FACTORS ASSOCIATED WITH AUTISTIC TRAITS AND AGE OF DIAGNOSIS FOR AUTISTIC PEOPLE

by

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Overview

This thesis is submitted in partial fulfilment for the degree of Doctor of Clinical Psychology at the University of Birmingham. This thesis comprises four chapters, the first presents a meta-analysis examining if the age of Autism Spectrum Disorder (ASD) diagnosis is impacted by sex and of gender. The results of this study found that boys were diagnosed earlier than girls; boys were diagnosed at 4.8 of and girls at 5.6 years of age. More research is needed to explore why females are diagnosed later than males, and to ensure that the terms sex and gender are not used interchangeably.

The second chapter is an empirical quantitative study, using a cross sectional design, with 205 undergraduate psychology students, examining if autistic traits can mediate the relationship between sleep difficulties, loneliness, and mental well-being. Autistic traits were found to fully mediate the relationship between sleep difficulties and loneliness and partially mediate the relationship between sleep difficulties and mental well-being. Due to the study's cross-sectional design, longitudinal research is required to explore the generalisability of the study's findings.

The third and fourth chapters each present a 'press release', regarding the meta-analysis and the empirical research. This section presents the main findings of each paper but is written in an accessible format for public dissemination.

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Dedication

This doctorate has been a journey, and like any journey there have been highs and lows. Here I want to thank the people who got me through.

Firstly, thanks goes to my parents, who have stood by me through it all, your words, your actions, and care have got me through, this doctorate is not only my achievement; but yours. Thank you also to my Grandad, to Grandma and Nan, you may not have seen me graduate, but your love and belief in me helped me get here. I know you would be proud. Thank you also to James for persuading me to not give up, I wouldn't have kept applying to the doctorate without you. I'm thankful we made peace; you won't be forgotten.

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Chapter 1

A META-ANALYSIS INVESTIGATING WHETHER SEX AND/OR GENDER IMPACT AGE OF AUTISM SPECTRUM DISORDER (ASD) DIAGNOSIS IN CHILDREN

Abstract

Background

Two previous meta-analyses investigated factors affecting age of Autism Spectrum Disorder (ASD) diagnosis. However, a meta-analysis has not directly examined whether sex and/or gender impact on the age of ASD diagnosis in children. This paper aims to complete a systematic search to identify papers that investigate whether sex and/or gender impact on the age of ASD diagnosis in children, and to conduct a meta-analysis on the papers indicated by the systematic search.

Methodology

The initial systematic search from date period 2013 to December 2021 indicated 3627 papers; 29 papers met the requirements of the meta-analysis. A purpose-made set of quality criteria based on The Cochrane Collaboration Risk of Bias Tool, reviewed the quality of the papers. Following data extraction, 30 effects were found that included 147, 885 participants. A random effects model using the generic inverse variance method was completed.

Results

A standardised mean difference was found between the age of ASD diagnosis of males and females: males were found to be younger than females at age of ASD diagnosis. Girls on average across the papers were diagnosed at 5.6 compared to 4.8 years of age for boys.

Discussion

Existing evidence indicates that males are diagnosed with ASD earlier than females. More research is needed to explore why females are/ have been diagnosed later than males, and to ensure that the terms sex and gender are not used interchangeably.

Introduction

Autism Spectrum Disorder (ASD) is a lifelong neurodevelopmental condition, diagnosed on account of difficulties with social interaction and communication, and restricted interests and/or repetitive behaviours, which negatively impact the person's life (American Psychological Association [APA], 2013). ASD is typically diagnosed based on one of two sets of diagnostic criteria: the Diagnostic Statistical Manual of Mental Disorders (DSM) and the International Classification of Disease ([ICD]; Kupfer et al., 2008). The ICD is regularly used in the UK and much of Europe (Kupfer et al., 2008), while the DSM is more commonly used in America and Australia (Narrow & Kuhl, 2011). The newest edition of each set of criteria (ICD-11 and DSM-5) removed the diagnoses: Pervasive Developmental Disorder (PDD), Asperger's disorder, Childhood Disintegrative Disorder, and Pervasive Developmental Disorder Not Otherwise Specified, in favour of using ASD as a catch-all diagnosis (Lai et al., 2013). As previously Asperger's Syndrome has been found to be diagnosed at an older age, comparatively to other ASD diagnosis (Daniels & Mandell, 2013). The conflation of multiple diagnosis, under the category of ASD in both DSM-V and ICD-11, was completed to increase the accuracy of diagnosis, which has arguably led to the increased recognition and thus prevalence of ASD in recent years (Lai et al., 2013).

ASD was once deemed a "rare condition" (Charman, 2011). However, in the last decade, there has been a worldwide rise in its reported prevalence (Lundström et al., 2022). For example, the prevalence of ASD has risen by 787% in the UK since 1998 (Russell et al., 2022). It is now approximated that one in 57 children in the UK (1.76%) have been diagnosed with ASD (Roman-Urrestarazu et al., 2021), and 1.9% of children in the United States of America (USA), 2.6% in South Korea, and 3.2% in Japan (Kim et al., 2011; Saito et al., 2020). One reason proposed for the increase in prevalence has been better recognition of ASD by schools and parents (Roman-Urrestarazu et al., 2021).

The importance of early Diagnosis

The importance of early recognition and diagnosis of ASD is firstly warranted from a service perspective. An early diagnosis can reduce the subsequent cost(s) of secondary interventions, by providing earlier primary support for parents and/or carers, in addition to the person with ASD (Fernell et al., 2013, Koegel et al., 2014). Furthermore, not knowing the cause of a child's difficulties can cause distress and stress to the child and their family; therefore, an early diagnosis can help explain the child's difficulties (Baker-Ericzn et al., 2005). In addition, following diagnosis, the young person and their family have improved access to financial, social care, and respite support (National Institute for Health & Care Excellence [NICE], 2013), thus early diagnosis provides many benefits to the child and their family. Early intervention literature, despite being contentious, also argues the importance of early diagnosis of ASD (Landa, 2018). The early intervention literature theorises that interventions with non-verbal children with ASD which occur in pre-school, are more likely to be successful if received prior to five years of age (Koegel, 2000). Thus, it is argued that intervention to help with the difficulties associated with ASD, such as social communication, must begin at the earliest point possible, to increase the likelihood of obtaining a successful clinical outcome (Landa, 2018).

Factors impacting on Age of Diagnosis

Due to the importance of early diagnosis, three existing systematic reviews have explored the factors impacting on the age of ASD diagnosis (Daniels & Mandell, 2014; Loubersac et al., 2021; Van't Hof et al., 2021). One was a literature review (Daniels & Mandell, 2014) which summarised the findings of the literature. Daniels & Mandell (2014) found that the following factors from the literature were reported to lead to an earlier age of diagnosis: greater symptom severity, high socioeconomic status, and greater parental concern regarding first symptoms (Daniels & Mandell, 2014). It was also found that the geographical location

could have a positive or negative impact on early ASD diagnosis, as the local resources and policies for that area could positively or negatively impact children's access to assessment and thus the timing of diagnosis (Daniels & Mandell, 2014). This is despite the NHS's founding aim being to provide universal, equitable and high-quality health free care for all (O'Dowd, 2023). The other two papers were meta-analyses (Loubersac et al., 2021; Van't Hof et al., 2021). Loubersac et al's (2021) systematic search indicated 50 studies for review, with 97, 719 participants' data; the mean age of ASD diagnosis was found to range between 2.2-9.8 years of age. Loubersac et al (2021) found that co-occurring intellectual disability and children having more difficulties with social communication and led to earlier age of ASD diagnosis and replicated Daniels & Mandells (2014) reports that higher autism spectrum disorder symptom severity also resulted in earlier diagnosis. However, in contrast Loubersac et al (2021) found unlike Daniels and Mandell (2014), that children in low socio-economic status families tended to have earlier autism spectrum disorder diagnosis compared to those in high socio-economic status families, however this trend was only found in children with greater severity of intellectual impairment, and when examining the impact of gender on age of ASD diagnosis, they also found no impact (Loubersac et al., 2021). Van't Hof et al's (2021), meta-analysis indicated 56 papers for review and 22 papers were used in the subsequent meta-analysis, including 120,540 participants with age of ASD diagnosis ranging from 2.58- 6.23 years of age. Van't Hof et al (2012) completed their review in contrast to Loubersac et al (2021) found conflicting or inconclusive information on whether type of ASD diagnosis, additional diagnoses such as intellectual disabilities and gender impacted on age of diagnosis. The wider small scale research findings on the subject of gender has also been mixed, with some studies finding that it does impact on age of ASD diagnosis (Rutherford et al., 2016; Salomone et al., 2016), while others have not found this effect (Mussey et al., 2017; Petrou et al., 2018), therefore, to date no confirmation has been found from research for whether gender does impact

on the age of diagnosis. Similarly, to gender, some studies also conclude that sex does not impact on age of diagnosis (Frenette et al., 2013; Wiggins et al., 2006), and conversely, Giarelli et al. (2010) found that sex does impact on the age of diagnosis. Therefore, further research is required to determine whether sex and gender does impact on the age of ASD diagnosis.

Autism Spectrum Disorder and Sex/Gender

Sex and gender are separate and distinct concepts (World Health Organisation [WHO], 2002). Gender comprises characteristics ascribed by society, which are learned throughout someone's lifetime and build a person's gender identity, and shape the gender roles chosen, or assigned (WHO, 2002). Gender, similarly, to ASD is described in terms of a spectrum, for example people who identify with the biological sex assigned at birth are called 'cisgender,' in comparison those who do not identify with their sex assigned at birth, who may instead use terms such as transgender, nonbinary or gender fluid (Dattaro, 2020). Researchers often characterise people on this gender spectrum as 'gender diverse', much like the term 'neurodiverse' is an umbrella term for people on the ASD spectrum or who have ADHD, ADD or other neuro-developmental conditions (Dattaro, 2020). Since the 1990s, there has been an increase in the record of children seeking support regarding their gender identity and a high number of these children were found to have ASD or autistic traits (Dattaro, 2020). Research is beginning to explore where/how the two spectrums overlap: initial research has found that gender identity is more varied among autistic people than in the general population, and ASD is three to six times as common in gender diverse than general population (Warrier et al., 2020). Therefore, the overlap between sex/gender and ASD indicates why research is needed into ASD and sex and gender. Secondly, it is a relatively new area of research, and as such this area of research is very much in its infancy regarding the relationship between ASD and gender diversity. However, one potential explanation for the increased prevalence of gender diversity in neuro-diverse community is that people with ASD are less influenced/aware of social cues

and norms, therefore people with ASD have less difficulty with not ascribing to former long standing social norms such as gender being a binary concept (Strang et al., 2019). A second theory is based in biology, as levels of hormones such as testosterone are believed to possibly play a role (Roselli, 2018). Exposure levels to hormones such as testosterone in the womb may be linked to ASD, some research shows; increased prenatal testosterone may also lead to more typically 'male' behaviours and to less common gender identities in females (Roselli, 2018). However, this theory does not explain why people who are biologically male identify as female in gender, but likewise, the biology of sexuality and gender is also presently unclear. Gender is measured in this research area by asking the person what gender they associate with. Asking a person their gender is important as biologically the person may present as male or female due to their anatomy, but their gender identify (i.e., male, female, non-binary) may differ from the person's biological sex (WHO, 2002). Sex in comparison is a term assigned at birth (male, female, or intersex) based on anatomy (WHO, 2002), and is often measured in studies by asking permission and accessing a person's health records, where biologically the persons sex would have been defined (i.e., male, female, intersex).

The importance of exploring the impact of sex and gender on ASD diagnosis is further warranted due to the rates of ASD diagnosis for males and females. This is as rates of ASD diagnosis are higher in males than females, with the most common ratio in the literature being cited as around 4:1 (Elsabbagh et al., 2012). The prevalence of ASD being higher in males is not a recent finding, as demonstrated by Kanner, who first described the profile of autism in his case study of 11 children: eight of whom were boys (Kanner, 1943). Furthermore, Hans Asperger in his depiction of Asperger's Syndrome described case studies of an entirely male group, composed of four boys and no girls (Asperger, 1944). Most recent research indicates that sex-related prevalence differences may be changed: as rates of ASD diagnosis grew faster for females than males between 1998-2018 (Russell et al., 2022), suggesting an increase in the

recognition of females with ASD. This increased recognition of girls with ASD is supported by the ratio of boys to girls diagnosed with ASD reducing from 4-5:1 to 3-4:1 in the UK (Loomes et al., 2017). Despite the increased recognition of ASD, its aetiology remains unclear. Baron-Cohen (2002) proposed the extreme male brain theory as a means of accounting for sex differences in ASD prevalence. The theory describes that during foetal development, ASD is more likely to occur if a person is exposed to higher levels of pre-natal androgens, which impact on sex differentiation (McCarthy, 2008). It is hypothesised that this exposure leads to the hyper masculinised traits seen in ASD (Greenberg et al., 2018). As males are already exposed to pre-natal androgens to differentiate their sex in utero (McCarthy, 2008), the extreme male brain suggests that males with ASD would be exposed to higher levels of androgens, which could under this theory lead to more recognisable and evident "extreme male/ASD traits", facilitating easier recognition of ASD in males.

A contrasting theory for the higher recognition of ASD in males is based on gender. Theory regarding gender describes the concept of "Gender roles", which are roles ascribed to males and females by society based on their sex (Eagly, 2009). Gender roles function in society in two ways, firstly as descriptions telling males and female what is typical for their sex in society and then there is a prescriptive part, which tells them what is expected/desirable behaviour for a man or women (Rudman & Glick, 2001). If males or females do not enact these gender roles in society, society will often criticise them or punish them, for example excluding them from social groups (Prentise & Carranza, 2002), additionally gender roles can also be internalised, which also ensures they are followed (Postmes & Speares, 2002). During their first years of life, children learn what is expected of males and females in society, this process is called 'sex typing', and is used to determine what are male or female personality traits, which toys to play with and how to dress, all before the age of three (Bem, 1981). This learning occurs from watching media, interactions with family, and later is consolidated through

socialisation/observation in school with peers and teachers (Endendijk et al., 2018). From a societal level, gender roles have been shown to influence the identification of ASD in females, as placidity is a more acceptable personality trait for girls than boys (Lai & Szatmari, 2017). Consequently, symptoms such as social withdrawal in girls, are more likely to be attributed to "shyness", a "feminine" and acceptable gender personality trait, thus not leading to ASD assessment (Lai & Szatmari, 2017). Furthermore, greater social expectations are also placed on females, for example from playground observations female children were observed to be expected to talk and socialise in smaller groups during play, whereas males socialised in larger groups and spent free time completing activities, which required less social communication (Kreiser & White, 2014). Consequently, females with ASD from an early age are theorised to adapt social compensatory strategies known as 'masking' or 'camouflaging' to meet required societal expectations (Hull et al., 2017). However, by masking ASD symptoms, such as social and communication difficulties, females can thereby avoid ASD being recognised (Hull et al., 2017). Further, ASD was first studied in males and as prevalence rates remain higher in males than in females (Russell et al., 2011; Russell et al., 2022), it is hypothesised that ASD criteria are consequently more in line with societally noted male behaviours (Lai & Szatmari, 2017). Therefore, these screening tools are arguably not equipped to assess the female presentation of ASD (Lai & Szatmari, 2017). In line with this argument screening tools will likely also require adapting to better identify ASD in gender diverse children (Dattaro, 2020), as no gender-diverse children were assessed when the initial criteria for ASD was defined by Asperger and Kanner (Asperger 1944; Kanner 1943).

It is therefore apparent that the traditional reasons for why the autism diagnosis rates in boys compared to girls have tended to conflate the concepts of sex and gender. Conflating sex and gender in this area is an important problem for three reasons. Firstly, sex and gender categories do not always overlap, with trans and non-binary experiences more common in

autistic than neurotypical young people (Strang et al., 2018; Walsh et al., 2018). Secondly, the distinction between sex and gender provides a way of understanding arguments for why autism diagnosis may function differently in boys in comparison to girls. Thirdly, as has been discussed above the male sex and gender-based behaviour has been used to create the ASD screening and diagnosis criteria, therefore the female sex and gender diverse persons arguably may struggle with obtaining a ASD diagnosis.

Only three existing systematic reviews have explored the impact of sex and or gender on the age of ASD diagnosis (Daniels & Mandell, 2014; Loubersac et al., 2021; Van't Hof et al., 2021) and all reviews *did not* have sex and genders impact on age of ASD diagnosis as the primary factor of interest. One was a literature review (Daniels & Mandell, 2014) which summarised the findings of the literature, while the other two papers were meta-analyses (Loubersac et al., 2021; Van't Hof et al., 2021). Loubersac et al's (2021) as stated previously when exploring the impact of gender on age of ASD diagnosis found no impact. However, these findings, must be considered in the context of the study itself having significant methodological limitations. Loubersac et al (2021), used autis* as a singular search term, which may have excluded papers which explored ASD populations who had a former separate ASD diagnosis (e.g., Asperger's Syndrome). Furthermore, Loubersac et al (2021) also only used the search terms ("age of diagnosis" OR "age at diagnosis"), which could have missed papers which used a different ordering of the words. The factor of gender was also only examined by the completion of a subgroup analysis on 14 papers. Although Loubersac et al (2021) did not find a significant impact of gender on diagnosis age, this could be because only 14 papers could be used in the subgroup analysis. Furthermore, from reading the papers reviewed, the terms sex and gender were used interchangeably, confusing the matter of whether Loubersac et al (2021) reviewed papers which explored the impact of gender, or sex, on the age of ASD diagnosis. Van't Hof et al's (2021), similarly to Loubersac et al's (2021) findings, Van't Hof

et al (2021) concluded that in 17 of the 22 studies examined, that there was no difference between the age at diagnosis for boys and girls. Once more, the findings of Van't Hof et al (2021) need to be considered in the context of the paper itself having limitations. Firstly, the researchers only searched one database, (PubMed). Secondly, the exploration of the impact of sex and gender was completed using a subgroup analysis on the 22 papers, which assessed the impact of sex and gender on age at ASD diagnosis. Once more, the studies reviewed by Van't Hof et al (2021) used the terms sex and gender interchangeably.

