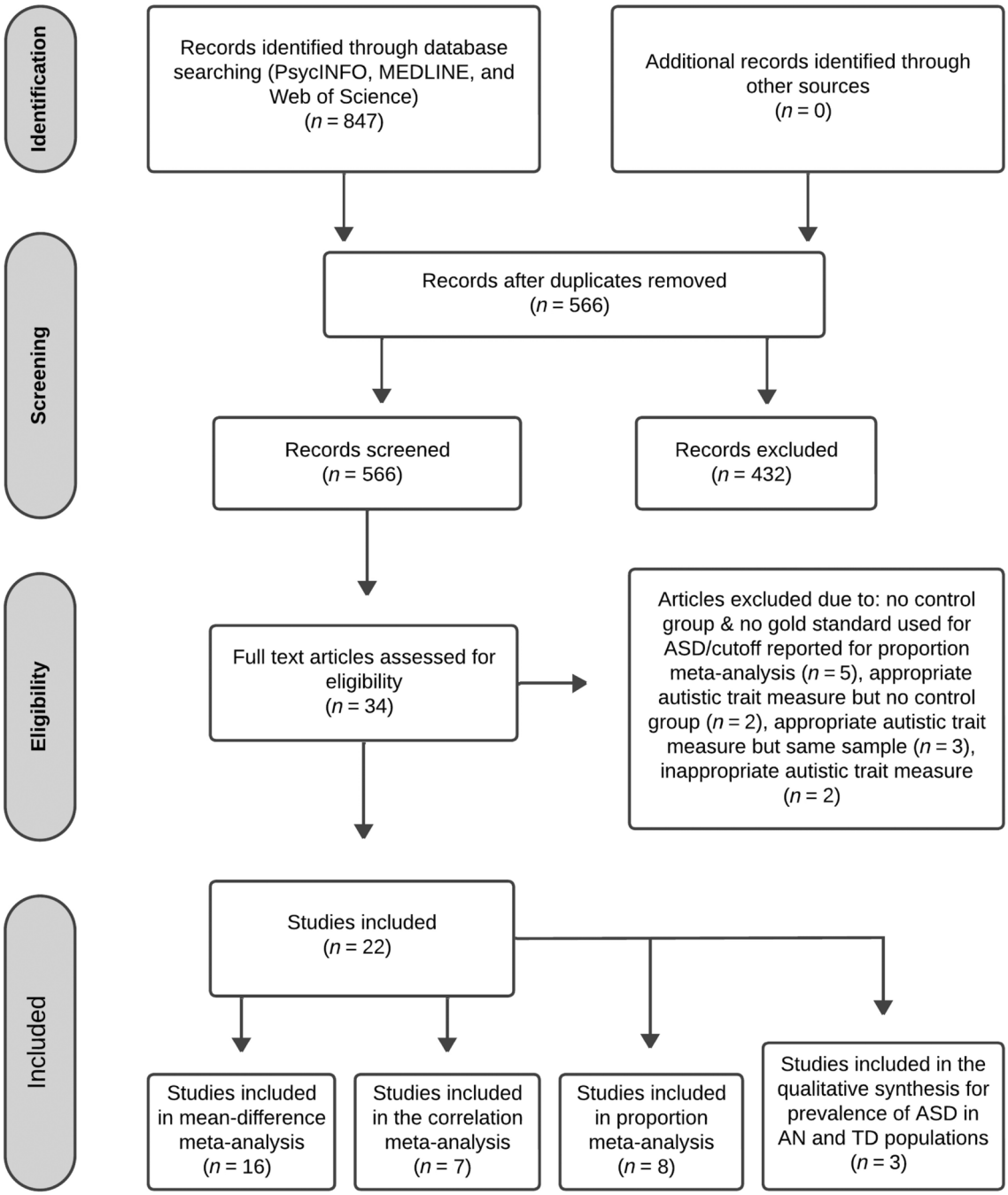

FIGURE 1 | Flow diagram of the search process.

Table 2) with AQ total scores being significantly higher in the AN group compared with the HC group. There was significant heterogeneity in the distribution of effect sizes for AQ total scores ($I^2 = 81.7\%$). There was no evidence of publication bias ($p = 0.17$) (Table 2; Figure S2).

4.1.3 | AQ Attention to Detail Subscale Scores

There was a significant difference between AN and HC groups in AQ attention to detail subscale, with scores being higher in the AN group compared with the HC group, however, the effect size was small ($g = 0.28$, CI = 0.13–0.42, $k = 9$; Figure 4; Table 2). The distribution of effect sizes for AQ attention to detail subscale was found to be fairly homogenous (Q-test $p = 0.723$). There was no evidence of publication bias ($p = 0.99$) (Table 2; Figure S3).

4.1.4 | AQ Attention Switching Subscale Scores

There was a significant difference between AN and HC groups in pooled AQ attention switching subscale scores ($g = 0.52$, CI = 0.28–0.78, $k = 9$; Figure 5; Table 2) with a moderate effect size indicating greater difficulties in attention switching for the AN group. There was significant moderate heterogeneity in the distribution of effect sizes for AQ attention switching subscale ($I^2 = 51.54\%$). There was no evidence of publication bias ($p = 0.27$) (Table 2; Figure S4).

TABLE 1 | Demographic and design summary of included studies in the meta-analyses.

Author/date	Group	N	Country	Race and ethnicity	SES	Age	Female (%)	BMI	Illness duration	Age at onset
						Mean (SD)		Mean (SD)	Mean (SD)	Mean (SD)
Baron-Cohen et al. 2013[a]	AN	66	UK	NR	NR	17.84 (0.39)	100	—	—	—
	HC	1609				18.56 (3.99)	100	—	—	—
Bentz et al. 2017[b,c,d]	FE-AN	43	DK	NR	NR	16.1 (1.5)	100	16.6 (1.2)	—	—
	REC-AN	28				18.4 (1.6)	100	21.3 (1.8)	23.9 (11.8)	—
	HC	41				17.7 (2.2)	100	22.0 (2.6)	—	—
Björnsdotter et al. 2018[a]	AN	25	SW	NR	NR	20.32 (2.23)	100	16.28 (0.93)	4.14 (3.54)	—
	HC	25				21.28 (2.11)	100	21.13 (2.27)	—	—
Calderoni et al. 2015[a,b]	AN-R	25	IT	NR	NR	14.34 (1.85)	100	14.63 (1.90)	—	—
	T-HC	25				14.30 (1.85)	100	20.60 (3.22)	—	—
	F-HC	25				14.25 (1.85)	100	19.34 (2.38)	—	—
Courty et al. 2013[a]	AN	15	FR	NR	NR	23.9 (4.7)	93.3	16.4 (1.7)	—	—
	AN-C	15				24.0 (4.9)	93.3	21.0 (1.8)	—	—
	ASD	15				—	—	—	—	—
	ASD-C	15				—	—	—	—	—

(Continues)

TABLE 1 | (Continued)