The aims of this meta-analysis were therefore to:

(i) Conduct a systematic search of the literature, to identify papers that report age of ASD diagnosis by gender or sex in children. It will use a more comprehensive set of search terms than previously used in former meta-analyses and be completed across four databases to improve the access to potential papers, based on critique of former reviews.

(ii) To define whether papers explore the impact of sex and gender on age of ASD diagnosis.

(iii) Perform a meta-analysis, with the primary focus to determine if a significant difference in age of diagnosis is found due to sex and or gender in children.

(iv) To conduct analysis of whether risk of bias factors and categorisation based on sex vs. gender impact on any heterogeneity found. In addition, to determine whether type of ASD diagnosis and country of diagnosis impact on any heterogeneity found, due to different countries being more likely to use either DSM or ICD criteria.

Method

Search Strategy

On the 14th of December 2021, Medline, PsycInfo, Embase and Psycarticles were systematically searched, using the terms displayed in Table 1.0. The aim of the search was to provide a comprehensive review of the existing literature on the impact of sex and gender on the age of ASD diagnosis. The search terms of the former two meta-analysis papers (Loubersac et al., 2021; Van't Hof et al., 2021) were considered in informing the terms below. Additional search terms were also sourced from the wider literature. The two former meta-analysis (Loubersac et al., 2021; Van't Hof et al., 2021) references were also screened, to ensure all studies meeting inclusion criteria were found and analysed by the present meta-analysis. The meta-analysis was completed following Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines (Page et al., 2020), and Table 1.1 displays the inclusion and exclusion criteria.

Table 1.0

Systematic Search Criteria

Construct	Free Text Search Terms	Method of Search
Autism	*"autis*""ASD" "ASC""asperg*" "pervasive developmental disorder""PDD""childhood disintegrative disorder" "pervasive developmental disorder not otherwise specified" "PDD-NOS"*	Free search terms All search terms combined with *OR* *All fields*
	AND	All construct terms on the left linked with AND
Age of diagnosis	"age adj3 diagnos*"	Adj3 used on all databases. All fields
	AND	
Sex and gender	*"sex" "gender*" "male*" AND female*" "boy* AND girl*" "transgend*" "non-binary"*	Free search terms, ALL search terms combined with OR
	AND	All fields
Under 18	*"child*""adolescen*" "infan*""toddler*" "youth*" "young per*" "teen*"*	Free search terms, ALL search terms combined with OR

Table 1.1

Inclusion and Exclusion Criteria

Inclusion Criteria	Rationale
Participants. Participants in papers should be under 18 and have a diagnosis of ASD	The age range was chosen due to age of diagnosis often occurring in childhood, and most studies exploring the age of diagnosis in this age group. To not skew data, papers exploring age of diagnosis in adult population were therefore not used. Further, only papers exploring children with a diagnosis of ASD were included (under 18 years of age or younger).
Study Content. Age of ASD diagnosis and its relationship with sex and or gender, will be accepted if in the format of mean age of diagnosis and standard deviation. Or takes the form of Pearson R, Chi square, Spearman or Phi statistic. Or if the information can be determined from F- Test statistics, Cohen's d effect size or an r effect size. If the paper is not in a format where the data can be transferred it will be removed.	The age of ASD diagnosis or ability to determine mean age of ASD diagnosis, or relationship between ASD diagnosis and sex and or gender must be included. This is to ensure the information required for meta-analysis can be extracted. If age of ASD diagnosis is not given, or compared by gender or sex, then the paper will not be included. Unisex or uni-gender papers where only one sex or gender is studied will also not be included, as they are not comparing the age of diagnosis between the sexes or genders.
Age of diagnosis. In format of Mean age of diagnosis or presented in a manner in which it could be determined had to be provided, not ranges of ages.	Studies were not included which gave age ranges, not ages, i.e., late or early diagnosis, as data could not be withdrawn in the required format.
Language. The paper should have been written or been translated into the English language.	Due to the researcher being monolingual, and only speaking and being able to read papers written in the English language.
Type of Article. The following article types were excluded: meta-analysis/theoretical papers/ screening papers/ reviews/commentaries/ clinical guidance/ non peer reviewed.	The type of articles on the left were not included, as they did not provide the outcome data required in this meta-analysis, or they have not been checked to ensure their quality by a peer review process.
Date Range. Date range was applied, papers were only used if they were published after 2013.	Papers from 2013 onwards were used, as papers prior to this would be using diagnosis criteria of ICD and DSM would be two editions later than the one now used and is thus significantly outdated.

Note. The inclusion and exclusion criteria used to screen the literature, are displayed in Table

1.1. Each criterion is explained, and a rationale is then provided.

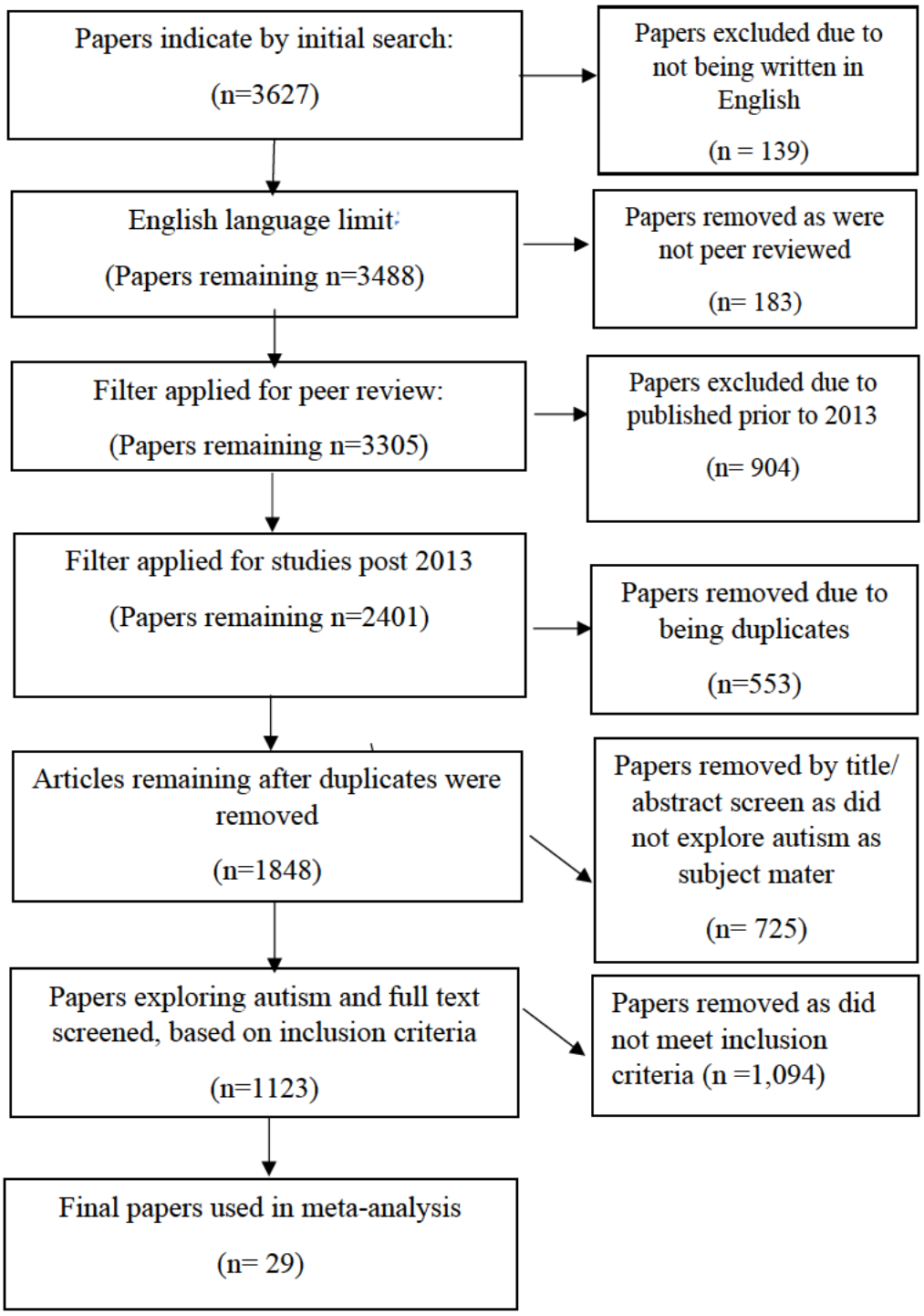
Systematic Search Results

The results of the systematic search are presented in Figure 1.0. The search yielded 3627 papers, which were screened using the inclusion/ exclusion criteria (Table 1.1). After a language limit was applied, 139 papers were removed, 183 papers were then excluded for not being peer reviewed, and 904 papers were removed as they were published prior to 2013. After a duplicate filter was applied, a total of 1,848 papers remained. A total of 725 papers were then excluded as their title and abstract confirmed that participants did not have ASD. This left 1,123 papers for full-text screening. A total of 29 papers were found to meet the full inclusion criteria, with a combined participant data pool of 147,885.

The references from the two meta-analyses conducted on a similar topic area (Loubersac et al., 2021; Van't Hoft et al., 2021) were then screened against inclusion and exclusion criteria. All papers meeting inclusion criteria had been found by the search. The papers found from the systematic search were also screened to ensure that participants used in the papers did not overlap. This process was completed by reviewing where the papers took their participants from and reviewed their participant characteristics and results. It was determined that it was highly unlikely that any papers used had the same participants and therefore no papers were removed for this reason.

Figure 1.0

Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) Diagram



Note. n is an abbreviation of number of studies. The number of remaining papers is presented on the left and papers removed on the right of the diagram, as per PRIMSA guidance.

Data Processing

All data were extracted by the author. A total of 22 papers provided the age of ASD diagnosis for males and females in the form of mean and standard deviation. Mean and standard deviation for age of diagnosis in years was extracted separately for boys and girls from the papers. When age of diagnosis was reported in months, this was converted to years. Variance reported as Standard Error or Confidence Interval was converted to Standard Deviation for males and females separately. One paper did not report standard deviation separately for males and females; therefore, a pooled standard deviation was used. For papers in which data were extracted from confidence intervals (two papers) and Z statistics (one paper), alongside the number of participants, appropriate conversion to mean and standard deviation of age of diagnosis was made for male and female data. For papers in which mean, standard deviation or confidence interval data were not reported, appropriate conversions were made for females and males separately. This included converting F statistics (for two papers) and Mann Whitney U (one paper), into Cohen's D (Cohen, 1988). Where papers reported data in subgroups, which were not felt likely to impact on the relationship between sex/gender and age of diagnosis (four papers), they were combined using the Borenstein et al's (2009) technique, but male and female data was kept separate. However, for one paper of the four, the subgroups were felt to be warranted, as the subgroups were formed due to examining age of diagnosis between two countries, one of the analyses of interest, consequently these two subgroups were kept and data for these two subgroups was recorded for males and females. This study was also noted, as the inclusion of two outcomes for one paper could reduce the overall confidence interval in which to find an effect (Higgins et al., 2011). Therefore, there were 29 studies providing separate data for males and females age of ASD diagnosis in the formats discussed, which was then used in the analysis, but 30 effects.

Defining Problematic Variance

Heterogeneity can occur within a meta-analysis due to differences in methodology in the studies reviewed, error in measurement, or individual differences in studies not being controlled for by the meta-analysis (Higgins, Thompson & Spiegelhalter, 2009). To measure heterogeneity in this meta-analysis, Higgins' I^2 (Higgins, Thompson, Deeks & Altman, 2003) was used, as it is a well-established method of measuring heterogeneity in systemic reviews (Higgins et al., 2003). Due to the studies selected having a range of methodologies, the relatively lenient criteria value of Higgins' I^2 value 75% was chosen, to reflect problematic heterogeneity (Higgins et al., 2003).

Risk of Bias Assessment

To assess the quality of the studies, a purpose-made set of quality criteria was developed, based on The Cochrane Collaboration Risk of Bias Tool (Higgins et al., 2011). Of the potential seven domains of risk of bias indicated by Higgins et al (2011), there were four types of bias felt to be relevant to the research reviewed in this paper. Treatment fidelity, performance and statistical bias were not relevant to the subject matter of this meta-analysis. Further details and the ratings, domains, and criteria attributed to each risk of bias, can be found in Table 1.2 below.

Table 1.2

Risk of Bias Domains

Domain	*Details*	*Risk of Bias*
Selection Bias	Were efforts made to minimise selection bias in the studies, such as reporting nonresponse rate, providing details of the study population and method of sampling? How was age of ASD diagnosis determined?	*High Risk*- No details of the study population and method of sampling and recruitment are provided. Failure to report method of autism spectrum disorder diagnosis. *Unclear Risk*-Non-response rate is not reported, if applicable. Either the characteristics of the study population are not clearly reported or reports method of diagnosis, but with insufficient detail, or both. *Low Risk*-Nonresponse rate is reported, if applicable. The characteristics of the study population are clearly described. Clinically recognised method of diagnosis used.
Detection Bias	What method of measuring age of ASD diagnosis	*High Risk*–Does not report how age of ASD diagnosis was determined/ or ASD diagnosis was provided by parent report *Unclear Risk*-Reports method of where ASD diagnosis was found, but not from clinical files. *Low Risk*-Clinically records consulted for age of diagnosis
Reporting Bias	Is there evidence of selective outcome reporting? Are outcomes reported in the results that were mentioned in the method section?	*High Risk*–Outcomes not reported, which were denoted would be by the method section/reported only a subsample of results/only significant results. *Unclear Risk*–Not all descriptive and/or summary statistics presented. Unclear reporting of outcomes. *Low Risk*–Reported all results outlined in the method section clearly.
Generalisation	Can the research findings be applied to settings other than that in which they were originally tested? Are there any differences between the study participants and those persons to whom the review is applicable?	*High Risk*-Small sample with or without idiosyncratic features (<50 per group). *Unclear Risk*-Sufficient sample for generalisation but with some idiosyncratic features (>50 per group). Or not enough information provided to determine if it is generalisable. *Low Risk*-Sufficient sample for generalisation and representative of target population (>50 per group).

Note. Each of the risk categories and criteria are colour coded. Red means high risk, yellow unclear and green represents low risk.

The Quality Index

The quality index was calculated as the total score from the risk of bias ratings (the sum of two points for "low risk", one point for "unclear risk" and 0 points for "high risk" for each of the areas of risk of bias). The risk of bias rating was then added to the score for the study's overall design within the study design hierarchy. The study hierarchy provided a score of 20 was provided to papers which were designed to assess participant characteristics. In contrast 10 points were assigned to papers which reported participants characteristics but did not aim to explore these characteristics. The combined risk of bias and study hierarchy score was then divided by the maximum possible score to obtain the percentage index score. The quality index scores for each of the 29 studies can be seen in Appendix A.

Selection Bias

From the 29 studies reviewed, eight were rated as low risk of bias, and 21 studies were rated as having an unclear risk of selection bias. The low-risk studies (Harrop et al., 2021; Höfer et al., 2019; Jensen et al., 2014; Kurasawa et al., 2018; McDonnell et al., 2020; Mishaal et al., 2014; Mussey et al., 2017; Tang et al., 2021) were clear in the reporting of how they recruited to their study, of sample characteristics and of how ASD was assessed. No studies were rated as high risk of selection bias.

Selection Bias

Nine studies were rated as having a high risk of detection bias, 15 studies were rated as having a low risk of detection bias, and six studies were rated as having an unclear risk of detection bias. The nine papers were rated as high risk (Begeer et al., 2013; Brett et al., 2016; Hiller et al., 2016; Kavanaugh et al., 2021; Kentrou et al., 2019; McCormick et al., 2020; Petrou et al., 2018; Salomone et al., 2016; Wang et al., 2018) as the reliability of the age of ASD

diagnosis provided as the method was not provided, or clinical data was not provided to validate parent reports.

Reporting Bias

From the 29 papers, 25 papers were classified as an unclear risk of bias regarding reporting, as they did not provide all descriptive and or summary statistics, or normality tests, or were unclear in the reporting of their outcomes. However, four studies (Gibbs et al., 2019; Harrop et al., 2021; Petrou et al., 2018; Shrestha et al., 2019), were rated as low risk of reporting bias and provided detailed and clear reporting of results. No studies were rated as a high risk of bias, as no studies were deemed to withhold, or to not report results which they described that they would discuss.

Generalisability

Of the 29 studies, six studies were rated as having a low risk of bias, regarding generalisability, five studies were reported as having a high risk of generalisability bias, and 18 studies were rated as having an unclear risk of generalisability bias. The five studies rated as having a high risk of bias (Gibbs et al., 2019; Höfer et al., 2019; Tang et al., 2021; Tanidir & Mukaddes, 2014; Zeleke et al., 2018), were rated in this way, as they used fewer than 50 males or females in their analysis, which poses a risk of the results not being generalisable to the studies target population. The six studies rated as having a low risk of generalisability bias (Harrop et al., 2021; Jenson et al., 2014; Kurasawa et al., 2018; McDonnell et al., 2020; Mishaal et al., 2014; Mussey et al., 2017), were rated as such, as they used good sample sizes and the sample was a good representation of the target sample.

Summary of Risk of Bias Assessment

The papers reviewed held a mixed level of bias across the four categories. Of the 29 papers reviewed, Harrop et al (2021) was found to be the highest quality paper, obtaining a low risk of bias for all four areas. Conversely, the lowest quality paper was McCormick et al (2020); however, the reason for the low-quality score can be in part attributed to the paper losing 10 points due to the study hierarchy rating, as assigned to papers which reported participant characteristics, but did not aim to explore these characteristics. Furthermore, McCormick's paper scored in the high-risk category for detection bias and in unclear risk in the other three categories for risk of bias. The risk of bias criteria, which had the most papers rated as high risk were detection bias and generalisability. The risk being highest rated for detection bias is due to the reporting of ASD diagnosis not being provided clinically, which may mean that the age of ASD diagnosis provided in the paper may not be accurate, as for example parents may have misremembered the age of diagnosis. Whereas, regarding the generalisability category, the main risk of this category is that results of the papers may not be generalisable to their target population, and the main issue with papers being marked as at risk of bias was due to the samples used being too small, or not reporting the details of the population.

Results

Summary of Papers

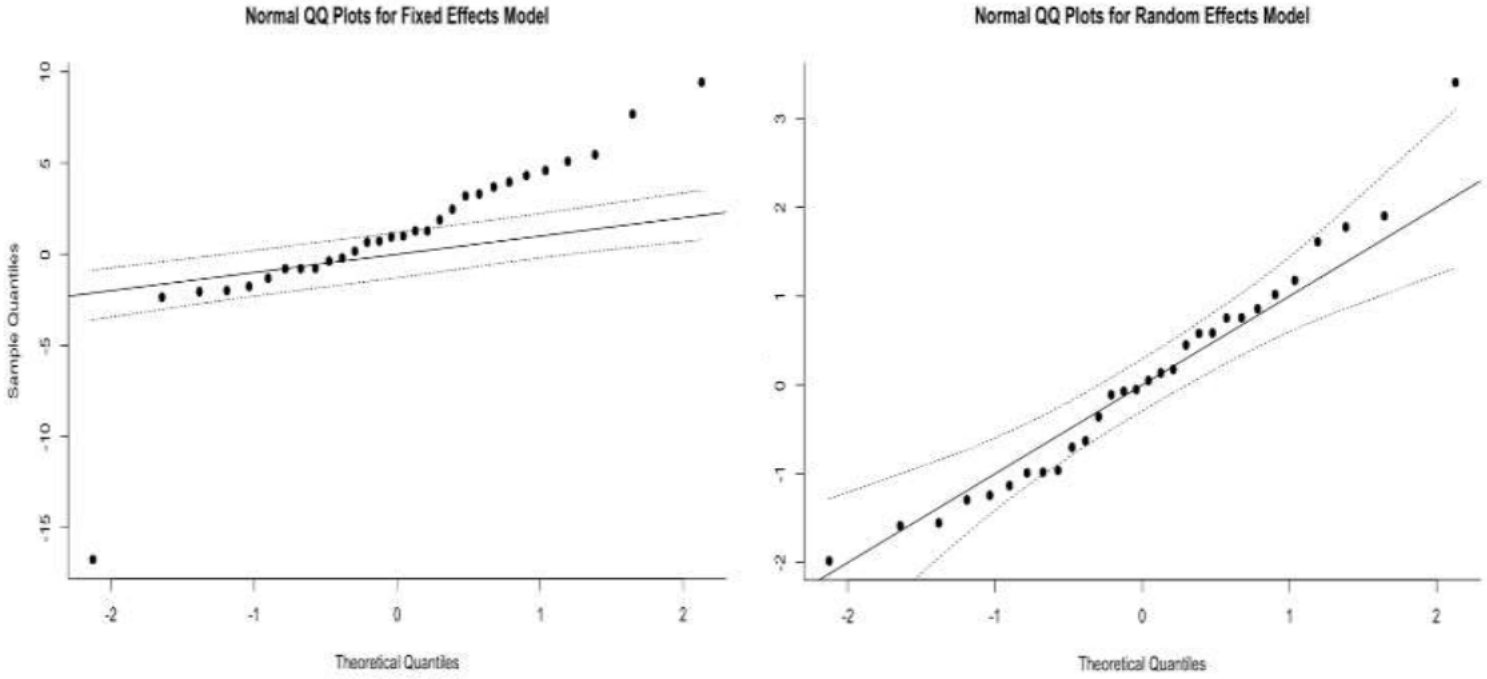
A total of 75% (22 papers) were designed to explore the question of age of ASD diagnosis for males and females, however, 25% (7 papers) provided the age of diagnosis for males and females in answering a different question. The mean age of diagnosis for participants ranged from 2.3 to 10.6 years for papers, 48% papers (14 papers) initially reported exploring if sex impacted on age of diagnosis of males and females and 31% (9 papers) explored whether gender affected the age of ASD diagnosis for males and females, furthermore 21% (6 papers) were unclear if they were exploring the impact of sex or gender on age of ASD diagnosis. In 100% or papers there was a higher proportion of males than females. The highest difference between males and females being 47,223 more males than females in Kavanaugh et al., (2021). The lowest difference in male and female participants in contrast was in Harrop et al (2021), which had only 15 more males than females. No studies reported participants who were non-binary or transgender, which is surprising considering there being higher rates of autistic people who identify as being transgender and non-binary (Strang et al., 2018; Walsh et al., 2018). The characteristics of each of the studies included in the meta-analysis is presented in Appendix B.

Selection of the Meta-Analytic Model

The distribution of differences in age of diagnosed autism between males and females is shown in Figure 1.1. The between studies variance (tau^2) was calculated using the DerSimonian-Laird estimator (DerSimonian & Laird, 1986).

Figure 1.1

Fixed Effects Model Compared to Random Effects Model



As can be seen from Figure 1.1, there is clear evidence of non-normality in the distribution of standardised mean differences when using the fixed effects model. The random effects using the DerSimonian-Laird estimator model (DerSimonian & Laird, 1986), shows a good fit to these data, and therefore the random effects model was used for the completion of the meta-analysis.

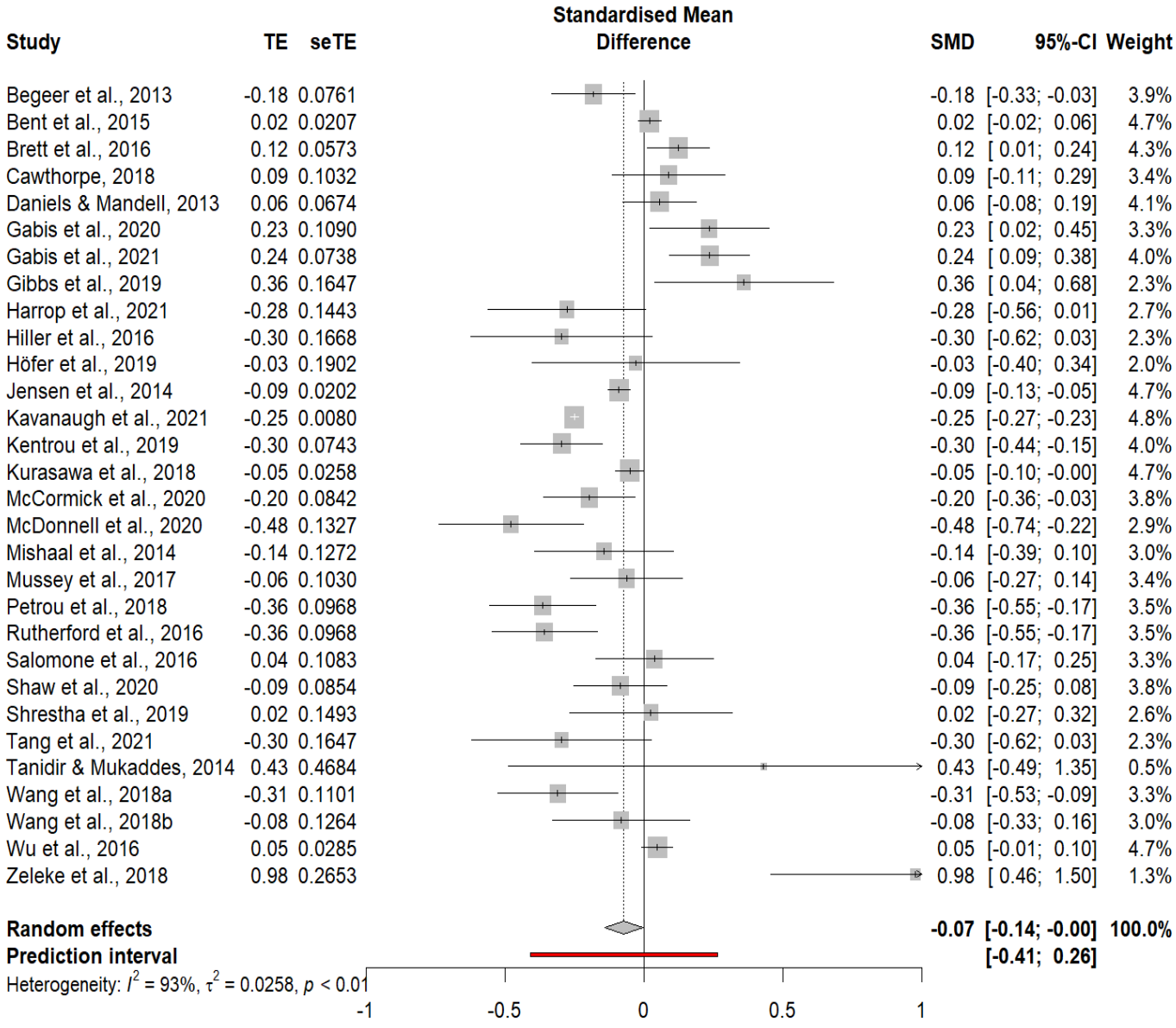
The Omnibus Test

The standardised mean differences at age of diagnosis as described in the included studies are reported in Figure 3. The effect type used in omnibus and sub-group testing was Cohen's D. A total of 147,885 participants' data were analysed and were taken from 29 studies, which described the mean age of autism diagnosis for males and females by sex or gender. However, 30 effects on the impact of sex and or gender on age of diagnosis were drawn from the 29 papers and were consequently analysed in the subsequent meta-analysis. A random effects models was calculated using the generic inverse variance method. The random effects model

(see Figure 1.2 below) returned a weighted average standardised mean difference between the age of diagnosis of males and females of -.07 (z =-2.06, $p < 0.05$) and a 95% confidence interval of between –0.14 and 0.00. Here a minus value reflects later age of diagnosis for girls.

Figure 1.2.

Forest Plot of Mean Age of ASD Diagnosis for Males & Females



Note. A negative effect value reflects earlier age of diagnosis for males.

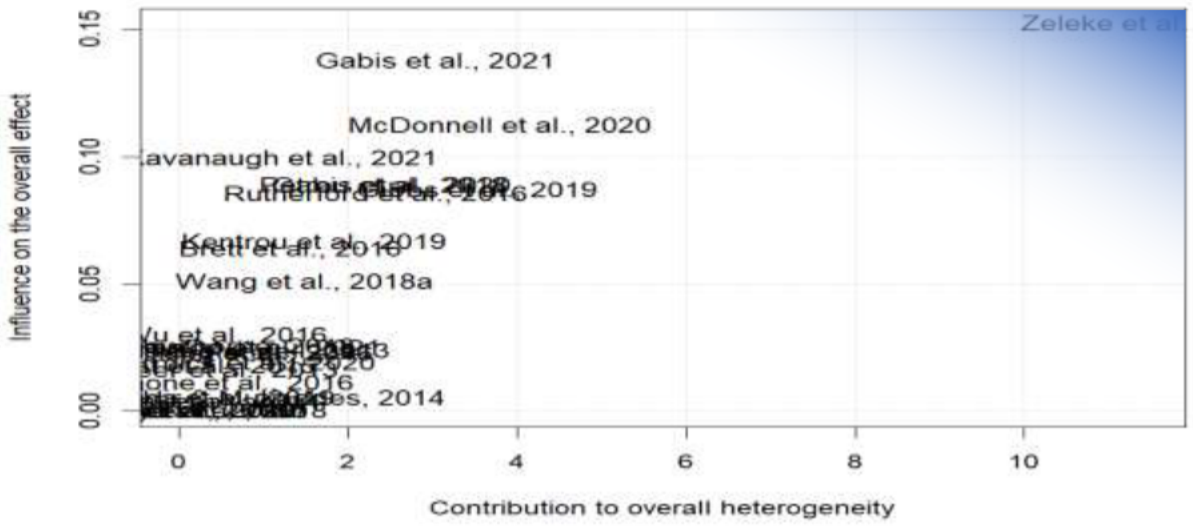
A high level of heterogeneity in the primary studies was observed (tau^2 = 0.0258, Higgins' I^2 = 93 %; Q = 425.20, $p < 0.01$), suggesting that the estimates of the difference at age of diagnosis may be influenced by the presence of uncontrolled or confounding factors. Therefore, the focus of the subsequent analyses will be upon the identification of the sources of heterogeneity between the estimates of age at diagnosis in the primary studies.

The Impact of Influential Primary Studies

The impact of disproportionately influential studies was assessed using a "leave-one-out" analysis, in which the random effects model was calculated with each of the primary studies removed in turn, and change in weighted average effect size (i.e., influence) and the change in heterogeneity (i.e., discrepancy) were recorded. The result of this "leave-one-out" analysis is presented on the Baujat plot (Baujat, Pignon, & Hill, 2002) in Figure 1.3 below.

Figure 1.3

Baujat Diagnostic Plot of Sources of Heterogeneity

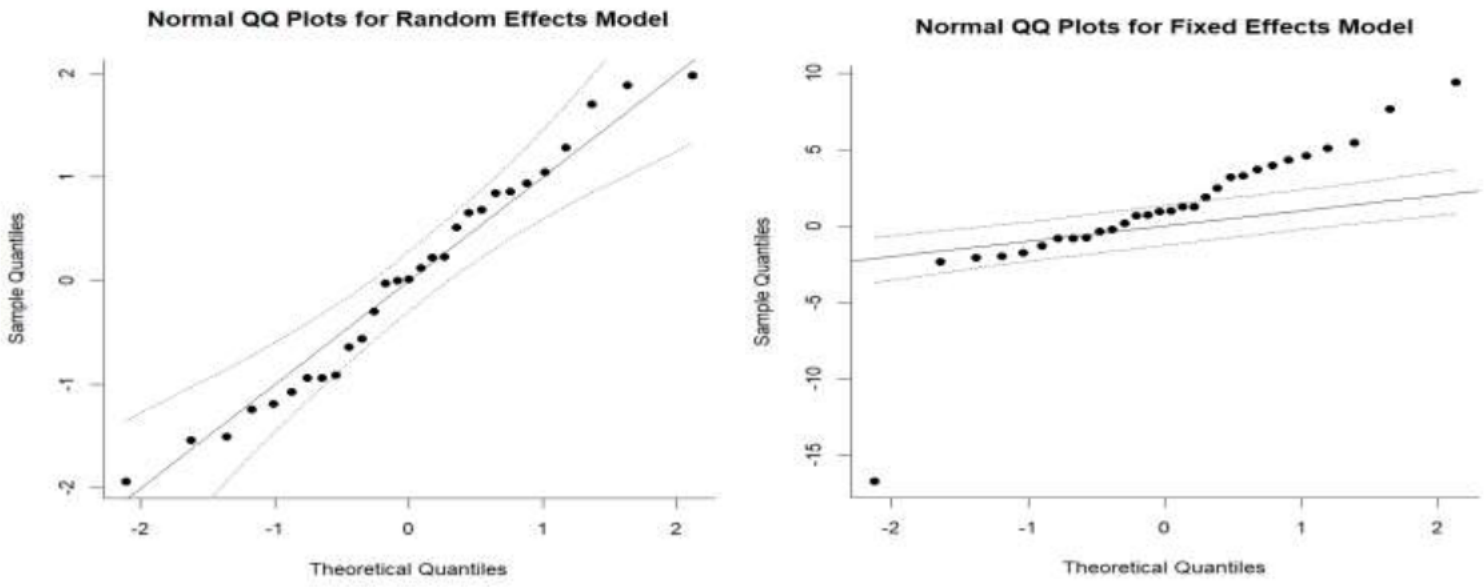


Note. The vertical axis reports the influence of the study on the overall effect and the horizontal axis reports the discrepancy of the study with the rest of the literature. The area shaded in blue would be associated with studies with highly influential and discrepant effects.

As can be seen from Figure 1.3, one of the studies (Zeleke et al., 2018) showed high overall contribution to heterogeneity and was highly influential on the overall effect. Compared to other studies, Zeleke had a small sample size (N= 97, the second smallest in the meta-analysis), but a good quality index score of 82%. Zeleke et al (2018), however compared to other papers, its findings were discrepant, as it found that males were being diagnosed later than females (males M=3.9, females M=2.3), with a mean difference of 1.6 years. Ultimately, given the extreme discrepancy and small sample, the paper was removed from further analysis. The omnibus testing, including choosing the model, leave one out test were then re-run, and as can be seen below, indicate that heterogeneity had reduced, and no other studies were now contributing above the acceptable rate of heterogeneity without Zeleke et al., (2018) included. The first test re-ran was selecting the model, which is shown below in Figure 1.4.