Author/date	Group	N	Country	Race and ethnicity	SES	Age	Female (%)	BMI	Illness duration	Age at onset
						Mean (SD)		Mean (SD)	Mean (SD)	Mean (SD)
Halls et al. 2023[a]	AN	94	UK	NR	NR	-19.09 (2.97)	100	18.17 (2.75)	3.9	—
	HC	40				19.16 (2.97)	100	22.7 (2.86)	—	—
Hambrook et al. 2008[a]	AN	22	UK	NR	NR	26.73 (4.77)	100	15.27 (1.22)	9.5 (5.0)	17.3 (2.6)
	HC	45				32.51 (9.63)	100	23.36 (3.76)	—	—
Hobson et al. 2020[c]	AN	96	UK	NR	NR	22.10 (13-47)	100	—	—	—
Huke et al. 2014[a,b]	AN	32	UK	British Caucasian 96.9% Black Carribean Caucasian mixed heritage 3.1%	Degree 43.8% Postgrad 21.9% A level 15.6% GSCE 15.6% No Qualifications 3.1%	28.7 (9.65)	100	14.71 (1.77)	11.03 (9.33)	—
	HC	32				24.9	100	22.15 (3.22)	—	—
Inoue et al. 2021[a,b]	AN	92	JP	NR	NR	13.4 (1.5)	96.7	−3.6 (1.5)	—	—
	ARFID	32				—	—	—	—	—
	HC	496				13.1 (0.8)	91.9	−0.4 (1.0)	—	—

(Continues)

TABLE 1 | (Continued)

Author/date	Group	N	Country	Race and ethnicity	SES	Age	Female (%)	BMI	Illness duration	Age at onset
						Mean (SD)		Mean (SD)	Mean (SD)	Mean (SD)
Iwasaki et al.2013[a,b]	AN-R	35	JP	NR	NR	24.8 (7.9)	100	13.9 (2.2)	47.7 (46.0)	20.9 (5.8)
	AN-BP	26				23.7 (5.8)	100	15.4 (1.8)	73.2 (73.8)	18.0 (2.3)
	BN-NP	10				—	—	—	—	—
	BN-P	13				—	—	—	—	—
	HC	59				20.0 (1.4)	100	—	—	—
Jermakow and Brzezicka 2016[a]	AN	11	PL	NR	NR	26.8 (4.3)	100	—	—	—
	ASD	10				—	—	—	—	—
	HC-F	33				21.33 (1.4)	100	—	—	—
	HC-M	27				—	—	—	—	—
Karjalainen et al. 2019[a,b]	AN	36	SW	NR	NR	19.6 (2.23)	100	16.1 (0.89)	2.73 (3.02)	—
	ASD	19				—	—		—	—
	HC	30				18.0 (2.47)	100	21.3 (2.18)	—	—
Kerr-Gaffney et al. 2021[a,c,d]	AN	64	UK, NL, DE, IT	NR	NR	21.53 (4.15)	100	16.63 (2.60)	—	16.80 (3.62)
	REC-AN	46				22.21 (3.47)	100	21.05 (3.11)	—	15.56 (2.52)
	ASD	41				—	—		—	—

(Continues)

TABLE 1 | (Continued)

Author/date	Group	N	Country	Race and ethnicity	SES	Age	Female (%)	BMI	Illness duration	Age at onset
						Mean (SD)		Mean (SD)	Mean (SD)	Mean (SD)
	HC	67				22.16 (3.60)	100	21.57 (1.70)	—	—
Lang et al. 2015[a]	AN	97	UK	NR	NR	22.40 (8.32)	100	15.44 (1.68)	6.20 (7.22)	16.4 (5.51)
	HC	96				23.72 (9.80)	100	22.34 (2.42)	—	—
Leppanen et al. 2022[c]	AN(T1) AN(T2)	105 65	UK	White European 90.2% Mixed heritage 7.3% Asian heritage 2.5%	NR	18.9 (3.26)	100	18.4 (2.80)	—	—
Postorino et al. 2017[a,c,d]	AN ASD AN-C ASD-C	30 27 35 30	IT	NR	NR	14.19 (1.56)-13.60 (1.61)—	100-100—	14.19 (1.56) 13.60 (1.61)	—	—
Pruccoli et al. 2021[b,c]	AN	23	IT	NR	NR	15.8 (1.5)	87	16.8 (2.1)	—	—
Saure et al. 2022[a]	AN	42	FI	NR	Education years 14.21 (2.43)	23.61 (3.69)	100	17 (2.64)	7.46 (3.65)	—
	HC	40			Education years 14.15 (1.82)	23.10 (3.03)	100	21.61 (1.22)	—	—
Tchanturia et al. 2013[a,b]	AN	66	UK	NR	Education years 15.08 (2.16)	26.35 (8.08)	100	14.90 (2.13)	10.59 (6.66)	15.52 (5.37)

(Continues)

TABLE 1 | (Continued)

Author/date	Group	N	Country	Race and ethnicity	SES	Age	Female (%)	BMI	Illness duration	Age at onset
						Mean (SD)		Mean (SD)	Mean (SD)	Mean (SD)
	HC	66			Education years 15.78 (3.57)	25.68 (9.74)	100	21.78 (2.46)	—	—
Westwood et al. 2017 [c]	AN	60	UK	NR	NR	23.45	100	15.22 (2.15)	6.18	—
Westwood et al. 2018 [c]	AN	40	UK	British Caucasian 83% Other Caucasian 7.5% Dual heritage 5% Indian 2.5% Black Carribean 2.5%	NR	15.20 (1.52)	100	—	1.00	14.08 (1.71)

Author/date	Diagnosis	Autistic traits		Clinical measures		Outcome	AN-ASD (%)	HC-ASD (%)
		Measures	Domains	Measures	Domains			
Baron-Cohen et al. 2013[a]	DSM-IV	AQ	—	EDE-Q	Restraint Eating concern Shape concern Weight concern Global	AT: AN > HC AQ not correlated to EDEQ		
Bentz et al. 2017[b,c,d]	ICD-10/	ADOS-2	Communication Social ınteraction Communication and Social Interaction T	EDE	—	ADOS: FE— AN = REC-AN > HC ADOS not correlated to EDE in FE-AN group only ($r_s = 0.08$)	18.31	0
Björnsdotter et al. 2018[a]	DSM-IV	AQ	—	—	—	AQ: AN > HC		

(Continues)

TABLE 1 | (Continued)

Author/date	Diagnosis	Autistic traits		Clinical measures		Outcome	AN-ASD (%)	HC-ASD (%)
		Measures	Domains	Measures	Domains			
Calderoni et al. 2015[a,b]	DSM-IV-TR	AQ	Social Skills	EAT-26	Dieting	AQ: AN-R > T—		
			Attention switching		Bulimia	HC		
			Attention to details		Oral	EAT26 correlated		
			Communication		Total	To AQ Communication ($r = 0.41$) AQ Total: ($r = 0.37$, $p > .05$)		
			Imagination					
			Total					
Courty et al. 2013[a]	DSM-IV-TR	AQ	Social Skills	EAT-26	Dieting	AQ: AN > AN-C		
			Attention switching		Bulimia			
			Attention to details		Oral			
			Communication		Total			
			Imagination					
			Total					
Halls et al. 2023[a]	DSM 5	AQ-10	—	EDEQ	Restraint	Longitudinal		
					Eating concern	assessment of		
					Shape concern	Autistic traits		
					Weight concern			
					Global			
Hambrook et al. 2008[a]	DSM-IV	AQ	Social skills	—	—	AQ: AN > HC		