Figure 1.4

Selecting the Model without Zeleke et al (2018)



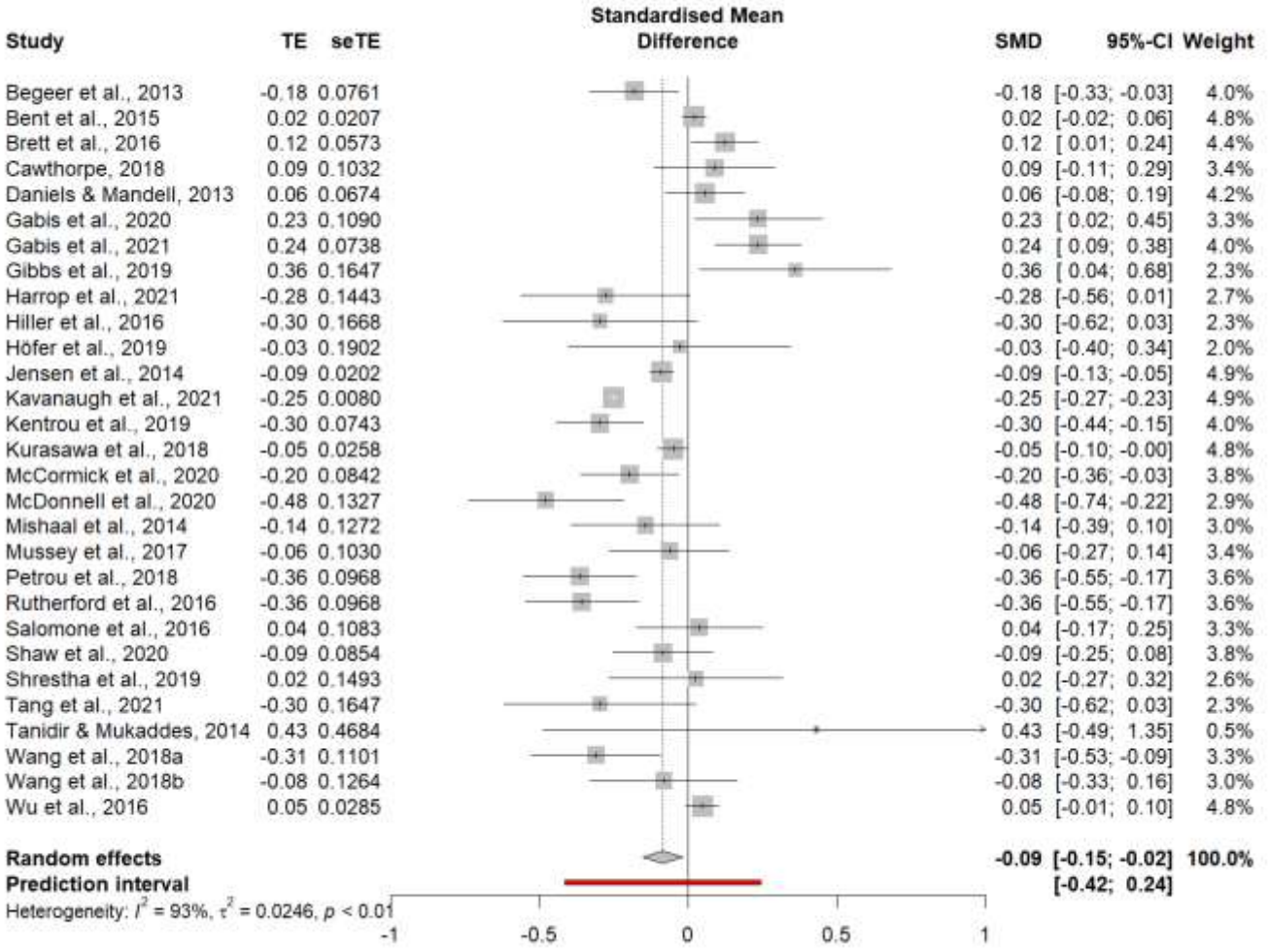
Note. Figure 1.4 shows the two QQ plot of the distribution of age of diagnosed autism between males and females within the primary studies, with Zeleke et al (2018) removed. The random effects model remained the best fit for the data.

The Omnibus Test

A random effects models was calculated using the generic inverse variance method, without Zeleke et al (2018). The random effects model (see Figure 1.5 below), suggested a weighted average standardised mean difference between the age of diagnosis of males and females of -0.09 (z = -2.47, p < 0.01) and a 95% confidence interval of between -0.15 and -0.02.

Figure 1.5

Forest Plot of Mean Age of ASD Diagnosis For Males & Females.



Note. A negative effect value reflects earlier age of diagnosis for males.

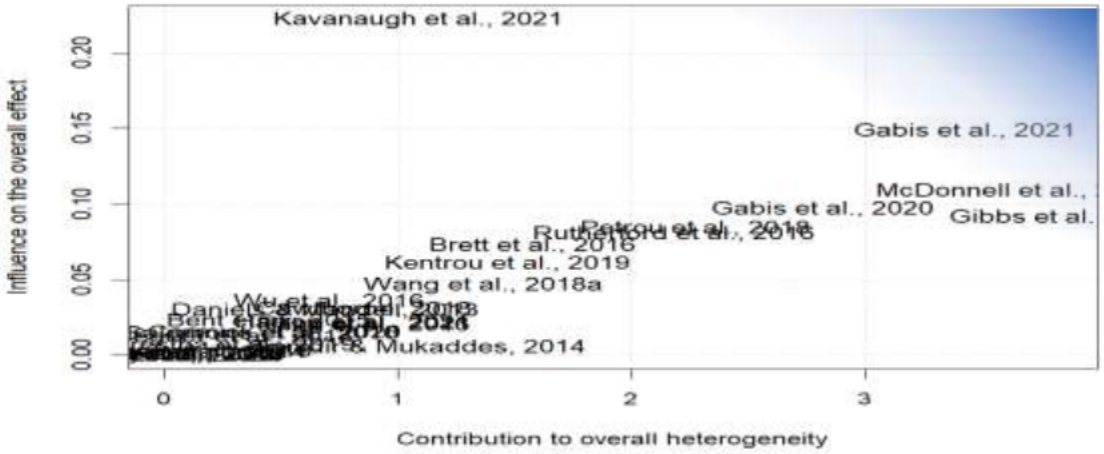
A high level of heterogeneity in the primary studies was observed (tau^2 = 0.0246, Higgins' I^2 = 93 %; Q = 406.63, p < 0.01), which was slightly lower than that observed with Zeleke et al, (2018) included (tau^2 = 0.0258, Higgins' I^2 = 93 %; Q = 425.20, p < 0.01). However, the heterogeneity without Zeleke et al., (2018), still continues to suggest that the estimates of the difference at age of diagnosis may be influenced by the presence of uncontrolled or confounding factors. Therefore, the focus of the subsequent analyses will be upon the identification of the sources of heterogeneity between the estimates of age at diagnosis in the primary studies.

The Impact of Influential Primary Studies

The impact of disproportionately influential studies was once more assessed using a "leave-one-out" analysis once more conducted without Zeleke et al (2018), in which the random effects model was calculated with each of the primary studies removed in turn and change in weighted average effect size (i.e., influence) and the change in heterogeneity (i.e., discrepancy) was recorded. The result of this "leave-one-out" analysis is presented on the Baujat plot (Baujat, Pignon, & Hill, 2002) in Figure 1.6 below.

Figure 1.6

Baujot Diagnostic Plot of Sources of Heterogeneity following Zeleke et al (2018) removal



Note: Baujat diagnostic plot of sources of heterogeneity. The vertical axis reports the influence of the study on the overall effect and the horizontal axis reports the discrepancy of the study with the rest of the literature. The area shaded in blue would be associated with studies with highly influential and discrepant effects.

As can be seen from Figure 1.6, no studies now showed high overall contribution to heterogeneity and were highly influential on the overall effect. Therefore, the omnibus test without Zeleke et al., (2018) proceeded.

Heterogeneity Relating to Study Design

To assess the impact of study level risk of bias on heterogeneity, a series of subgroup analyses were conducted on the age of mean diagnosis in males and females for the risk of bias ratings of "low risk" and "any risk" (i.e., unclear risk and high risk of bias combined), for each of the four types of methodological bias, and the results are displayed in Table 1.3 below.

Table 1.3

The Effect of Risk of Bias

	Low Risk			Any Risk				
	EFFECT	95% CI	K	EFFECT	95% CI	k	X^2	P
Selection bias	-.06	-.02;-.08	5	0-.09	.02; .01	24	.13	.72
Detection bias	-.01	-.22;.02	5	-.08	-.16;-.01	24	.06	.81
Reporting bias	-.08	-.04;.02	4	-.08	-.16-;-.01	25	.00	.98
Generalisability bias	-.28	.6; .01	1	-.08	-.15; -.01	28	1.75	.19

Note. This table shows each of studies sensitivity to the four types of potential risk of bias. The figures in the table are rounded to two decimal points.

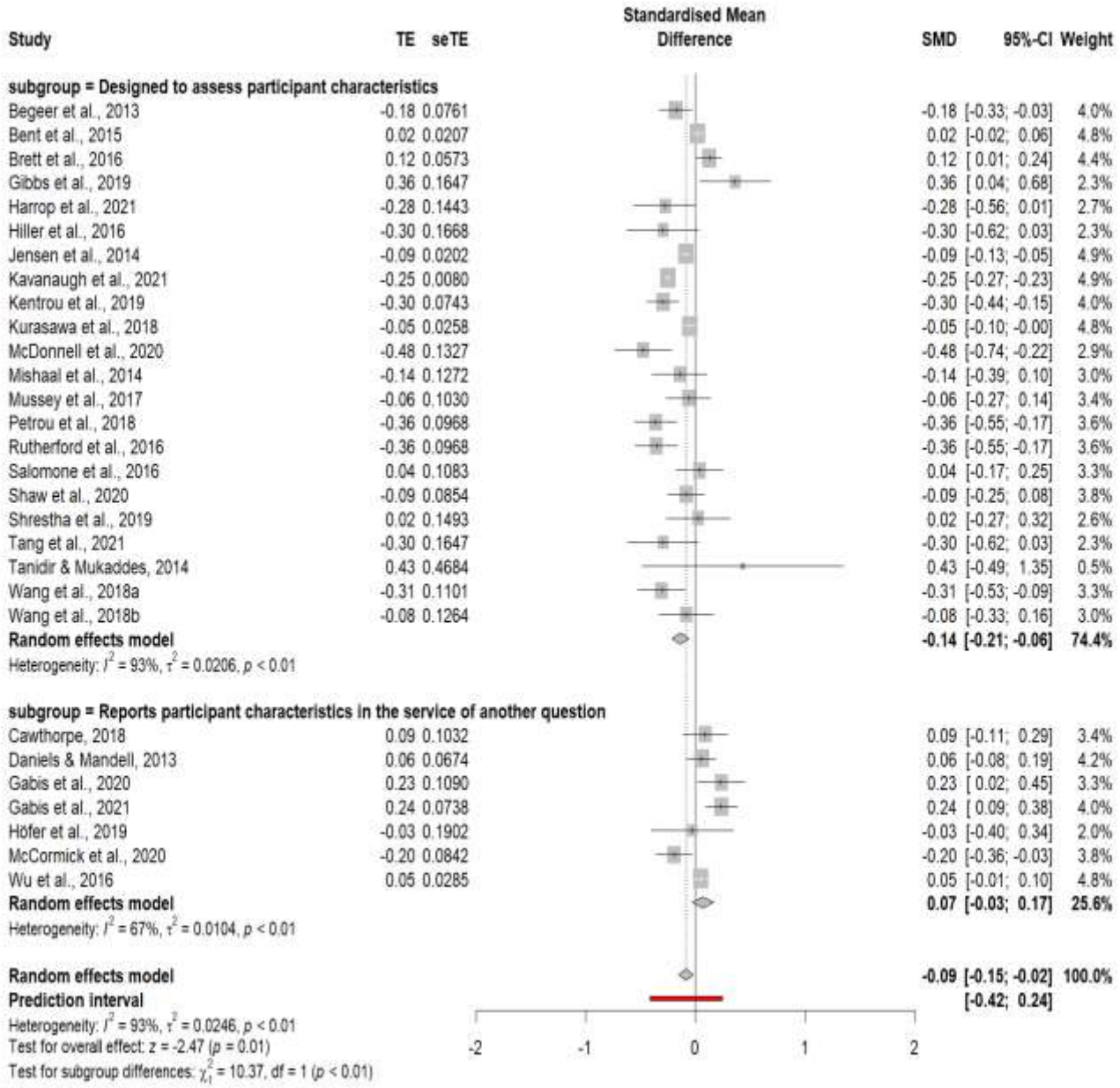
None of the four sources of bias analysed showed statistically significant differences in the estimate of the overall standardised mean difference, as can be seen from Table 1.3 above. This suggests that Risk of Bias was not primarily responsible for heterogeneity across studies.

Subgroup analysis

The included studies in the first subgroup analysis exploring if study design impacted age of diagnosis were rated as (a) the paper was designed to assess participant characteristics, or (b) the paper reports participant characteristics in the service of another question. Figure 1.7 depicts a subgroup plot of these two different types of study design.

Figure 1.7

Design of study's impact on age of diagnosis



Note. A negative effect value reflects earlier age of diagnosis for males.

Figure 1.7 above shows that there was a significant difference between the average difference in age of diagnosis between the two types of study design ($X^2 = 10.37$, $p < 0.01$). Studies reporting participant characteristics in the service of another question reported no difference between male and female age of diagnosis – if anything trending towards girls being diagnosed earlier (SMD = .07, 95% *CI*: -.03- .17). However, it should be noted that there were only seven studies that reported the age of ASD diagnosis, in the service of another question.

The next subgroup analysis below in Figure 1.8, explored whether it was gender or sex which impacted on difference in age of diagnosis between males and females. The included studies were categorised according to whether they had reported difference in mean age of autism diagnosis by (i) sex (ii) gender or (iii) if it was unclear if the paper was exploring sex or gender.

Figure 1.8

The Effect of Whether it is Gender or Sex Affected Age of ASD Diagnosis

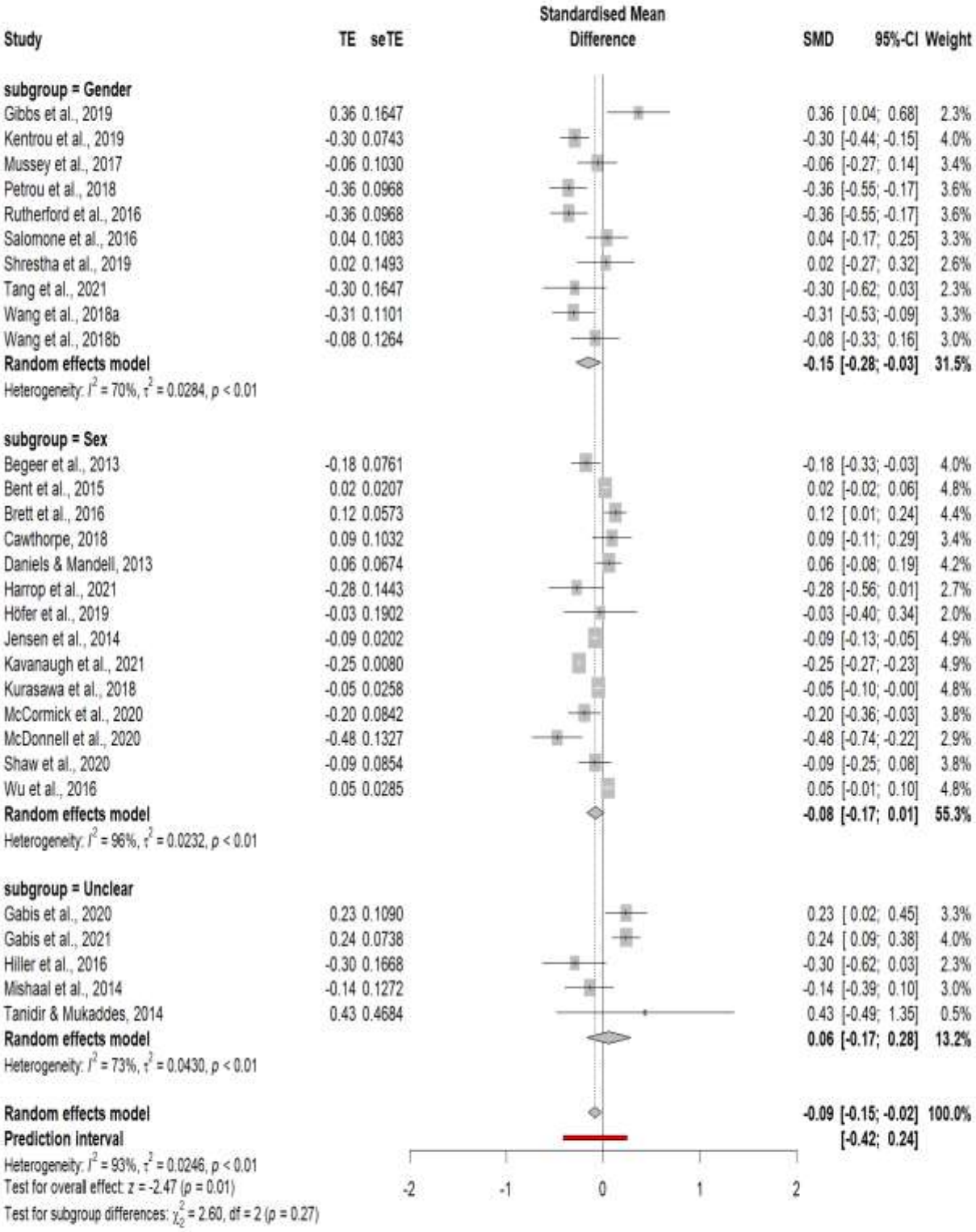
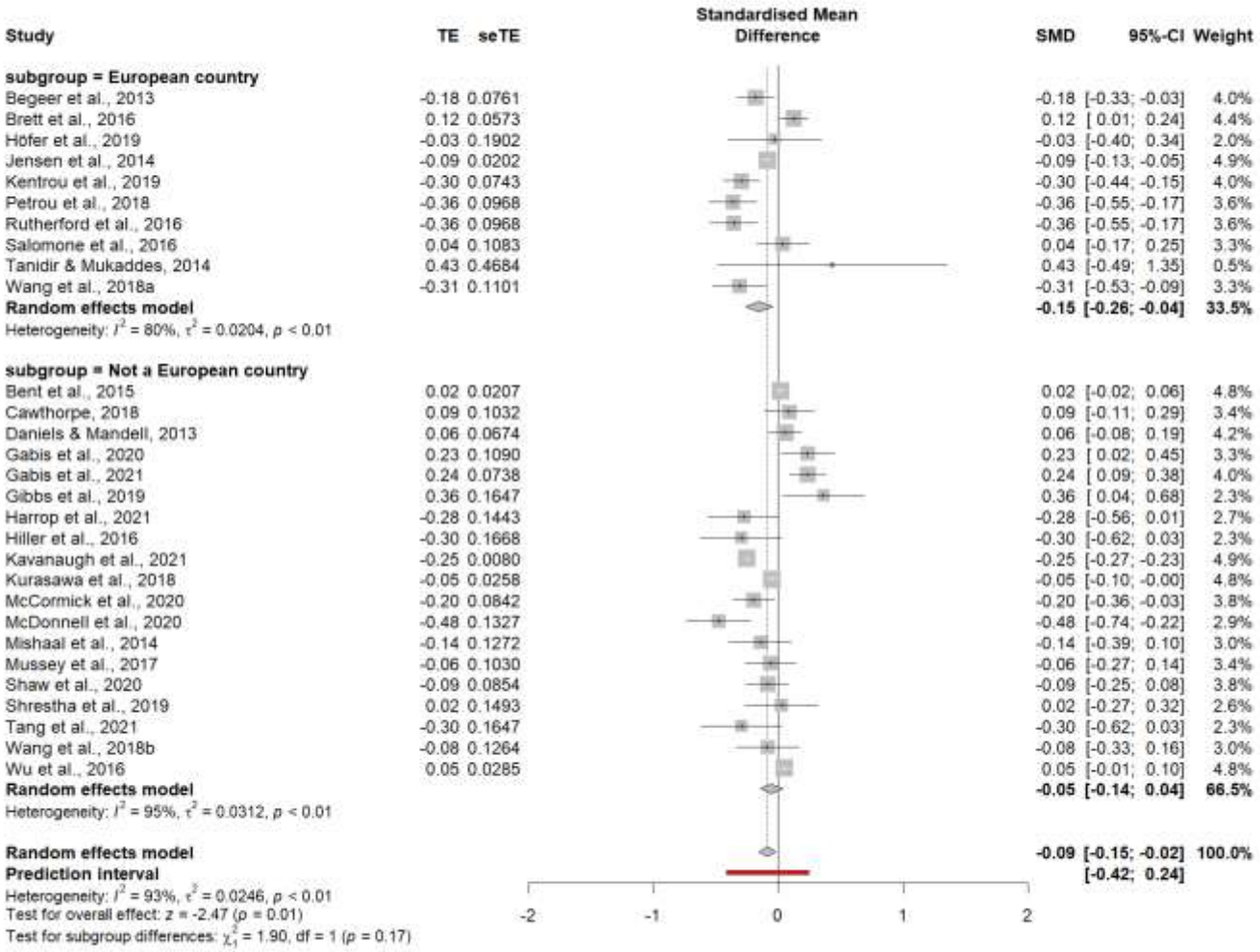


Figure 1.8 depicts that there was not a significant difference (X^2 = 2.60, p =0.27) observed, for the age of diagnosis for males and females categorised by sex compared to gender. The effect of European versus no European study origin was also tested using a subgroup analysis, displayed below in Figure 1.9. The studies were categorised by whether the country the sample was from was a (i) European country, (ii) Not a European country, (iii), to explore whether this impacted on mean age of autism diagnosis for males and female.