(Continues)

TABLE 1 | (Continued)

Author/date	Diagnosis	Autistic traits		Clinical measures		Outcome	AN-ASD (%)	HC-ASD (%)
		Measures	Domains	Measures	Domains			
			Attention switching			Total, social		
			Attention to details			Attention Switch		
			Communication			Imagination		
			Imagination					
			Total					
Hobson et al. 2020[c]	DSM 5	ADOS	Total	—	—	—	34.38	—
Huke et al. 2014[a,b]	DSM-IV	AQ	Social skills	EDE-Q	Global	AQ: AN > HC		
			Attention switching			AQ EDEQ not		
			Attention to details			Correlated ($r = 0.269$)		
			Communication					
			Imagination					
			Total					
Inoue et al. 2021[a,b]	DSM 5	AQ	Social Skills	ChEAT-26	Thinness	AQ: AN > HC		
			Attention switching		Food preoccupat	All subscales		
			Attention to details		Dieting	No correlation to		
			Communication		Social pressure	ChEAT ($r = -0.039$)		
			Imagination		Purging			
			Total		Total			
Iwasaki et al.2013[a,b]	DSM-IV	AQ	Social Skills	EDI	—	AQ: AN > HC		

(Continues)

TABLE 1 | (Continued)

Author/date	Diagnosis	Autistic traits		Clinical measures		Outcome	AN-ASD (%)	HC-ASD (%)
		Measures	Domains	Measures	Domains			
			Attention switching			Total, social		
			Attention to details			Skills, attention		
			Communication			To detail		
			Imagination			AN-R AQ EDI		
			Total			Correlated (AN-R $r=0.49$; AN-BP $r=0.36$)		
Jermakow and Brzezicka 2016[a]	ICD-10	AQ	Social skills	—	—	AQ:ASD = AN>		
			Attention switching			HC		
			Attention to details					
			Communication					
			Imagination					
			Total					
Karjalainen et al. 2019[a,b]	DSM-IV	AQ	Total	SWEAA	—	AQ: AN > HC		
	Confirmed					AQ and SWEAA correlated ($r_s=0.58$)		
	DSM 5							
Kerr-Gaffney et al. 2021[a,c,d]	DSM 5	AQ10	—	EDE-Q	—	AQ: AN = REC > H	26.6	3

(Continues)

TABLE 1 | (Continued)

Author/date	Diagnosis	Autistic traits		Clinical measures		Outcome	AN-ASD (%)	HC-ASD (%)
		Measures	**Domains**	**Measures**	**Domains**			
		ADOS 2	Social affect			ADOS RRB:	15.2	
		SRS2	Restrictive-repetitive behavior			AN = REC > HC	Pooled:21.8	
			Total			SRS: AN = REC > H		
Lang et al. 2015[a]	DSM-IV	AQ10		EDE-Q	Restraint	AQ10: AN > HC		
					Eating concern			
					Shape concern			
					Weight concern			
					Global			
Leppanen et al. 2022[c]	DSM 5	AQ10 ADOS 2		EDE-Q		Longitudinal assessment of Autistic traits	41	
Postorino et al. 2017[a,c,d]	DSM 5	AQ ADOS2	Social Skills Attention switching Attention to details Communication Imagination Total Social affect Restrictive-Repetitive Behavior	EAT-26 EDI-3	EAT-26 Total Drive for thinness Bulimia Body dissatisfaction Low self-esteem Personal alienation Interpersonal insecurity Interpersonal alientation Interoceptive deficits Emotional dysregulation Perfectionism Ascetism Maturity fear BUT Total	AQ: AN = AN-C	10	

(Continues)

TABLE 1 | (Continued)

Author/date	Diagnosis	Autistic traits		Clinical measures		Outcome	AN-ASD (%)	HC-ASD (%)
		Measures	Domains	Measures	Domains			
Pruccoli et al. 2021[b,c]	DSM 5	AQ ADOS 2	Social skills Attention switching Attention to details Communication Imagination Total Communication Social interaction Imagi/creativity Repetitive behavior Total	EDI-3	Eating disorder Risk Ineffectiveness Interpersonal Problems Affective Problems Overcontrol Global Psychological Maladjustmen	AQ-EDRC: ns ($r = 0.174$)	22	
Saure et al. 2022[a]	DSM 5	AQ	Total	EDE-Q	Total	AQ: AN > HC EQ: AN < HC* (ANCOVA: ns)		
Tchanturia et al. 2013[a,b]	DSM IV	AQ-10	Total	EDE-Q	Total Restraint Eating concern Weight concern Shape concern	AQ: AN > HC AQ-10/EDE-Q global not correlated ($r = 0.12$)		
Westwood et al. 2017 [c]	DSM 5	ADOS 2	—	EDE-Q	—	—	23.3	
Westwood et al. 2018 [c]	DSM 5	ADOS 2	—	EDE-Q	—	—	52.5	

Abbreviations: ADOS = Autism Diagnostic Observation Schedule; AN = anorexia nervosa; AN-BP = anorexia nervosa, binging-purging subtype; AN-C = control group for AN; AN-R = anorexia nervosa-restrictive subtype; AQ = Autism-Spectrum Quotient; ARFID = avoidant/restrictive food intake disorder; ASD = autism spectrum disorder; ASD-C = control group for ASD; BMI = body mass index; BN-NP = non-purging Bulimia nervosa; BN-P = purging Bulimia nervosa; ChEAT-26 = childrens' eating attitude test; DSM IV-TR = Diagnostic and Statistical Manual of Mental Disorders, fourth edition, text revision; DSM 5 = Diagnostic and Statistical Manual of Mental Disorders fifth edition; EAT-26 = the eating attitude test; EDE-Q = the eating disorders evaluation questionnaire; EDI = the eating disorder inventory; F-HC = false healthy controls; FE-AN = first episode anorexia nervosa; HC = healthy controls; HC-F = female healthy controls; HC-M = male healthy controls; REC-AN = recovered anorexia nervosa; SWEAA = The Swedish Eating Assessment for Autism Spectrum Disorders; T-HC = true healthy controls.

[a]Studies included in mean-difference meta-analysis.

[b]Studies included in correlation meta-analysis.

[c]Studies included in proportion meta-analysis.

[d]Studies included in LogOR meta-analysis.

4.1.5 | AQ Imagination Subscale Scores

No significant difference between AN and HC groups in AQ imagination subscale scores were found ($g = 0.26$, CI = −0.05–0.57, $k = 9$; Figure 6; Table 2). There was significant heterogeneity in the distribution of effect sizes for pooled AQ scores ($I^2 = 71.1\%$). The inspection of the funnel plot and Egger's test ($p = 0.001$) provided evidence of publication bias (Table 2; Figure S5). After the trim and fill analysis, the estimated effect size remained the same.

4.1.6 | AQ Communication Subscale Scores

There was a significant difference between AN and HC groups in AQ communication subscale scores ($g = 0.48$, CI = 0.22–0.74, $k = 9$; Figure 7; Table 2) with the scores being higher in the AN group compared to the HC group, indicating difficulties in communication for the AN group. There was significant heterogeneity in the distribution of effect sizes for pooled AQ scores ($I^2 = 58.72\%$). There was no evidence of publication bias ($p = 0.36$) (Table 2; Figure S6).

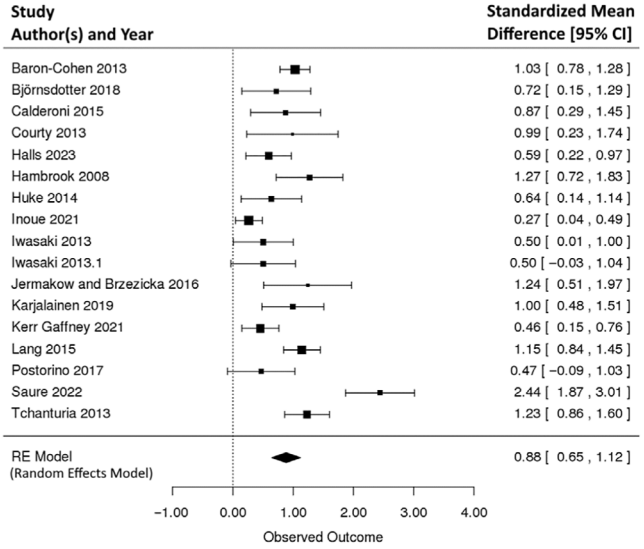

FIGURE 2 | Forest plot of standardized mean differences from studies comparing pooled AQ10 and AQ total scores for AN and HC groups (positive effect indicating greater autistic traits in the AN group).

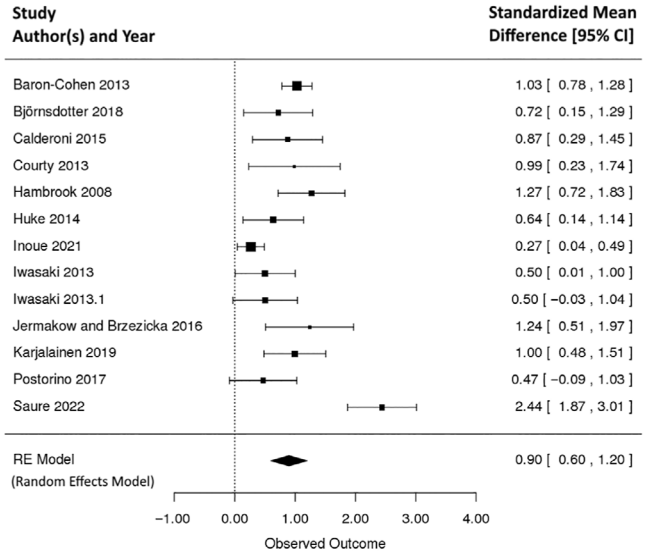

FIGURE 3 | Forest plot of standardized mean differences from studies comparing AQ total scores for AN and HC groups (positive effect indicating greater autistic traits in the AN group).

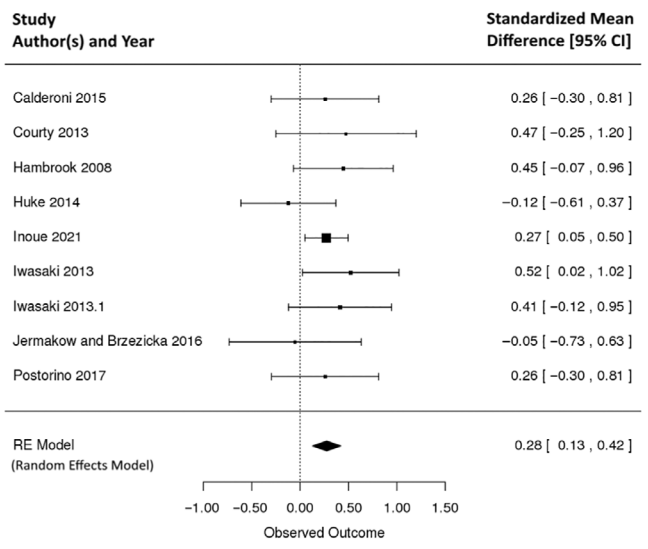

FIGURE 4 | Forest plot of standardized mean differences from studies comparing AQ Attention to detail subscale scores for AN and HC groups (positive effect indicating greater attention to detail in the AN group).

TABLE 2 | Effect sizes for AQ and AQ subscales between AN and HC.

Test	*k*	AN	HC	*g*	95% CI	*Z*	*p*	*Q*-test *p*	I^2	Bias
AQ total/AQ 10 pooled	17	817	2706	0.88	0.65–1.12	7.32	<0.0001*	<0.0001	81.12	0.18
AQ total score	13	450	2437	0.90	0.60–1.20	5.85	<0.0001*	<0.0001*	81.70	0.17
AQ attention to detail	9	281	733	0.28	0.13–0.42	3.66	0.0003*	0.723	0	0.99
AQ attention switching	9	281	733	0.53	0.28–0.78	4.34	<0.0001	0.0406	51.54	0.27
AQ imagination	9	281	733	0.26	−0.05–0.57	1.66	0.967	<0.0001	71.1	0.01*
AQ communication	9	281	733	0.48	0.22–0.74	3.65	0.0003*	0.0247	58.72	0.36
AQ social skills	9	281	733	0.70	0.43–0.97	5.15	<0.0001*	0.0045*	59.65	0.03*

Note: *p* values indicates the statistically significant values.
Abbreviations: AQ = Autism-Spectrum Quotient, AN = anorexia nervosa, Bias = *p* value for the Egger's test, *g* = Hedge's *g*, HC = healthy controls, *k* = number of studies.
*$p < 0.05$.

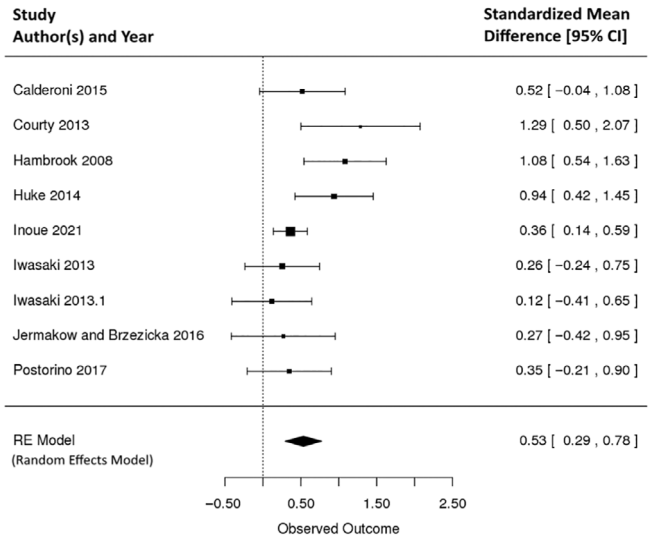

FIGURE 5 | Forest plot of standardized mean differences from studies comparing AQ attention switching subscale scores for AN and HC groups (positive effect indicating greater difficulties in attention switching in the AN group).