Figure 1.9

The impact of European Versus Non-European Study Origin on Age of Autism Diagnosis



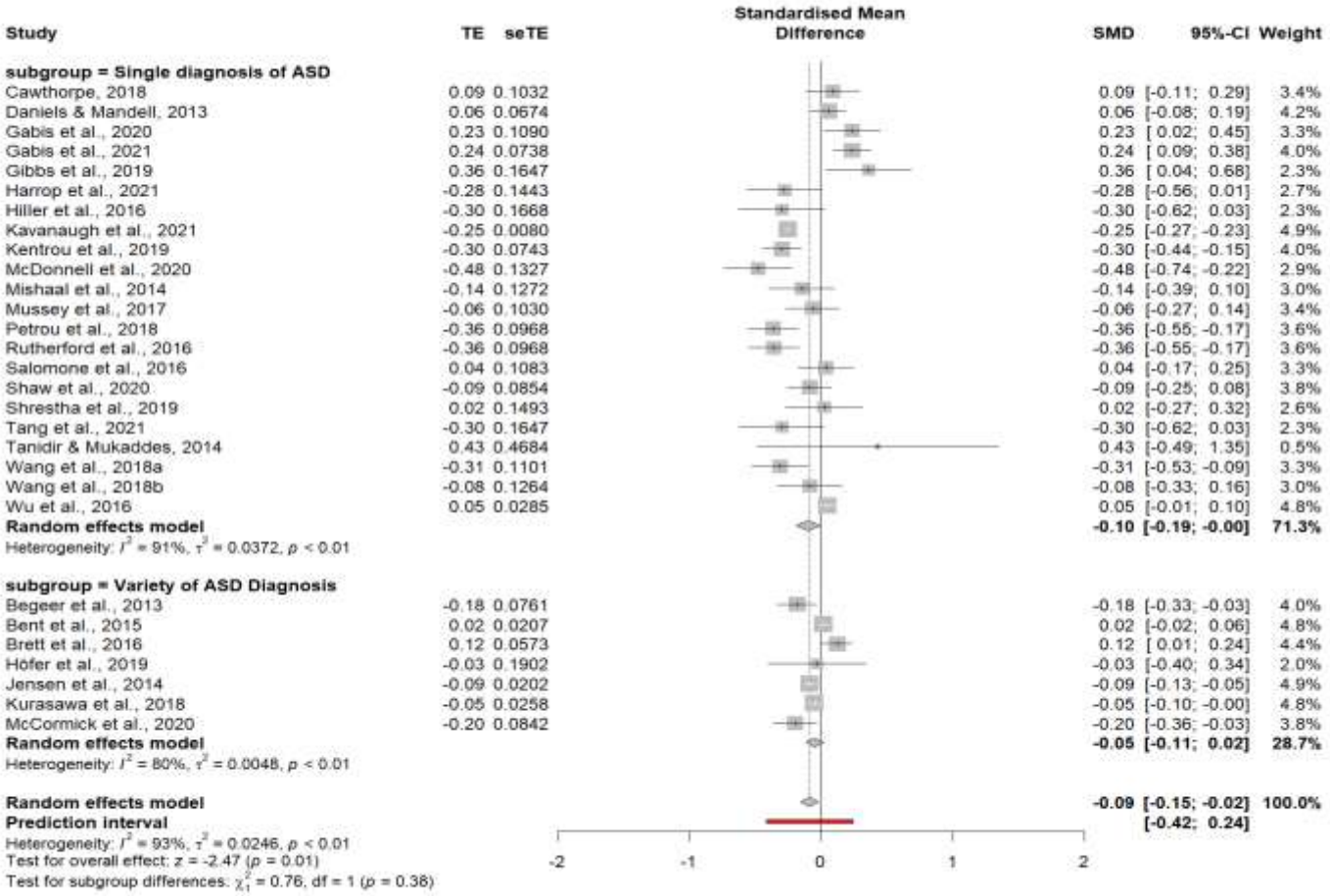
Note. A negative effect value reflects earlier age of diagnosis for males.

Figure 1.9 above, indicates that there was not a significant difference ($X^2 = 1.90$, $p = 0.17$) observed, for the age of diagnosis for males and females, when examined by whether the diagnosis was provided in a European county or not.

The studies were additionally analysed by the type of diagnosis of autism, and whether this impacted on mean age of autism diagnosis for males and female, which is shown below in Figure 1.10. The type of diagnosis was categorised as either classified as (i) single autism diagnosis (ii) variety of autism diagnoses.

Figure 1.10

Type of ASD Diagnosis effect on Age of Autism Diagnosis Between Males & females



Note. A negative effect value reflects earlier age of diagnosis for males.

Figure 1.10 indicates that there was not a significant difference (X^2 = 0.76, p = 0.38) for the age of diagnosis for males and females, regarding type of autism diagnosis reported the autism diagnosis.

Results Summary

To summarise, there was a significant difference in age of diagnosis between males and females, with males being diagnosed earlier than females. No effects were found from the subgroup analysis, which could explain the heterogeneity of the model. A weighted average mean average was also conducted on the means of all the studies data for age of diagnosis for males and females. The overall weighted mean age of ASD diagnosis for males of all the studies (without Zeleke et al., 2018) was 4.8 and for females was 5.6 years of age.

Discussion

The aims of this meta-analysis were: (i) Conduct a systematic search of the literature on age of ASD diagnosis by gender and sex in children, using a more comprehensive set of search terms than previously used and across four databases, (ii) perform a meta-analysis to determine if a significant difference in age of diagnosis is found due to sex and/ or gender in children. (iii) clearly define between papers (where possible and indicating when not possible), which explore gender compared to sex, and their impact on age of ASD diagnosis. (iv) Conduct analysis to explore the heterogeneity, on data which required further exploration (country of origin and type of ASD diagnosis), as suggested by former literature. The first aim was addressed in the systematic search of the literature conducted and described in the method section. The second aim was met by completing a meta-analysis using the inverse variance method and a random effects model on the data found by the systematic search. The third aim was addressed by splitting studies in the meta-analysis by whether they were reported to explore sex or gender, or whether this was unclear/not defined by the authors. The fourth aim was met using leave one out analysis, and through subgroup analyses, in the attempt of explaining the high heterogeneity, assessing if it was due to autism diagnosis, country, sex or gender, risk of bias factors or study design.

Loubersac et al., (2021) found that the mean age of diagnosis across papers ranged from 2.2-9.8 years of age and Van't Hof et al., (2021) determined that the mean age of diagnosis was between 2.58- 6.23 years of age. The present meta-analysis found across its own papers that the mean age of diagnosis ranged between 2.3 years and 10.6 years of age. The range of mean age of diagnosis across papers was similar to Loubsersac et al (2021), and less similar to Van't Hof et al., (2021), and the wider range of ages is likely due to the larger range of papers not found by the two former meta-analysis due to the more robust search strategy used by the

present meta-analysis. This is as the present meta-analysis used a more robust set of search terms than previous meta-analysis (Loubersac et al., 2021; Van't Hof et al., 2021), and was conducted across four databases. However, this paper like Loubsersac et al., (2021) and Van't Hof et al (2021) collected the data from prior papers on this subject and completed further secondary analysis across papers, based on a set inclusion and exclusion criteria and a systematic search. This led to this paper finding 29 papers for the meta-analysis, and 30 effects. Following Zeleke's removal, 28 studies and 29 effects remained in the meta-analysis, which is still a larger number of papers than either of the former reviews 14 and 22 respectively (Loubersac et al., 2021; Van't Hof et al., 2021). The larger number of papers, and consequently participants, was due to the more robust search strategy applied, including an increased number of search terms, and searching more databases than the former studies (Loubersac et al., 2021; Van't Hof et al., 2021).

The overall weighted mean age of diagnosis for females across the 28 papers was 4.8 for males and 5.6 for females. The random effects model suggested a significant difference between the age of diagnosis of males and females, which supports the prior empirical findings of (Giarelli et al., 2010; Rutherford et al., 2016; Salomone et al., 2016) who using samples taken from clinical databases analysed data to determine if there was a difference between males and females in the age of ASD diagnosis based on sex or gender and all found a significant difference with males being found to be diagnosed earlier than females. The results of this meta-analysis (finding a significant difference between males and females in age of ASD diagnosis) are not in line with former meta-analysis by Loubersac et al (2021) and Van't Hof et al (2021), however, it is believed that this could be due to the former studies (Loubersac et al., 2021; Van't Hof et al., 2021) having conducted meta-analysis using fewer studies, due to the aforementioned limitations in their search strategies. Furthermore, from reading the papers reviewed, the terms sex and gender were used interchangeably, confusing the matter of

whether Loubersac et al (2021) reviewed papers which explored the impact of gender, or sex, on the age of ASD diagnosis.

However, this paper did not find a significant difference between how sex and gender separately impact on age of diagnosis in males and females, this could be due to poor reporting, as following Zeleke's removal (with 28 papers and 29 effects for analysis) 18% of papers (five papers; Gabis et al., 2020; Gabis et al., 2021: Hiller et al., 2016; Mishaal et al., 2014; Tanidir & Mukaddes., 2014) were unclear in how/whether they were reporting sex and/or gender, as they used the terms sex and gender interchangeable and did not clearly define how sex/gender were measured, therefore it could not be determined what was likely being meased. In comparison 50% (14 papers) reported exploring if sex impacted on age of diagnosis of males and females and 32% (9 papers), collected this data from databases coded with demographic details from assessment. The five unclear papers lost 18% of data which could have been analysed in the meta-analysis to define if sex and or gender impacted on age of diagnosis, which may be why a difference could not be found. In addition, it should be noted that no papers described asking the child their gender. As discussed previously, the best form of measurement for gender is to ask the person with what gender they associate with (WHO, 2002). Therefore, it is supposed that this data was gathered from parent report, or assumed based on sex. Thus, this data may not be accurate and strengthens the case for correct measurement of gender in future research and for research to specify how gender is being measured, to determine if it is being measured accurately. In addition, when considering these findings, it should be considered that the average age of diagnosis across papers was between two to 10 years of age. Sex typing does not occur until three years of age (Bem, 1981), and gender roles continue to form during school (Endendijk et al., 2018), therefore especially on the lower end of the diagnosis level (2-4 years of age) it is unlikely that children could/would know the words to communicate that they identify as another gender at this age (despite having

begun the sex-typing process), therefore parents or children may not be aware of being gender diverse, and in turn are not able to communicate this to researchers. This further makes it unclear if sex and gender reported in papers was accurate, which may explain why a significant difference between sex and gender finding in age of diagnosis was not found. Methods of research which build on the difficulties noted in this paper for determining if it is sex and gender which impact on age of diagnosis will now be discussed.

Limitations & Areas for Future Research

To improve the accuracy of recording gender in the future, research could be conducted in an adult population, examining the effect of whether it is sex or gender which effect the age of ASD diagnosis in an adult population. An adult population should be used as self-report of gender could be gathered from the person and accuracy in reporting would be more likely due to adult persons likely having increased communication skills, compared to two to ten year olds, and this would help researchers ensure that gender is being recorded correctly. Therefore, a meta-analysis exploring whether age of ASD diagnosis is impacted by sex and or gender using papers exploring the age of diagnosis in an adult ASD population is advised.

In addition, neither the leave one out analysis, nor subgroup analyses, explained a substantial proportion of the high heterogeneity of the model. A further limitation of this study was that for one study (Wang et al., 2018), two effects were used from one paper; this split was made as one sample of the empirical research conducted to explore age of ASD diagnosis was taken from a clinical database storing data from the Netherlands (a European country) and the second from a Chinese database (a non-European country), and individual means for each country for males and females were presented. However, using two effects from one paper may have reduced the variance in full sample – though notably heterogeneity remained very high despite this.

Secondly, the risk of bias ratings and search were reviewed and repeated to ensure reliability, however a second researcher due to timing and availability was unavailable to review the risk of bias criteria, paper screening, and the systematic search, therefore the inter-rater reliability of this meta-analysis could be in question. Consequently, it would be advised that future research on this topic area ensures that a secondary researcher reviews the risk of bias ratings, paper screening and systematic searches; to ensure inter-rater reliability.

Furthermore, this meta-analysis had an inclusion criterion of only including literature which had been peer reviewed. This decision was made as peer reviewed literature has been reviewed by academic peers regarding quality of its results and of the study (Quintana, 2015). Therefore, it was hoped the literature reviewed and findings would be less likely to be biased or have errors, as it had been peer reviewed. This was important to consider as this meta-analysis results are dependent on the papers' reviewed results being accurate and reliable. However, by making this decision the meta-analysis did miss out on the "grey literature" (non-peer reviewed papers) and could have been subject to the "file draw effects" which is when papers are not published in peer reviewed journals, as they did not find a significant or strong enough effect (Quintana, 2015). Although, in this case it should be noted that the papers published did not all find a significant effect and therefore it is hoped this effect would have been at a minimum. Although, this could still be a limitation of this paper and thus future research on this topic area should include grey literature, to ensure the file draw effect did not impact on this studies results.

Furthermore, the overall quality of the papers was low, despite being peer reviewed, as indicated by the risk of bias analysis. Therefore, the papers themselves being of low quality may limit the confidence which can be taken in the results found, but also indicates that the quality of studies in this area of research requires improvement. Future research should subsequently aim to improve the quality of studies, specifically in the areas of detection and

generalisability which were reported as the highest risk of bias in papers assessed in this meta-analysis.

An additional choice made was to include papers (Daniels & Mandell, 2013; Gibbs et al.. 2019; Kentrou et al., 2019; Rutherford et al., 2016; Shaw et al., 2020; Zeleke et al., 2018), in which the method of ASD diagnosis was unclear. This choice was made as having more data was felt to be useful in looking for an effect if there was one to be found in the data. However, this choice may have led to papers being reviewed by participants who self-diagnosed. Therefore, future research in this area should be clearer in describing the method of autism diagnosis, as this can help future meta-analysis and reviews in inferring which studies to use, when exploring autism spectrum disorder as a subject matter.

In addition, five papers were unclear in reporting if they were exploring sex or gender (Gabis et al., 2020; Gabis et al., 2021: Hiller et al., 2016; Mishaal et al., 2014; Tanidir & Mukaddes., 2014), and overall papers were often not clear in how they determined participants' sex and gender. As previously discussed, sex and gender are different concepts (WHO, 2002) and require reporting as such. Papers overall, were mixed in their reporting of these terms, and used them interchangeably. A key point for future research in this area is the accurate and concise use of the terms sex and gender, and explanation of how sex and gender were recorded. Papers also did not report any participants being non-binary or transgender, despite research indicating that autistic people are more likely to identify as transgender or non-binary than neuro-typical population (Strang et al., 2018; Walsh et al., 2018). Thus, why this group has been missed by present research, requires further exploration and research i.e., was this due to age of the children studied, or was this population missed through not measuring gender by asking participants.

Clinical Implications

Despite limitations to this meta-analysis and the literature reviewed, there are clinical implications which can be taken from the findings. As girls were diagnosed at a later age than boys, at the school-level, more attention should be paid to girls in schools to assess if they meet criteria for ASD. Particularly attention should be paid to girls presenting as "shy", a "feminine" a personality trait which is more acceptable in girls than boys, and the 'shy' girl may be autistic and miss early assessment and thus diagnosis due to societal expectations of girls (Lai & Szatmari, 2017). This is as at a societal level, gender roles have been shown to influence the identification of ASD in females, as placidity (a feminine personality trait) is more acceptable in girls than boys (Lai & Szatmari, 2017). Further, children and teachers are primed to see such gendered personality traits as "normal" for girls (Bem, 1981), and this can cause difficulties when screening for ASD. However, as greater social expectations are also placed on female children, i.e., they have been observed to be expected to talk and socialise in smaller groups during play, (Kreiser & White, 2014), these social interactions are a prime opportunity for teachers to observe girls' interactions and communication, to look for signs of difficulties which may warrant an ASD assessment. In addition, teachers and parents should be aware that screening for girls with ASD can be more difficult, due to camouflaging and masking used by females due to societal expectations (Hull et al., 2017). Therefore, training should be sought and provided to parents and teachers from the NHS to enable better identification of the more subtle ways in which autism can present in girls, improving efficiency of screening, and leading to earlier diagnosis, which will then help reduce the more costly secondary interventions to the NHS at later dates (Fernell et al., 2013; Koegel et al., 2014).