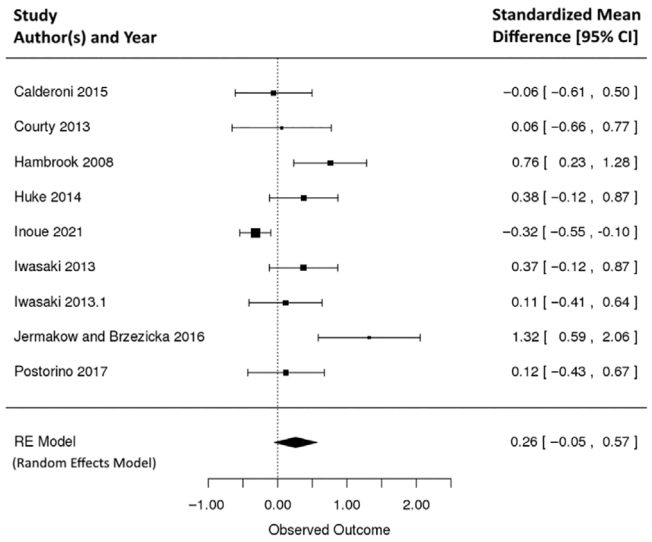

FIGURE 6 | Forest plot of standardized mean differences from studies comparing AQ imagination subscale scores for AN and HC groups (positive effect indicating poor imagination in the AN group).

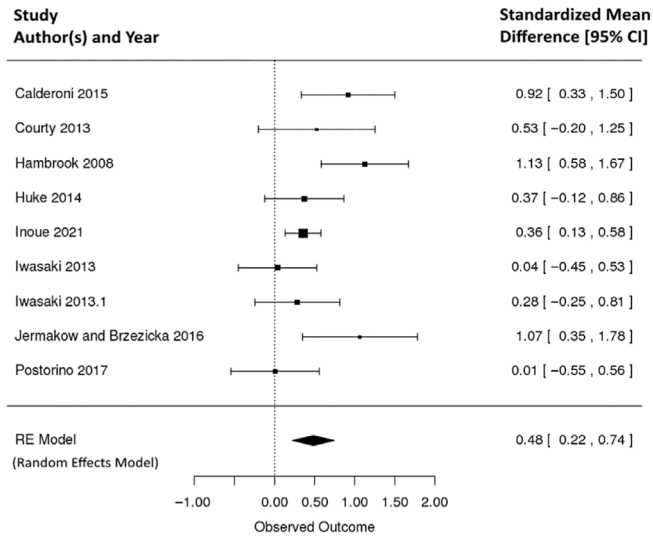

FIGURE 7 | Forest plot of standardized mean differences from studies comparing AQ communication subscale scores for AN and HC groups (positive effect indicating poorer communication skills in the AN group).

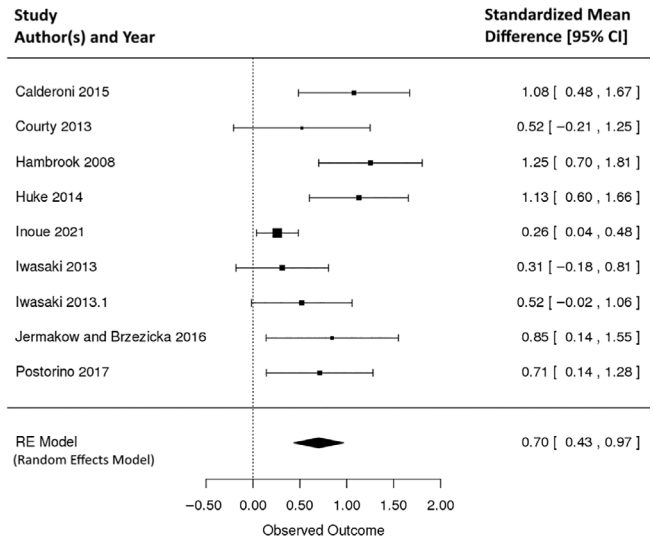

FIGURE 8 | Forest plot of standardized mean differences from studies comparing AQ social skills subscale scores for AN and HC groups (positive effect indicating poorer social skills in the AN group).

4.1.7 | AQ Social Skills Subscale Scores

There was a significant difference between AN and HC groups in pooled AQ social skills subscale scores ($g = 0.70$, CI = 0.43–0.97, $k = 9$; Figure 8; Table 2). The AQ Social Skills scores were significantly higher in the AN group compared with the HC group, indicating poorer social skills for the AN group. There was significant heterogeneity in the distribution of effect sizes for pooled AQ scores ($I^2 = 59.65\%$). There was evidence for funnel plot asymmetry (Egger's $p = 0.03$) (Table 2). However, the inspection of the funnel plot suggested that this was due to heterogeneity rather than publication bias (Figure S7).

4.2 | Autistic Traits and ED Symptomatology

Seven studies with a total of 335 AN patients also reported AQ and ED symptom correlations (measured by EDE-Q Global, EAT-26 Total, ChEAT-26 Total, EDI-Total, EDI-3 EDRC, and SWEAA scores) and were included in the correlation meta-analysis.

In correlational meta-analyses of studies investigating AQ and ED symptoms ($k = 8$), a weak correlation was found ($r = 0.28$, CI = 0.11–0.44, $Z = 3.08$, $p = 0.0021$; Figure 9) for 335 patients with AN; although significant heterogeneity $Qp = 0.014$ $I^2 = 60.2$ was observed. There was evidence for funnel plot asymmetry

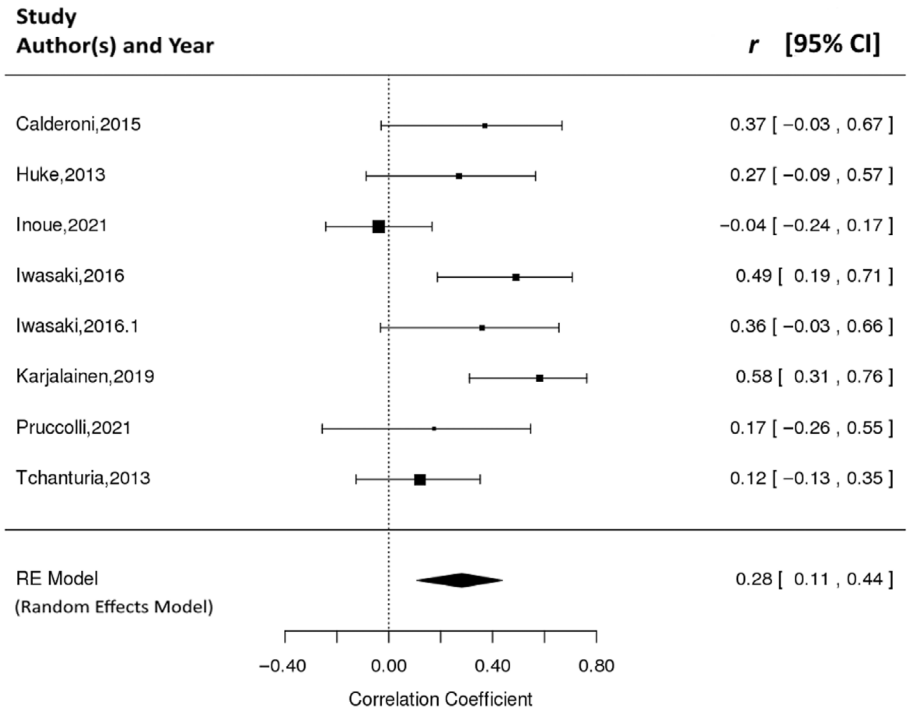

FIGURE 9 | Forest plot for correlation meta-analysis for autistic traits as measured by AQ and AQ10 and eating disorder symptoms in AN group.