In addition, at a clinical level, education and training may also be required in assessing and diagnosing girls with autism, due to the criteria being based on male presentation (Asperger, 1944; Kanner, 1943), to ensure that at a clinical level diagnosis happens at the

earliest point possible and is not missed. The early and correct identification of ASD is important when children access services, as service access itself is dependent on the geographical location of the child and their family, the local area resources for ASD assessment and policies can positively or negatively impact the child's access to ASD assessment and thus support or impede an early ASD diagnosis (Daniels & Mandell, 2014). This is despite the NHS founding aim to be to provide universal, equitable and high-quality health free care for all (O'Dowd, 2023). However, recent challenges including a global pandemic and shortage in staff due to pay disputes and burnout, in addition to insufficient service funding for the growing populations needs from the present government, has put more burden on NHS service (O'Dowd, 2023). Once more, training would likely be useful at a clinical level, but this must be considered in wider pressures in the NHS context, therefore internal training would likely be most cost effective and possible during these turbulent times. This internal training could be completed by a clinical psychologist in the service, who has specialist knowledge in how ASD can present differently in females.

Furthermore, due to the high rates of ASD in transgender and non-binary children (Strang et al., 2018; Walsh et al., 2018) the sex and gender distinction in ASD diagnosis is particularly important and clinicians should be aware of the potential impact of sex and gender on the diagnosis process. This is as research has found that gender identity is more varied among autistic people than in the general population, and ASD is three to six times as common in gender diverse than general population (Warrier et al., 2020). Gender unlike sex is not based on anatomy and thus efforts to ask and explore a child's gender identity when completing an ASD assessment is important at a clinical level (Dattaro, 2020), due to the higher rates of gender diversity in the neuro-diverse than general population (Strang et al., 2018; Walsh et al., 2018). Furthermore, ASD was first studied in males and as prevalence rates remain higher in males than in females (Russell et al., 2011; Russell et al., 2022), it is thus hypothesised that

ASD criteria and screening tools are more in line with societally noted male behaviours (Lai & Szatmari, 2017). Therefore, present screening tools and criteria are arguably not equipped to be assessing female presentation of ASD (Lai & Szatmari, 2017), nor for gender diverse children (Dattaro, 2020), as no gender-diverse children or females were assessed when the initial criteria for ASD was defined by Asperger and Kanner (Asperger 1944; Kanner 1943). Therefore, to further improve early identification of ASD in male/ female and gender diverse children, the tools used for screening for ASD further need assessment to ensure they are considering the differing presentations in these groups.

Additionally, services may benefit from completing a local-level service evaluation to assess if there is disparity in the age of autism diagnosis between girls and boys within services, again being the most cost-effective and viable method for NHS research presently (O'Dowd, 2023) and would ensure that geographical differences in resources and local ASD policy (Daniels & Mandell, 2014) are considered. If differences in age of diagnosis between girls and boys is found by services, then exploration into what reasons may be causing this difference would be useful at the local clinical level, but also could inform future research directions. As ultimately, despite the likelihood of prevalence rates in boys continuing to be higher than in girls (Loomes et al., 2017), the early identification of ASD in either gender/sex is crucial due to the benefits early diagnosis brings. This would not only be beneficial for clinical systems (Fernell et al., 2013; Koegel et al., 2014) such as the NHS who are already under great financial and resourcing burden (O'Dowd, 2023), but also for children and their families (Baker-Ericzyn et al., 2005, Koegel, 2000; Landa, 2018; NICE, 2013).

Summary

In summary, girls were shown by this meta-analysis of standardised mean difference to be diagnosed later, on average, than boys. The average age of diagnosis across the papers for girls was shown to be 5.6 compared to 4.8 years of age for boys. This finding was not found by prior meta-analyses in this area (Loubersac et al., 2021; Van't Hof et al., 2021), likely due to the current meta-analysis assessing a higher number of papers and implementing a more robust search strategy. The meta-analysis showed high heterogeneity, which could not be explained. Further, it used studies that were appraised as being of inconsistent quality. Areas potentially warranting improvement through future research included attention to sample generalisability and detection bias (i.e., citing how autism was diagnosed). However, the current paper does indicate areas for future research and clinical implications, including the importance of not using the terms 'sex' and 'gender' interchangeably, using an adult population and ensuring inter-rater reliability of the methodology. In addition, the importance of further training for teachers, parents, and clinicians in assessing girls with autism, provided by the NHS and review of the present screening tools accuracy for female and gender diverse presentations is recommended. This paper also advises local service evaluations as the most cost effect method in the current NHS climate in determining why there is a difference in the age of autism diagnosis for boys and girls.

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Chapter 2

DO AUTISTIC TRAITS MEDIATE THE RELATIONSHIP BETWEEN SLEEP DIFFICULTIES, LONELINESS AND MENTAL WELL-BEING?

Abstract

Background

Autistic traits have been found to predict sleep difficulties and correlate with loneliness and mental well-being. Existing evidence has not looked at these relationships alongside one another.

Method

Cross-sectional questionnaire data were collected through an online survey. A total of 205 undergraduate students completed questionnaires measuring sleep difficulties, loneliness, mental well-being, and autistic traits. Data were analysed using three spearman rho tests and two boot-strapped mediation models.

Results

Autistic traits and loneliness positively correlated with sleep difficulties, while mental well-being negatively correlated with sleep difficulties. Autistic traits fully mediated the relationship between sleep difficulties and loneliness and mediated the relationship between sleep difficulties and mental well-being, but only partially.

Discussion

This study was the first to find that autistic traits mediate the relationship between sleep difficulties, loneliness, and mental well-being. Longitudinal research is required to explore causality. Clinical implications discussed include the importance of sleep and mental well-being interventions, and screening for autistic traits in the student population.

Introduction

Research into sleep difficulties is warranted by the prevalence of this issue. The National Institute of Health and Care Excellence (NICE) state that around a third of adults from western countries report experiencing sleep difficulties once a week (NICE, 2022). Sleep difficulties include issues with initiation, duration, maintenance, and quality of sleep (Muzni et al., 2020). In addition to being highly prevalent, sleep difficulties impact negatively on physical health and link to a higher risk of mortality (Liu et al., 2017). Sleep difficulties have also been found to predict mental health difficulties, including depression, anxiety, psychosis, and alcohol abuse (Hertenstein, 2019). Sleep difficulties also relate negatively with mental well-being i.e. poorer sleep quality reduces mental wellbeing (Graham et al., 2021), and to an increased risk of suicide (Liu et al., 2020). Two specific populations who experience disproportionate frequencies of sleep difficulties are people with higher levels of autistic traits (Hochard et al., 2020; Merikanto et al., 2019; Salmela et al., 2019; Stewart et al., 2020; Tsai et al., 2021) and university students (Lund et al., 2010). Autistic traits, remain a contentious concept and their relation to Autism Spectrum Disorder (ASD) is widely debated (Mottron & Bzdok, 2020; Sasson & Bottema-Beutel, 2022).

Autism Spectrum Disorder and Autistic Traits

ASD is a lifelong neurodevelopmental condition, characterised by difficulties with social interaction, communication, and restricted interests and/ or repetitive behaviour, which negatively affects a person's daily life (American Psychiatric Association [APA], 2013). Alongside looking at ASD as a condition, a growing body of research has investigated the day-to-day functioning of people with 'sub-threshold' autistic traits in the general population (Mottron & Bzdok, 2020). Sub-threshold autistic traits are defined as features of ASD, including difficulties with social interaction and communication, which do not meet clinical

criteria for ASD, as classified by the Diagnostic and Statistical Manual fifth edition ([DSM-V], American Psychiatric Association, 2013) or the International Classification of Diseases tenth edition ([ICD-11], World Health Organisation [WHO], 2019). Autistic traits are measured by questionnaires such as the Autism Quotient ([AQ], Baron-Cohen et al., 2001) or the Social Responsiveness Scale (Constantino et al., 2002). As autism symptomology can be measured as a quantitative trait, researching the relationship between such traits and other factors allows for the development of plausible hypotheses about autistic people and the difficulties they experience (Sasson & Bottema-Beutel, 2022). One such hypothesis relates to sleep difficulties. People with high levels of autistic traits have been found to report more sleep difficulties than those with lower levels of autistic traits (Stewart et al., 2020). This relationship not only allows us to identify those most likely to experience sleep problems, but also to improve our understanding of why sleep problems are so prevalent in autistic people.

Autistic Traits, and Sleep Difficulties

Sleep difficulties are among the most commonly reported difficulties experienced by adults with autism, with a reported prevalence rate of up to 79% (Gotham et al., 2015). The factors which are theorised to underly sleep difficulties in autistic people are thought to be bio-psycho-social (Richdale & Schrek, 2009). The biological factors which are hypothesised to impact negatively on sleep quality in autistic people compared to the general population include circadian rhythm disruption, melatonin uptake, and genetic factors that alter brain structure and biochemistry (Richdale & Schrek, 2009). In addition, psychological or behavioural characteristics such as anxiety and hyperactivity, which often commonly co-occur with ASD, are also negatively associated with sleep difficulties (Richdale & Schrek, 2009). Furthermore, social factors in the home such as bedtime routine, are also hypothesised to play a role in sleep difficulties experienced by autistic people, as autistic people are said to be less able to note the social cues suggesting it is time to sleep (Richdale & Schrek, 2009). The complex interactions

between these bio-psycho-social factors underlying sleep difficulties in autistic people, however, are not clearly determined and thus this remains an evolving field. An additionally related growing research field is the relationship between autistic traits and sleep difficulties. A small number of recent studies have explored the relationship between autistic traits and sleep difficulties in adults (Cox et al., 2022; Hochard et al., 2020; Stewart et al., 2020), and found higher levels of autistic traits, predicted increased level of reported sleep difficulties, finding a positive relationship between the two factors. Understanding this mechanism requires further data, but it is likely that at least part of this reflects the overlap of psycho-social traits experienced by autistic people and those with subthreshold traits.

Sleep Difficulties, Mental Well-being, Loneliness and Autistic traits

A second widely researched factor related to autism is mental health. A meta-analysis, which identified papers reporting on the prevalence of psychiatric conditions (as defined by Lai et al., 2019) in autistic people, found that 96 studies had explored this topic (Lai et al. 2019). All studies exploring the relationship between mental health difficulties, and ASD, found that mental health difficulties, were more prevalent in autistic adults than the general population (Lai et al., 2019), suggesting that autism may lead to mental health difficulties. Several studies, in the last ten years, have additionally explored the relationship between autistic traits and mental health in adults (Beck et al., 2020; Geurts et al., 2016; Lundström et al., 2011; Oshima et al., 2014), and mental health conditions have also been found to be more common in adults with autistic traits (Beck et al., 2020; Geurts et al., 2016; Lundström et al., 2011; Oshima et al., 2014), suggesting that higher levels of autistic traits increase the likelihood of a person developing mental health conditions.

Mental health is part of the wider multifaceted concept of mental well-being (Bond et al., 2012). Mental well-being is composed of factors including positive emotions (i.e., happiness), life satisfaction, positive psychological functioning, sense of accomplishment,

meaningful activity, and positive relationships with self and others (Bond et al., 2012). Thus, a person can experience mental health difficulties, but still have 'good' mental well-being (Weich et al., 2011). However, there is a lack of evidence regarding the relationship between the wider construct of mental well-being and autism (Maitland et al., 2021; Perry et al., 2021). The limited evidence base suggests that autistic people who feel part of a social group have higher self-reported levels of mental well-being (Maitland et al., 2021). Stigmatisation due a ASD diagnosis, can lead to self/societal exclusion from social groups and reduced mental wellbeing (Perry et al., 2021). Only one study (Stimpson et al., 2021), has explored the relationship between autistic traits (using subscales of the Broader Autism Phenotype Questionnaire) and mental well-being (using the Warwick Edinburgh Mental Well-being Scale) in adults. Stimpson et al (2021) found that one subscale (aloofness) of the BAPQ a measure of autistic traits (independent variable) negatively correlated and was able to alone predict a significant amount $(b = -4.57)$ of mental-well-being (dependent variable) using linear regression models (Stimpson et al., 2021).

Mental well-being has also been found to negatively relate to sleep difficulties (Graham et al., 2021; Trabelsi et al., 2021), with sleep difficulties being the independent variable predicting poorer mental well-being (dependent variable) in both students (Graham et al., 2021) and older adults (age 56-80; Trabelsi et al, 2021). However, the mechanism for how this occurs has not been determined. One mechanism that has been suggested is that sleep difficulties negatively impact the processing of negative emotions- a key part of mental well-being (Baglioni et al, 2010). One such negative emotion is loneliness, loneliness occurs when there is a disturbance between the hoped for and actual degree of social interaction a person has access to (Christiansen et al., 2016). Loneliness is therefore linked to mental well-being, due to the importance of positive relationships with others (Bond et al., 2012). Hom et al., (2020) meta-analysed 84 cross sectional and longitudinal studies exploring the relationship between

sleep quality and loneliness and found that sleep difficulties (independent variable) increased feelings of loneliness (the studies dependent variable). Cacioppo et al (2002), conducted a controlled double bind laboratory study, measuring sleep quality using a night cap sensor and asked students to self-report their loneliness (Russell et al., 1980). Sleep difficulties as an independent variable predicted loneliness the dependent variable, indicating a positive relationship (Cacioppo et al 2002). A second reason for increased loneliness (dependent variable) was found to be higher levels of autistic traits the dependent variable (Caruana et al., 2021; Stice & Lavner, 2019). Loneliness can occur in people with higher levels of autistic traits, due to autistic traits including difficulties with social communication and interaction (Caruana et al., 2021). Issues with social communication and interaction in turn can lead to people with autistic traits experiencing less social interaction than hoped for, thus leading to feelings of loneliness (Caruana et al., 2021).

Rationale

A small number of robust studies have reported a positive relationship between sleep difficulties and autistic traits (Hochard et al., 2020; Stewart et al., 2020). Separately, autistic traits have been shown to be positively related to loneliness (Caruana et al., 2021; Stice & Lavner, 2019) and negatively related to mental well-being (Stimpson et al., 2021). Each of these relationships requires further replication with different samples. Thus, this paper will examine whether the relationships between mental well-being, loneliness, and sleep difficulties, are mediated by autistic traits. Autistic traits are hypothesised to be a good candidate to mediate these factors, as they reflect a relatively stable variable, which has been found to be independently linked to sleep difficulties, mental well-being, and loneliness (Caruana et al., 2021; Hochard et al., 2020; Stewart et al., 2020, Stice & Lavner, 2019). Autistic traits were chosen as a *whole* construct to mediate these factors as Stimpson et al (2021) found one sub-scale predicted a significant amount of mental wellbeing but could not explain all the

variance, therefore, the total score on a measure of autistic traits will instead be used, rather than its individual sub scales.

Clinical Relevance of the Study

It is clinically relevant to understand the nature of these associations, due to the clinical factors which are associated with each studied variable. Firstly, sleep difficulties can predict mental health difficulties, including depression, anxiety, psychosis, and alcohol abuse (Hertenstein, 2019), and relate to lower levels of mental well-being (Graham et al., 2021), and to an increased risk of suicide (Liu et al., 2020). Research also indicates that sleep difficulties increase the risk for mental health conditions, and that early intervention can lead to better mental health outcomes and improve quality of life (Heege et al., 2020). Loneliness has also been found to relate to mental health problems from leading to obsessive compulsive disorder (Meltzer et al., 2013) to depression (Victor & Yang, 2012), stress and alcohol problems (Mushtaq et al., 2014). Mental wellbeing has additionally been found to be protective against worsening mental health and to protect against relapses in mental health conditions including anxiety, depression, and psychosis (De Cates et al., 2015). Furthermore, mental health conditions have also been found to be more common in adults with autistic traits (Beck et al., 2020; Geurts et al., 2016; Lundström et al., 2011; Oshima et al., 2014). The mental health conditions associated with sleep difficulties, loneliness, poor mental wellbeing, and autistic traits all require clinical support and resources, therefore early screening and/or intervention could reduce the later impact on an the already stretched NHS, which is struggling with resourcing and staffing due to poor funding and having had to manage an unprecedented global pandemic (O'Dowd, 2023).

It is further clinically relevant to understand the nature and direction of these associations, as this can inform which factors to screen for, which is important due to a lack of clinical resources and capacity in the NHS (O'Dowd, 2023). If autistic traits are found to

mediate sleep difficulties relationship with loneliness and mental wellbeing, it would arguably indicate that this is the factor to target, as it would underlie these factors relationships with one another. Therefore, autistic traits if found to mediate these relationships should be the factor screened for and early intervention for subsequent related difficulties targeted toward, meaning one area to focus on for an overburdened and stretched NHS (O'Dowd, 2023).