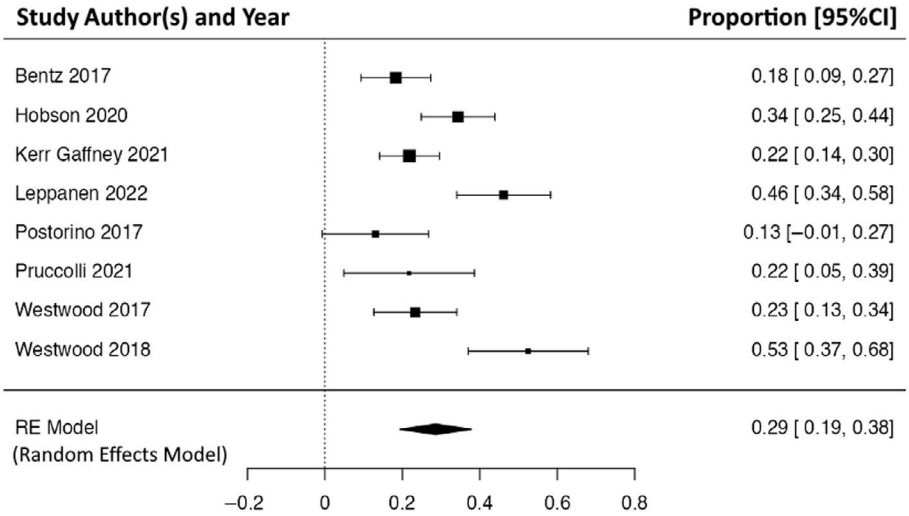

FIGURE 10 | Forest plot for ratio meta-analysis for the proportion of individuals with AN scoring above the ADOS for a possible ASD diagnosis.

(Egger's $p = 0.0049$). However, the inspection of the funnel plot suggested that this was due to heterogeneity rather than publication bias (Figure S8).

4.3 | ASD Comorbidity in AN

4.3.1 | Proportion Meta-Analysis

A proportion meta-analysis using the JAMOVI version 2.4.12 with the MAJOR module was conducted on eight studies reporting estimated prevalence rates of ASD screened with valid and reliable gold-standard diagnostic tools ADOS and ADOS-2 in children and adults with AN ($n = 488$). The effect size of 0.29 (CI = 0.19–0.38, $Z = 6.06$, $p < 0.001$; Figure 10) indicates that 29% of children and adults with AN met the diagnostic criteria for ASD. However, $Qp < 0.001$ and $I^2 = 81$; 77% indicate high heterogeneity in the included studies. Inspection of a funnel plot did not suggest evidence of publication bias (Figure S9).

4.3.2 | Qualitative Review of Studies Comparing Prevalence of ASD Symptomatology in AN and TD Populations

Studies utilizing ADOS with both AN and TD samples were initially planned to be included in a separate LogOR meta-analysis. However, due to the small number of studies available ($n = 3$), we were able to conduct a qualitative review of these studies but not a meta-analysis.

TABLE 3 | Meta-regression with moderators of female percentage, age, and BMI. $F(3,9) = 0.089$, $p = 0.965$, $I^2 = 78.49$, $Qp < 0.001$.

					95% CI	
	Estimate	**SE**	***t***	***p***	**LL**	**UL**
Female percentage	−0.003	0.108	−0.029	0.979	−0.249	0.243
Age	0.024	0.050	0.481	0.642	−0.089	0.137
BMI	0.041	0.132	0.310	0.763	−0.258	0.340

Postorino et al. 2017 report 30 participants with AN, with 27 scoring below the ASD threshold and 10% ($n = 3$) exceeding the conventional ADOS-2 cutoff. However, despite one participant scoring in the diagnostic range for autism and two others being within the autism spectrum range, the authors report that detailed clinical interviews did not support an ASD diagnosis for any of these individuals. Another study reports 21% of individuals with their first episode of anorexia ($n = 41$) and 16% of those in recovery ($n = 28$) scored above the ASD cutoff, resulting in approximately 18.8% of the combined anorexia sample exceeding the threshold. No HCs scored above this cutoff in this study (Bentz et al. 2017). In contrast, 26.6% of the AN group ($n = 64$) and 15.2% of the recovered anorexia group ($n = 46$) surpassed the ADOS-2 threshold, (translating to 21.8% of the combined sample), while 3.0% of the TD group ($n = 67$) also screened positive for ASD (Kerr-Gaffney et al. 2021). Additionally, only 56.1% of individuals with ASD ($n = 41$) in this study scored above the ADOS threshold. As a summary, all three available studies showed that a much higher proportion of individuals with AN, compared with HCs, scored above the ADOS threshold of ASD.

4.4 | Meta-Regression Analyses

Meta-regressions, using R version 4.2.0 with the .metafor package, were conducted to investigate influences on combined AQ total and AQ10. Variables of female percentage, age of sample, and BMI were regressed in the same model to account for the variation in the observed effect sizes of autistic trait measures. Among the included variables, none were found to be significant predictors for autistic traits. There was considerable heterogeneity for studies included in the meta-regression, $Qp < 0.001$, $I^2 = 78.49\%$. A summary of the meta-regression results can be found in Table 3.

An additional meta-regression model was conducted that included the restrictive subtype as a percentage to examine its effect on autistic traits alongside BMI and age. Despite this model not yielding significant results, detailed information can be found in the Table S1.

5 | Discussion

The present meta-analysis investigated the representation of autism and autistic traits in AN from multiple perspectives. Autistic traits measured by AQ were significantly higher in AN compared with HCs. In addition, this difference was notable in four of the five AQ subscales. Autistic traits and ED symptoms were found to be significantly but modestly correlated. Furthermore, a significant portion of patients with AN scored above the cut-off in ADOS, and the odds of screening positive for ASD were found to be significantly higher in AN compared with HCs.

The first objective of this meta-analysis was to assess the prevalence of autistic traits in individuals with AN through AQ or AQ-10. Our findings indicate a notable difference in AQ scores between individuals with AN and HCs, with those diagnosed with AN scoring significantly higher. This contrast was similarly highlighted in a prior meta-analysis that specifically focused on the AQ and AQ-10, aligning with the outcomes of our study, although the reported effect sizes were larger for both total scores and five subdomains of AQ (Westwood et al. 2016). In addition to the higher prevalence of autistic symptoms in EDs compared with HCs, specific subdomains within autistic symptomatology also appear to be implicit. Our study reveals a significant, albeit small, difference between individuals with AN and HCs in the attention to detail subdomain. This finding aligns with a limited number of empirical studies indicating weak central coherence, which contrasts with higher attention to detail in individuals with AN. One such study observed that participants with AN performed more effectively in tasks requiring local processing but demonstrated poorer performance in tasks necessitating global processing compared with the control group (Lopez et al. 2008). In support of this notion, a meta-analysis reported that individuals with recovered AN displayed superior local processing skills but poorer global processing skills compared with HCs (Lang et al. 2014). The persistence of weak central coherence in a subgroup of recovered AN patients suggests that it may serve as a neurocognitive endophenotype independent of the disorder's status. This implies that weak central coherence might not be a causal factor in the development of AN but rather a risk factor indicating or increasing the likelihood of its development (Zhou, McAdam, and Donnelly 2018).

Our study observed a significant difference in attention switching between individuals with AN and the control group, with a moderate effect size. Attention switching, defined as the ability to shift focus from one task to another, is a crucial skill implicated in both the core symptoms of ASD and anorexia. The rigid way of thinking and restrictive eating behavior toward food and weight, a core diagnostic feature of AN, may be explained by difficulties in set-shifting (Oldershaw et al. 2011; Zucker et al. 2007) Although evidence regarding set-shifting in AN in children and adolescents is inconclusive (Lang et al. 2014), difficulties are consistently reported in adults with AN even after weight restoration (Keegan, Tchanturia, and Wade 2021; Roberts et al. 2007). Furthermore, one study reports that unaffected twin sisters

of individuals with AN demonstrated poorer set-shifting abilities compared with healthy participants as well, suggesting a potential hereditary cognitive trait preceding AN rather than set-shifting difficulties resulting from AN (Holliday et al. 2005). Interestingly, the rigidity and inflexibility observed in AN due to set-shifting deficits align with behavioral phenotypes typical of ASD, such as repetitive and restrictive behaviors endophenotype (Westwood and Tchanturia 2017; Zhou, McAdam, and Donnelly 2018; Zucker et al. 2007).

Although no distinction was noted in the imagination subdomain of the AQ compared to previous meta-analyses, both the communication and social skills subdomains exhibited significantly higher scores in individuals with AN compared with the control group, with moderate effect sizes. The items in the imagination subscale of AQ encapsulate both "social imagination" preceding theory of mind skills and "mental visualization." Reports suggest that women with anorexia may have more vivid visual representations (Hijne, Ben Chamach, and Dingemans 2021), and thus, the lack of difference in this subscale between groups may potentially be the result of the clustering of two different forms of "imagination." Theory of mind, a key component of social cognition skills that lays the foundation for both communication and social skills, is believed to be disrupted in AN, including difficulties in empathizing with others, similar to those in ASD (Bora and Köse 2016; Oldershaw et al. 2010). While social skills and communication are not direct measures or outcomes of theory of mind, the ability to cognitively or empathically relate to others is closely linked with both perceived social adaptability and communication skills (Ma et al. 2023). The social cognition difficulties observed in females with AN appear to be more pronounced during the acute phase of starvation and may exacerbate existing comorbidities. Although individuals who have recovered from AN were reported to have difficulties in empathizing with others compared to controls, acutely anorectic patients displayed greater difficulties compared to recovered AN patients (Oldershaw et al. 2010). Also of note, studies report that the presence of high autistic symptoms in both acute and recovered AN conditions appear to be associated with reduced social attention (Kerr-Gaffney et al. 2021) and lower empathy (Kerr-Gaffney, Harrison, and Tchanturia 2020), similar to ASD, although the latter is reported to be more pronounced in ASD compared with AN (Leppanen et al. 2018).

ED symptoms and autistic traits, measured by a variety of validated self-report measures, were found to be significantly but moderately correlated in our correlational meta-analysis. However, the studies included displayed considerable heterogeneity. The relationship between autistic symptoms and ED symptoms is complex, as autistic traits are varied even within subtypes of AN. Notably, it has been reported that individuals with the AN-Restrictive subtype tend to exhibit higher rates of autistic symptoms compared with those with AN-Binging/Purging subtype (Schröder et al. 2022), a distinction that was not explored in our study. Although there are indications that autistic symptoms are associated with the severity of ED psychopathology in individuals with AN, resulting in more frequent and prolonged inpatient stays and poorer treatment outcomes (Nazar et al. 2018; Nielsen et al. 2015; Stewart et al. 2017; Wentz et al. 2009), as well as heightened ED symptoms in nonclinical populations (Christensen et al. 2019). One recent network meta-analysis reports that this observed correlation between ED symptoms and autistic traits could be mediated by social anxiety. They state that both central and bridge nodes identified were broadly under the social and interpersonal items in autistic and ED measures used, indicating social and communicative deficits contribute to the association of ASD and AN (Kerr-Gaffney et al. 2020).

Our meta-regression analysis incorporating age, gender, and BMI indicated that none of these variables were predictive of autistic traits. As far back as 70 years ago, long-term starvation has been linked to harmful effects on cognitive and social functioning (Kalm and Semba 2005). Although such unethical practices are abandoned today, novel scientific research also shows that cognitive and social challenges, such as emotional responses to faces and structural brain changes linked to starvation, which overlap with those seen in ASD, sometimes improve following weight restoration (Brodrick et al. 2021; Dinkler et al. 2019; Leslie et al. 2020; Nuyttens et al. 2024). Notably, (Fornaro et al. 2020) observed that individuals with severe AN, which is primarily designated in the DSM-5 based on the BMI scores, exhibited more pronounced autistic traits compared to those with nonsevere AN. In addition, (Karjalainen et al. 2019) a notable reduction in autistic traits was documented during a 1-year follow-up. However, most studies report that autistic traits persist even after weight restoration (Kerr-Gaffney, Harrison, and Tchanturia 2020; Kerr-Gaffney et al. 2020, 2021; Nazar et al. 2018; Tchanturia et al. 2019). This is also supported by studies using retrospective reports predating the onset of starvation, which examined individuals who have recovered from AN and continue to reveal elevated levels of autistic traits in people with EDs (Vagni et al. 2016). Despite the apparent disparities in the literature, our results are in line with the extant literature regarding that fluctuations in BMI scores have minimal effect on autistic symptoms observed in individuals with AN, without a clear link with weight restoration (Nuyttens et al. 2024). Since only two studies provided information on both acute and recovery states in anorexia and BMI, conducting a moderator analysis was not possible in our study. Further research is needed to clarify the relationship between BMI, as measured in acute versus recovery states to potentially serve as a proxy for starvation, and autistic traits while controlling for other potential confounders to accurately assess the impact of starvation on autistic symptomatology. Furthermore, the impact of illness duration, which could not be assessed in our study due to the reciprocal relationship where longer illness duration may prolong starvation and increase autistic traits, and vice versa, should be investigated through prospective longitudinal studies. These studies should measure autistic traits, BMI, and other starvation predictors at multiple time points to provide a comprehensive understanding.