Mediation compared to moderation was chosen as the method of analysis due to moderation analysis exploring the strength and direction of a relationship between two constructs, i.e. In the strength of the relationship between the two constructs changes in line with the level the moderator construct changes (Hair et al., 2021). Whereas a mediation analysis tests whether the effects of X (the independent variable in this case sleep difficulties) on Y (the dependent variable in this instance loneliness and mental wellbeing) operate through a third variable, M (the mediator- autistic traits) (Hair et al., 2021). By completing this process, the mediator (autistic traits) explains the causal relationship between two variables or "how" the relationship works. However, to establish that mediation is possible, autistic traits, loneliness, and mental wellbeing must be found to correlate (Hair et al., 2021). A positive relationship between autistic traits and sleep difficulties in adults has previously been found (Cox et al., 2022; Hochard et al., 2020; Stewart et al., 2020). Furthermore, prior research suggests that there will be a positive relationship between sleep difficulties and loneliness (Cacioppo et al 2002). In addition, sleep difficulties and mental wellbeing have been indicated previously to relate negatively (Graham et al., 2021; Trabelsi et al, 2021). Therefore, the hypotheses for this piece of research were:

Hypotheses

i) Sleep difficulties will positively correlate with loneliness

ii) Sleep difficulties will negatively correlate with mental well-being

iii) Sleep difficulties will positively correlate with autistic traits

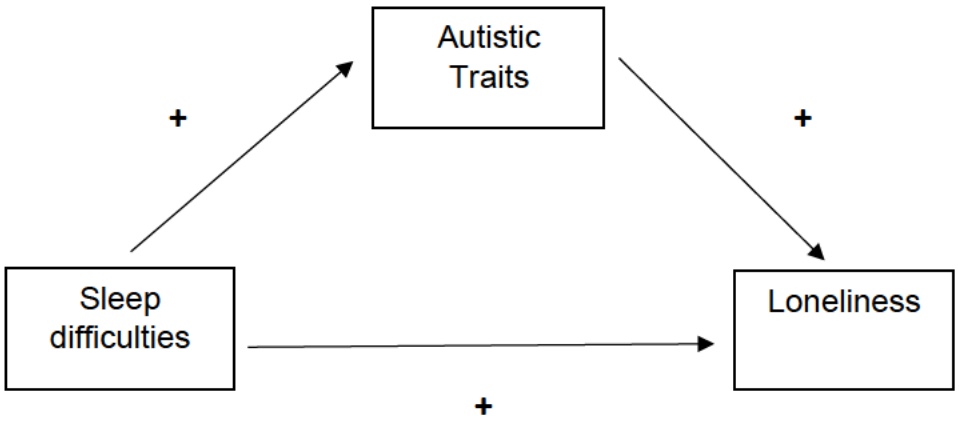
iv) Autistic traits will mediate the relationship between sleep difficulties and loneliness

iv) Autistic traits will mediate the relationship between sleep difficulties and mental well-being

The hypothesised relationships are shown in Figure 2.0 and 2.1 below.

Figure 2.0

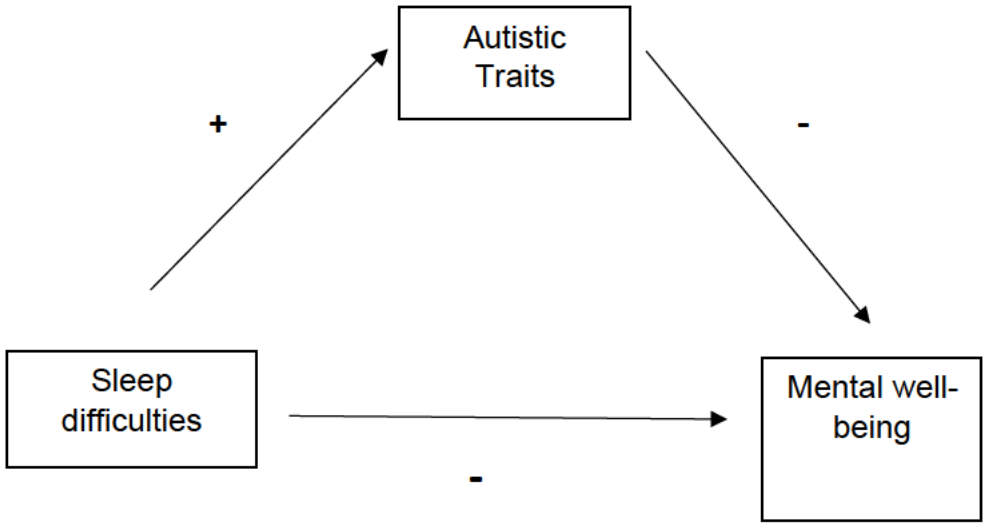
The expected relationships between Sleep difficulties, Loneliness and Autistic Traits



Note. This diagram shows how Autistic Traits are hypothesised to mediate the relationship between Sleep difficulties and Loneliness.

Figure 2.1

The expected relationships between Sleep difficulties, Mental Well-being, and Autistic Traits



Note. This diagram shows how Autistic Traits are hypothesised to mediate the relationship between Sleep difficulties and Mental Well-being.

Method

The method employed here collected self-reported data of sleep, autistic traits, loneliness, and mental well-being. These measures were included as part of a broader study on autistic traits and well-being, with core data of sleep difficulties and autistic traits are reported in Cox et al. (2022).

Participants

A total of 223 participants consented to complete the study. Following data cleaning (discussed below), 205 participants' data were used in the analysis. Participants' ages ranged from 18 to 51 (M = 19.12, SD = 2.93), 89.8% of the sample were female. Most of the sample (62%) reported their ethnicity as White British, 28.8% were Asian, 2.4% were Black: African, Caribbean, or British, 3.4% were of a mixed ethnicity, 2.9% reported being of an ethnicity not listed, and 0.5% answered that they preferred not to say.

Procedure

All data were collected via an online survey posted on a university School of Psychology Research Participation System, which was accessible from the 2nd to the 30th of November 2021. The online survey began with an information sheet describing the project's aims (see Appendix C), then participants were required to complete a consent form (Appendix D). Participants' demographic information (age, gender, and ethnicity) were then collected (see Appendix E). Participants were next directed through the project questionnaires (see Appendix F-H, apart from the Social Responsiveness Scale version two [SRS-2] due to copyright). The questionnaires for this project were the Warwick Edinburgh Mental Wellbeing Scale ([WEMWBS], Tennant et al., 2007), the Pittsburgh Sleep Quality Index ([PSQI], Buysee et al., 1998), the University College of Los Angeles (UCLA) version three Loneliness Scale ([UCLA-3], Russell, 1996), and SRS-2 (Constantino & Gruber, 2012). Additional

questionnaires for other projects measuring mental health were also part of the survey, but are not provided in the appendices, as they were not felt to be relevant to this project. Following participants' completion of the questionnaires, a debrief sheet was displayed (Appendix I). The questionnaire had been piloted and 300 seconds (at a minimum) was required, to read the questions and answer attentively.

Eighteen participants were excluded from the study for the following reasons: Not completing all four questionnaires (six), inattentive responding – as indicated by participants completing the entire survey in less than 300 seconds (ten) and answering prefer not to say for more than 20% of items on a scale (two).

Measures and Scoring

The scoring and construct of each measure is described below.

Warwick Edinburgh Mental Well-being Scale

Permission was asked from the authors of the WEMWBS (Tennant et al., 2007) to use this measure in this study, and a licence for its use was provided (see Appendix J). The WEMWBS was indicated in the United Kingdom (UK), to show good validity and reliability (Maheswaran et al., 2012; Stewart-Brown et al., 2011), and is consequently the most used mental wellbeing measure in the UK (Tennant et al., 2007). The WEMWBS is additionally recommended for measuring mental well-being in a student population (Barkham et al., 2019). The WEMWBS comprises 14 items which explore positive affect, satisfying aspects of interpersonal relationships and positive functioning and measures symptoms over a two week period (Tennant et al., 2007). Table 2.0 provides examples of questions used in the WEMWBS, the full WEMBS can be found in Appendix F). Each question is scored on a five-point Likert scale (none of the time, rarely, some of the time, often, all the time). The Likert scale represents a score for each item from one to five, therefore meaning a participant could have a minimum score of 14 and a maximum score of 70 (Tennant et al., 2007). The WEMBWS does not have

any reverse scoring (see Appendix K), therefore participants' raw scores were summed to determine a total scale score, higher scores indicated better mental well-being (Tennant et al., 2007).

Table 2.0

Example of the questions in the Warwick Edinburgh Mental Well-being Scale

Item	Example
1	I've been feeling optimistic about the future
2	I've been feeling useful
3	I've been feeling relaxed
4	I've been feeling interested in other people

University of California Los Angeles Loneliness Scale Version 3

The UCLA version three is composed of 20 questions and explores feelings of loneliness. In measuring loneliness, the UCLA Loneliness Scale version three (Russell, 1996) holds good reliability and validity in university age population (Russell, 1996). The UCLA-Version 3 is also the most common tool used for exploring loneliness, alongside sleep difficulties (Hom et al., 2020). Items are scored on a four-point Likert scale and are not based on a time period (i.e. no time period for loneliness stated so does not measure over weeks, months or years but frequency) (Russell, 1996). Examples of the questions are displayed below in Table 2.1, and the full UCLA version three can be found in Appendix G. Reverse scoring was required for the following nine items (questions one, five, six, nine, 10, 15, 16, 19 and 20, see Appendix L). A total highest score of 80 was possible and the lowest score possible would have been 20, higher scores on the UCLA-version 3 indicate higher levels of loneliness (Russell, 1996). In university students, the average loneliness score is mean 40.1 and median 40 (Russell, 1996).

Table 2.1

Questions in the University of California Los Angeles Loneliness Scale Version three

Item	Example
1	I feel in tune with the people around me
2	I lack companionship
3	There is no one I can turn to
4	I do not feel alone

Social Responsiveness Scale Version Two (SRS-2)

Autistic traits were measured using the SRS-2 (Constantino & Gruber, 2012). Due to viewing autistic traits as a variable in itself, the total score on autistic traits will be used and not the individual subscales of the SRS-2 as it is hypothesised that it is autistic trait as a construct which will mediate the relationship between sleep difficulties, loneliness and mental wellbeing. The original Social Responsiveness Scale (SRS) was developed to measure the level of autism symptomology displayed by a person as a quantitative trait over a six-month period (Constantino, 2002). The SRS can be used with people with or without ASD, as it can determine between the clinical and subthreshold level of autistic traits (Constantino, 2002). The SRS-2 was introduced in place of the SRS, as it indicated better accuracy, and reliability in quantifying ASD symptoms/autistic traits (Constantino & Gruber, 2012). The SRS-2 is composed of 65 items, split across five subscales: social awareness, social cognition, social communication, social motivation, and restricted interests and repetitive behaviours (Constantino & Gruber, 2012). The SRS-2 is copyrighted; therefore, a full copy cannot be shared in the appendices, but examples of a question from each of the five subscales are displayed in Table 2.2 below. Items were scored on the four-point Likert-scale and the 15 coded items on SRS-2 were also reverse scored, before the SRS-2 subscale scores were then summed to produce a total SRS-2 score (Constantino & Gruber, 2012). The maximum total score on the

SRS-2 is 195: higher scores indicated higher levels of autistic traits (Constantino & Gruber, 2012). T-scores are used to quantify the level of autistic traits of the person assessed, compared to the general population, t-scores below 59 (raw score 67) indicate autistic traits expected in normal population without ASD (Constantino & Gruber, 2012).

Table 2.2

Examples of questions from the Social Responsiveness Scale Version Two

Subscale	Item	Example
Social Awareness	7	I am usually aware of how others are feeling (reverse scored).
Social Cognition	15	When people change their tone or facial expression, I usually pick up on that and understand what it means (reverse scored).
Social Communication	13	I am awkward in turn-taking interactions.
Social Motivation	6	I would rather be alone than with others.
Restricted Interests and Repetitive Behaviours	24	I have more difficulty than others with changes in my routine.

Pittsburgh Sleep Quality Index

The Pittsburgh Sleep Quality Index (PSQI) is a self-report measure, which shows good reliability and validity in several non-clinical university aged students in the measurement of sleep quality (Dietch et al., 2016; Aloba et al., 2007; Yang et al., 2003). The PSQI comprises 19 items, with seven sub scales: subjective sleep quality, sleep latency, sleep duration, habitual sleep efficiency, sleep disturbances, use of sleeping medication, and daytime dysfunction, the PSQI measures sleep difficulties over a one-month period (Buysee et al., 1998). Each item within the subscale, is scored on a four-point Likert scale (Buysee et al., 1998). Examples of questions from three subscales are shown below in Table 2.3, and the full PSQI can be found in Appendix H and scoring in Appendix M. Subscales items were added together and indicated a score of zero to three, subscale scores were then summed to

determine a total score with the maximum score being 21 and minimum of zero, whilst scores above five indicated sleep difficulties (Buysee et al., 1998).

Table 2.3

Examples of questions from the Pittsburgh Sleep Quality Index

Example item	Component
5a. During the past month, how often have you had trouble sleeping because you cannot get to sleep within 30 minutes?	Sleep disturbance
8. During the past month, how much of a problem has it been for you to keep up enough enthusiasm to get things done?	Daytime dysfunction
9. During the past month, how would you rate your sleep quality overall?	Subjective sleep quality

Ethical Approval & Considerations

The study and its content were approved by the University of Birmingham Science Technology Engineering and Mathematics ethics committee, an approval letter confirming this can be found in Appendix N. The consent forms, information sheet, original online surveys and any identifiable information regarding participants were anonymised and stored in line with the University of Birmingham ethics guidelines. The information sheet described how participants' information would be stored, and how their anonymity and confidentiality would be maintained. To ensure participants were aware of their right to withdraw, the information sheet also clarified that they could withdraw at any time, without consequence. The questionnaires' content was assessed by the research supervisor, and it was felt that questions would be unlikely to cause substantial distress to participants, however, support was signposted for participants on the debrief sheet. The study aim was also made clear to participants in the survey information, and it was communicated that their scores on questionnaires were not able

to be used in diagnosis. Further it was clarified that the study was not screening for autism, or sleep difficulties. For the information and debrief sheets see Appendix C and I.

Data Processing & Analysis

In processing the data, 12 participants had their data pro-rated for responding that they preferred not to say for fewer than 20% of items on a scale. Data were analysed using SPSS 27.0. Initially the data were tested for normality by completing a Shapiro Wilk test (Shapiro & Wilk, 1965).

As the SRS-2 (Constantino & Gruber, 2012), PSQI (Buysee et al., 1998) and UCLA version three (Russel, 1996) data were not normally distributed (see results), the equivalent nonparametric correlational test; Spearman Rho (Spearman, 1904) explored relationships between the scales. As multiple comparisons were completed, a Bonferroni correction was applied. The three Spearman's Rho (Spearman, 1904) correlations were therefore conducted using a Bonferroni alpha level of 0.016 (0.05/3), as advised by Lee (2010), to explain hypothesis one to three.

Two simple mediation analyses using model four from Hayes's (2018) PROCESS macro for SPSS were conducted (Hayes, 2018). As data were not normally distributed, bootstrapping was employed, as advised by Preacher and Hayes (2004). For the mediation analyses, mediation was significant if the 95% bias corrected and accelerated confidence intervals for the indirect effect did not include zero (Preacher & Hayes, 2004).

Results

As can be seen from Table 2.4, the WEMWBS was normally distributed $w(205) = .992$, $p = .278$, however, all other scales were not normally distributed $p < .001$.

Normality Tests

Table 2.4

Normality Tests for each scale

Scale	Statistic	df	Sig
SRS-2	.968	205	<.001
PSQI	.967	205	<.001
WEMWBS	.992	205	.278
UCLA	.974	205	<.001

Note. df = degrees of freedom and Sig = significance.

Descriptive statistics

Table 2.5 below, displays the descriptive statistics for each scale. The table includes the minimum and maximum scale scores, mean, standard deviation (SD), median and Interquartile Range (IQR).

Table 2.5

Descriptive statistics for each scale

Scale	N	Minimum	Maximum	Mean	SD	Median	IQR
SRS-2	205	5.0	142.0	52.4	24.4	51.0	33.5
PSQI	205	0.0	16.0	6.9	3.1	6.0	4.0
WEMWBS	205	26.0	69.0	45.2	8.6	45.0	12.0
UCLA	205	20.0	67.0	39.1	10.4	38.0	16.5

Note. Table 2.5 figures are rounded to one decimal points. SD= standard deviation, N= number in the sample and IQR= interquartile range.

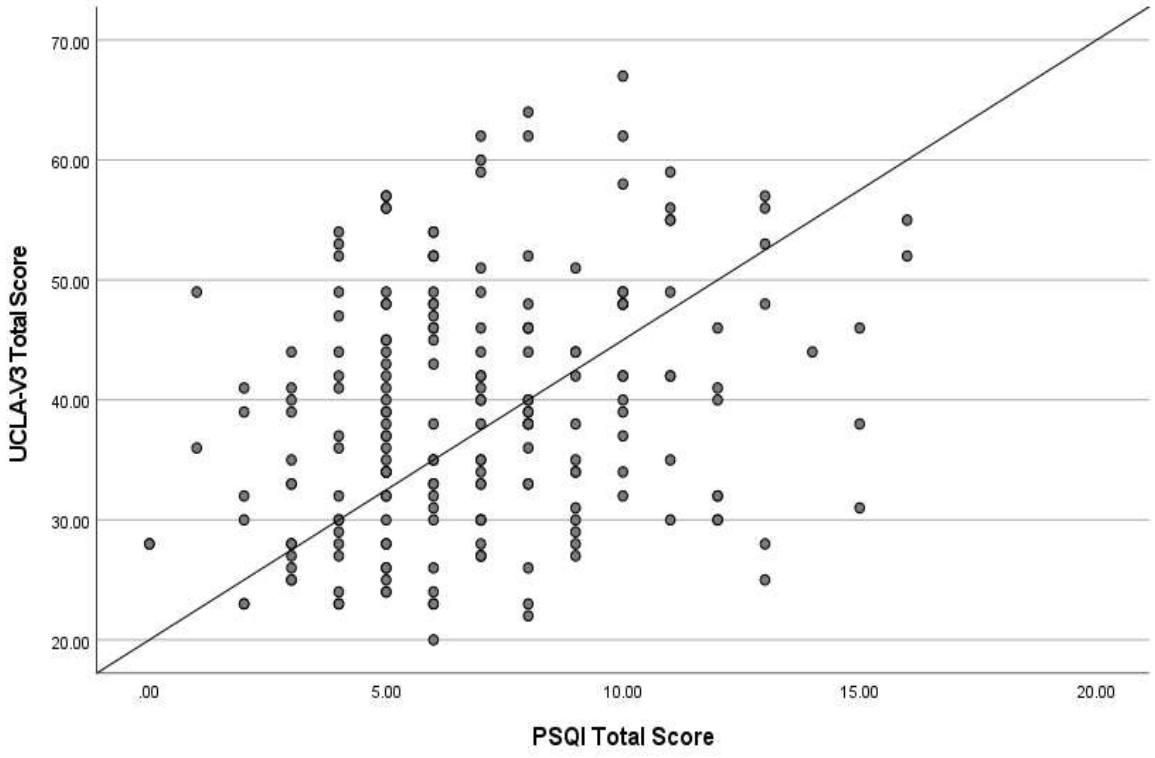
Participants' mean WEMWBS score (M = 45.2) was below average for the general UK population (M = 51.0, Tennant et al., 2007). Further, only 22.4% of the sample scored above the cut off for poor mental well-being. The samples' median PSQI score was above five, which is above the cut off score to indicate sleep difficulties (Buysse et al., 1988). 62.4% of the sample, scored above five on the PSQI, which indicated that on average participants were experiencing sleep difficulties (Buysse et al., 1988). Participants' median score on the SRS, meant that on average participants were scoring broadly in line with that expected in the general population (Constantino & Gruber, 2012), however, a total of 24.9% of the sample obtained a raw score of 67, which is above the number of autistic traits expected in the normal population (Constantino & Gruber, 2012). A total of 38% of participants scored above average expected score for loneliness (M = 40 and median 30) on the UCLA-3 scale, however, the mean score for the overall sample was below that scored by prior university populations.