In our meta-analysis, it was revealed that 29% of individuals with AN meet the diagnostic criteria for ASD as determined by gold-standard semi-structured clinical observations. These figures align with the extant literature, as a recent systematic review estimates 20%–30% of patients with AN meet the diagnostic criteria of ASD (Westwood and Tchanturia 2017). Another systematic review examining the prevalence of ASD in ED populations revealed an average rate of 22.9% (Huke et al. 2013).

However, it is important to note that psychiatric disorders often co-occur with one another. In addition to ASD, conditions such as obsessive-compulsive disorder, social anxiety, and depression are also overrepresented in patients with anorexia. While conservative estimates suggest that lifetime OCD occurs in approximately 15% of patients with anorexia, cross-sectional studies have reported comorbidity rates as high as 40% (Mandelli et al. 2020). Rates as high as 88.2% for social anxiety (Swinbourne and Touyz 2007) and 80% for depression (Godart et al. 2015) were reported in AN, with a majority of studies estimating that nearly half of all patients experience depressive symptoms (Hambleton et al. 2022). Therefore, the overrepresentation of autistic symptoms should be interpreted with this context in mind.

In three studies using ADOS with both AN and TD groups, 10%–21.1% of participants with AN were found to exceed the ADOS cutoffs. In contrast, only 0%–3% of HCs had scored above the ADOS threshold. However, clinical interviews in one study did not confirm an ASD diagnosis for those who scored above the cutoff, indicating that a positive ADOS screen does not always equate to a clinical diagnosis of ASD (Postorino et al. 2017). It was also quite notable that only 56.1% of individuals with ASD scored above the ADOS threshold in one study (Kerr-Gaffney et al. 2021), further highlighting the distinction between screening and a clinical diagnosis of ASD. These findings underscore the importance of using ADOS assessments in both acute and recovery phases of AN, as well as in comparison groups, to obtain more accurate estimates of autistic symptomatology. This approach would allow analyses that assess the likelihood of a positive ASD screen in AN samples compared with typically developing samples. Further studies are needed to estimate the magnitude of the increased risk of ASD in AN in comparison to HCs.

There is a noticeable overrepresentation of females in anorexia diagnoses, contrasting with a similar trend of overrepresentation of males in ASD diagnoses. However, recent evidence suggests that ASD may affect more females than previously believed, indicating that diagnostic criteria and research practices may have contributed to an exaggerated gender gap (Chellew, Barbaro, and Freeman 2022; Hull, Petrides, and Mandy 2020; Lai et al. 2015). Indeed, the comparative study by Oldershaw et al. (2011) poses a significant question in its title: Is anorexia nervosa a version of autism spectrum disorder? The answer to this query could potentially alleviate the disparity between gender patterns in these two disorders, namely the male predominance and female predominance in ASD and AN, respectively.

ASD can manifest differently in females compared with males, potentially leading to under-diagnosis or mislabeling as other impairments (Ferri, Abel, and Brodkin 2018). For instance, females with ASD have been observed to exhibit better social skills than their male counterparts (Head, McGillivray, and Stokes 2014), and they may outperform males on tests measuring certain executive functioning subdomains (Bölte et al. 2011; Kiep and Spek 2017), which is of particular importance given that executive functioning deficits are reported to be more strongly associated with core autistic symptoms in females than in males (Torske et al. 2023). Given this potential difference in cognitive profile, restricted interests displayed by females may align more subtly with gender stereotypes, with their restricted interests manifesting with a focus on activities or behaviors traditionally labeled as "feminine," such as an increased focus on body parts and appearance, obsession with dietary regulations, or fixation on resembling an idol (Brede et al. 2020). Given the profoundly significant association between ASD and AN, it is vital to identify autistic symptoms in patients presenting with AN, as there are reports indicating a less favorable response to treatment (Tchanturia et al. 2019) or less improvement in overall functioning compared to individuals with AN alone (Nazar et al. 2018).

6 | Strengths and Limitations

Despite being comprehensive and incorporating various meta-analyses and literature reviews, our study has several limitations. First, relying on self or parent reports for the AQ may not accurately capture autistic symptomatology, particularly in females who often exhibit different symptoms compared with males and may engage in masking behaviors. Second, a subgroup analysis comparing recovered versus acute anorexia patients and restrictive versus binging-purging anorexia was not feasible as only two studies differentiated between recovered and acute anorexia patients, and among seven studies reporting on anorexia subtypes, only one provided mean and standard deviation values for these subgroups. As such, the observed discrepancies could be affected by starvation or variations in cognitive profiles associated with autistic traits across different subtypes.

Third, the variation in measures used for assessing eating symptomatology across studies in correlation meta-analysis introduces significant heterogeneity and publication bias. Fourth, although the inclusion of studies incorporating only gold-standard measures for autism diagnoses was an important strength, this resulted in a limited selection of studies, particularly impacting the LogOR meta-analysis. Conducting ADOS assessments on both HCs and patients with anorexia was necessary for the LogOR meta-analysis, and studies performing ADOS on healthy samples are sparse. Nevertheless, we posit that these findings could stimulate future research to incorporate ADOS assessments on HCs, where feasible, to enhance the robustness of future meta-analyses when a larger body of studies becomes available for updates. For future research, the authors recommend using the full AQ for its detailed subscales, which facilitate nuanced analysis. However, if the study design is constrained, the AQ-10 remains a valid measure of autistic traits. Additionally, incorporating the ADOS with typically developing individuals could establish baseline autistic symptomatology and aid in autism screening. Thus, including the ADOS for both autism and comparison groups, if feasible, would significantly enhance the study.

Finally, other potential confounders such as IQ, illness duration, and age at onset could not be included in the meta-regression analysis due to their infrequent reporting in the included studies, and autistic symptoms or traits associated with overall functioning were not explored in this research but should be explored in further research. In addition, the reporting of demographic characteristics was inadequate in most of the included studies, with many also failing to provide details on race and ethnicity. Among the studies that reported race and ethnicity, the majority

of participants were identified as Caucasian, which may limit the generalizability of the results.

7 | Conclusions

AN often coincides with both autistic traits as a transdiagnostic concept and core ASD symptoms, with individuals displaying AN and comorbid autistic traits typically experiencing poorer illness outcomes (Boltri and Sapuppo 2021). Consequently, it would be favorable to assess autism and autistic traits in individuals with AN to prioritize targeted interventions and customize treatments for individuals with AN who also present with comorbid autism or exhibit high autistic traits.

Author Contributions

Ipek Inal-Kaleli: data curation, formal analysis, writing – original draft, writing – review and editing. **Nurhak Dogan:** data curation, formal analysis, writing – review and editing. **Sezen Kose:** conceptualization, methodology, project administration, supervision, writing – review and editing. **Emre Bora:** conceptualization, data curation, formal analysis, methodology, project administration, supervision, validation, writing – review and editing.

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The authors have nothing to report.

Conflicts of Interest

The authors declare no conflicts of interest.

Data Availability Statement

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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Supporting Information

Additional supporting information can be found online in the Supporting Information section.