Correlations

Spearman's Rho correlations were completed to test the relationships between Loneliness, Sleep Difficulties, Autistic Traits and Mental Well-being. The first correlation examined the relationship between Loneliness and Sleep difficulties, which is shown by Figure 2.2 below.

Figure 2.2

The relationship between the University of California Los Angeles Loneliness Scale Version three and the Pittsburgh Sleep Quality Index total score

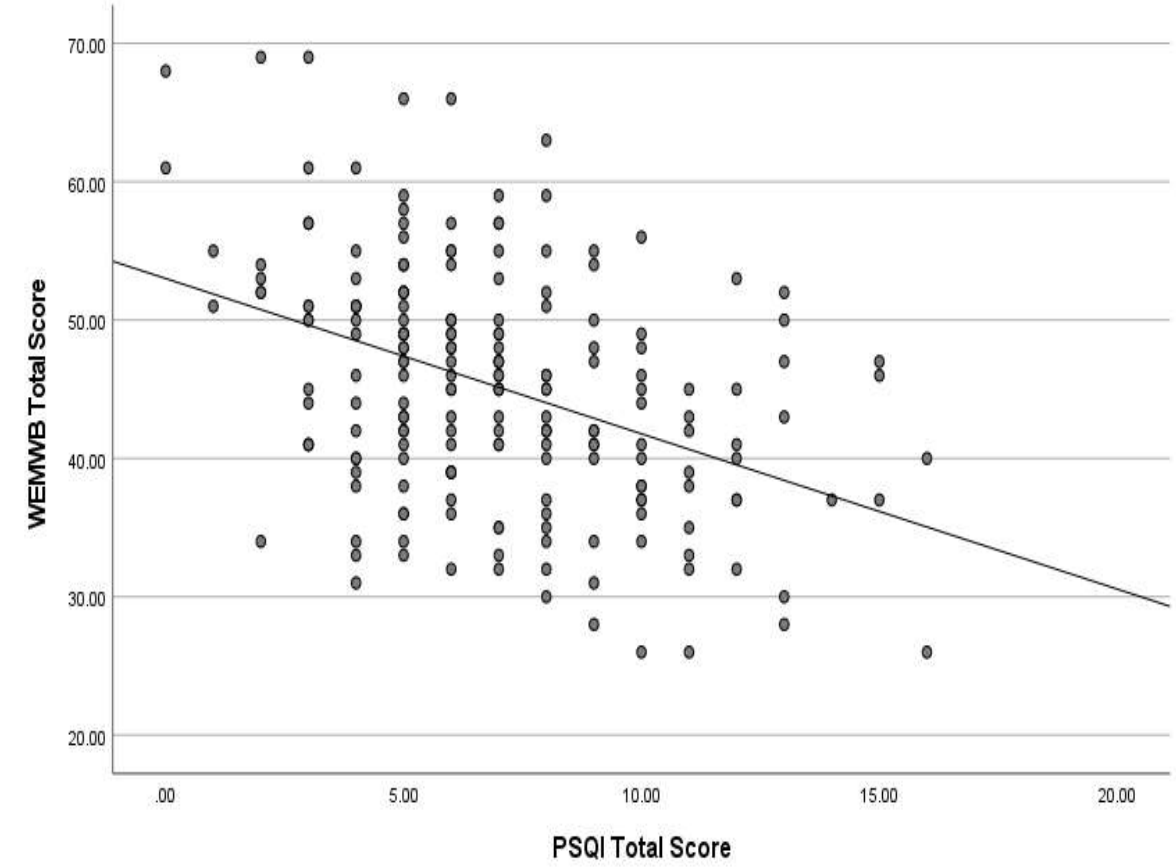


Note. Figure 2.2 shows positive relationship for 205 participants.

UCLA-3 total score positively correlated with their total PSQI scores, $r(205) = .263$, $p < .001$. Figure 2.3 below shows the scattergram for the relationship between WEMWBS and PSQI total scores.

Figure 2.3

Scatter diagram of the relationship between Warwick Edinburgh Mental Well-being Scale and Pittsburgh Sleep Quality Index total scores

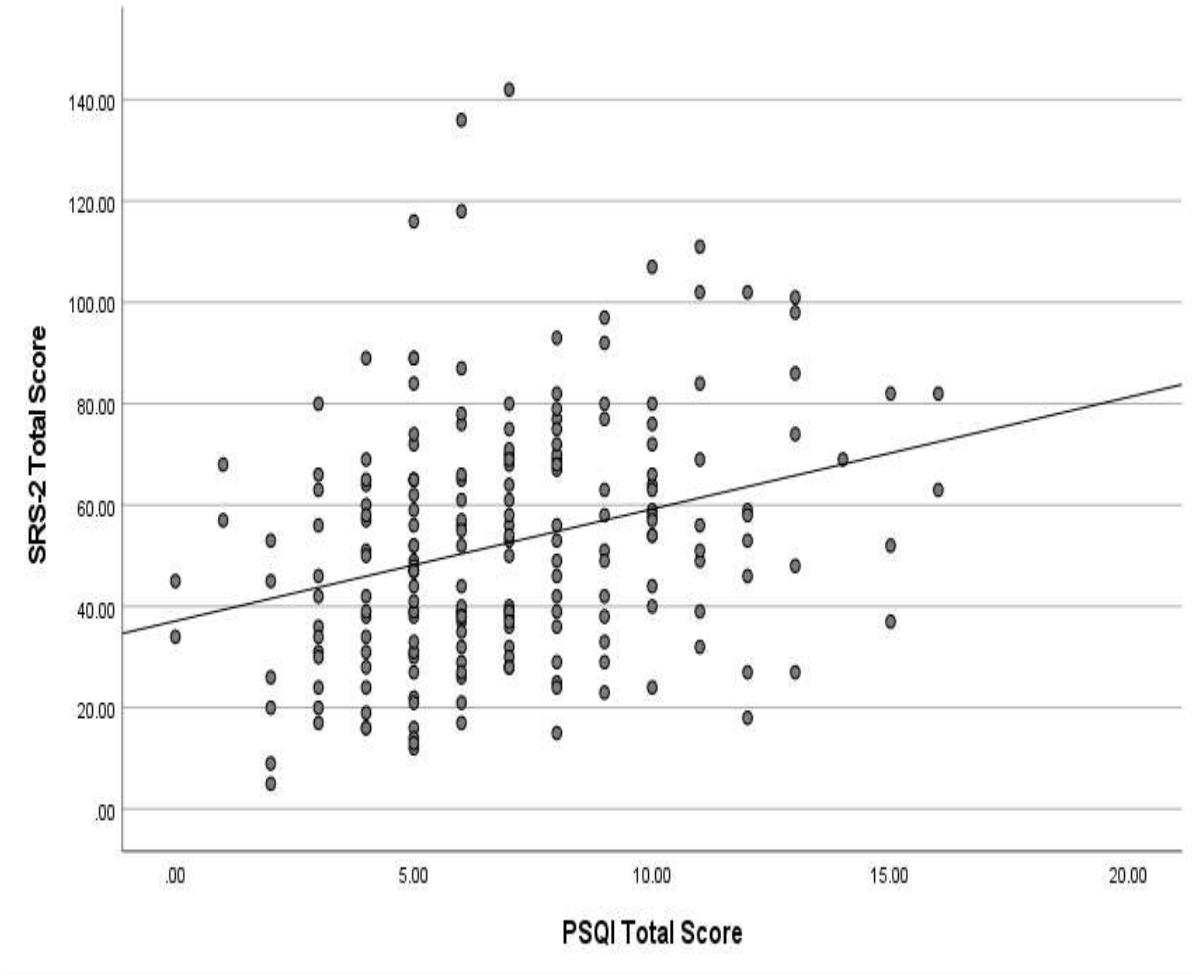


Note. Number of participants was 205.

WEMWBS total score negatively correlated with PSQI total score $r(205) = -.385$, $p < .001$. Figure 2.4 below shows a scatter diagram depicting the relationship between SRS-2 and PSQI total scores.

Figure 2.4

Scatter diagram of the relationship between Social Responsiveness Scale Version two and Pittsburgh Sleep Quality Index total scores



Note. Total participants were 205.

Total SRS-2 score positively correlated with total PSQI score $r(205) = .298$, $p < .001$

The full correlations between all measures total scores are displayed below in Table 2.6.

Table 2.6

Spearman's correlations between all measures

			1	2	3	4
1.	UCLA-3 Total score	Correlation Coefficient	--	.263**	-.518**	.677**
2.	PSQI Total score	Correlation Coefficient	--	--	-.385**	.298**
3.	WEMWBS Total Score	Correlation Coefficient	--	--	--	-.472**
4.	SRS-2 Total Score	Correlation Coefficient	--	--	--	--

Note. **Correlation is significant at the 0.01 level (1-tailed).

Mediation Analysis

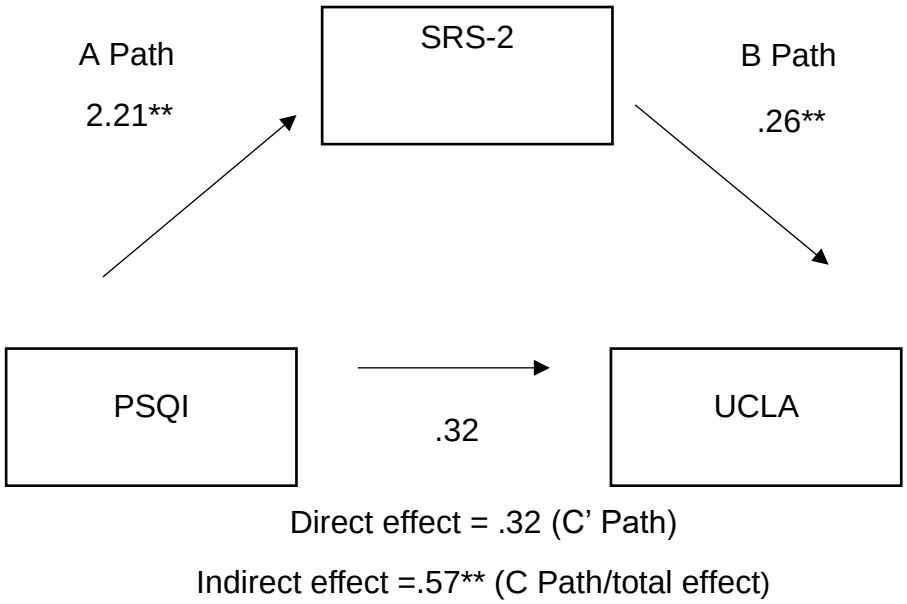
Examination of the correlation coefficients found significant correlations between all four variables, whereby the predictor sleep difficulties related to the predicted variables UCLA-3 total score and WEMWBS total scare. The potential mediator (Autistic traits) also related to WEMWBS total score and UCLA-3 total score, therefore the conditions for mediation analysis were met.

The first mediation analysis showed that Autistic Traits significantly mediated the relationship between Sleep Difficulties and Loneliness. The total indirect effect (Path c indicated on the diagram below) showed that Autistic Traits significantly mediated the relationship between Sleep difficulties and Loneliness, b = .57, 95% CI [.30, .87], p <.001. Path a (the relationship between Sleep and Loneliness) was significant, b =2.21, 95% *CI* [1.18, 3.24],

t(202) = 4.24, *p* < .01. Path b (relationship between autistic traits and loneliness) was also significant, *b* = .26, 95% *CI* [.21, .30], *t*(202)=10.7, *p* < .001. Path c' (the direct path from Sleep Difficulties to Loneliness) was not significant *b*=.32, 95% *CI* [-.05, .68], *t*(202) = 1.7, *p* =.09, meaning that Sleep Difficulties did not have a significant impact on Loneliness once Autistic Traits had been controlled for. Therefore, the effect of Sleep Difficulties on Loneliness is fully mediated by Autistic Traits. The total variance the model explains is R^2=.47, *p* < .0001. See Table 2.7 and Figure 2.5 which summarise this mediation model.

Figure 2.5

Autistic traits mediation of the relationship between Sleep difficulties and Loneliness



Note. ** Indicates significant coefficients. Figure 2.5 Displays the findings of completing Hayes model four mediation analysis, to determine whether autistic traits mediate the relationship between Sleep Difficulties and Loneliness.

Table 2.7

Mediation paths of the relationship between Autistic Traits, Sleep Difficulties and Loneliness

Path	*b*	*SE*	*T*	*p*	95% Confidence Interval	
					Lower	Upper
PSQI -> SRS-2 (A path)	2.21	.52	4.24	<.001	1.18	3.24
SRS-2->UCLA-3 (B path)	.26	.02	10.7	<.001	.21	.30
PSQI ->UCLA-3 (C' path/direct effect)	.32	.19	1.7	.09	-.05	.68
PSQI ->SRS-2-> UCLA-3 (C Path/Indirect/total effect)	.57	.15	-	<.001	.30	.87

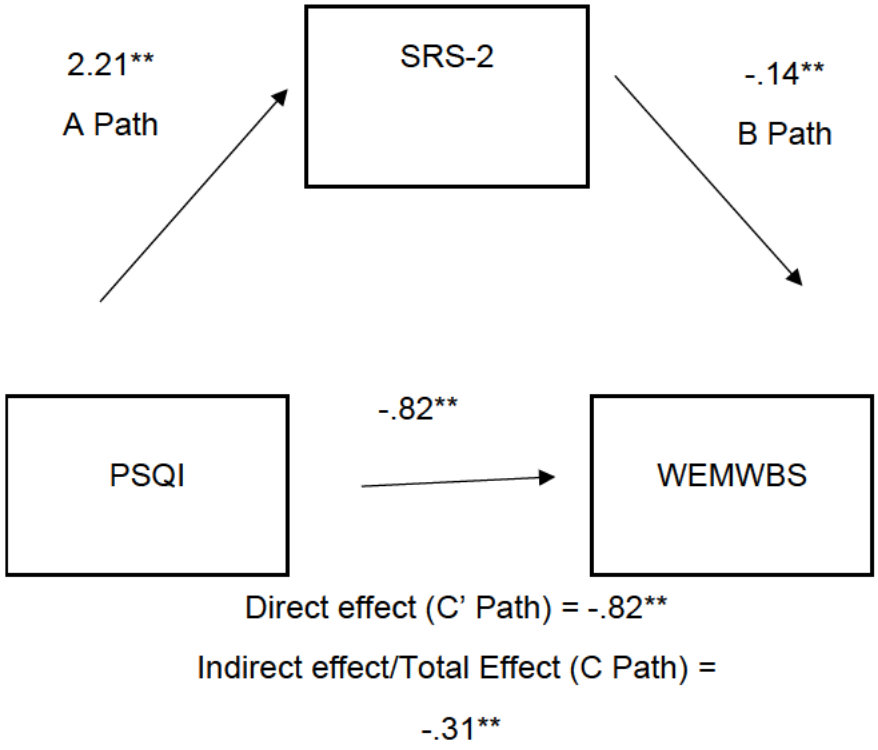
Note. Figures cited to one decimal place.

The second mediation analysis showed that Autistic Traits (SRS-2 total score), significantly mediated the relationship between Sleep difficulties (PSQI total score) and (WEMWBS total score), but only partially. The total indirect effect of the mediation model showed that Autistic Traits (SRS-2 total score) mediated the relationship between Sleep difficulties and Mental Well-being, b = -.31, 95% *CI* [-.49, -.16], p <.001. Both paths a (the relationship between PSQI score and SRS-2 score) b =2.21, 95% *CI* [1.18, 3.24], $t(202) = 4.24$, p <0.01 and b (the relationship between PSQI total score and with total WEMBS score) b = -.14, 95% *CI* [-.18, -.1] $t(202)$= -6.42, p < .001 were significant. After accounting for the mediating role of autistic traits, sleep difficulties remained a significant predictor of Mental Wellbeing, not consistent with full mediation, b =-.82, *CI* [-1.15, -.49], $t(202) = -4.88$, p < .01. Therefore, the effect of Sleep Difficulties on Mental Well-being is mediated, but only partly,

by Autistic Traits. The total variance explained by the model was R^2=.31, $p < .0001$. See Table 2.8 and Figure 2.6 which summarise this mediation model.

Figure 2.6

Autistic Traits mediation of the relationship between Sleep difficulties and Mental wellbeing



Note. ** Indicates significant coefficients. Figure 2.6 Displays the findings of completing Hayes model four mediation analysis, to determine whether autistic traits mediate the relationship between Sleep Difficulties and Mental Well-being.

Table 2.8

Mediation paths of the relationship between Autistic Traits, Sleep Difficulties and Mental Well-being

Path	*b*	*SE*	*t*	*p*	95% Confidence Interval	
					Lower	Upper
PSQI->SRS-2 (A path)	2.21	.52	4.24	<.001	1.18	3.24
SRS-2→ WEMWBS (B path)	-.14	.02	-6.42	<.001	-.18	-.1
PSQI->WEMWBS (c ‘path/direct effect)	-.82	.17	-4.87	<.001	-1.15	-.49
PSQI->SRS-2->WEMWBS (c’ path/Indirect/total effect)	-.31	.09	-	<.001	-.49	-.16

Note. Mediation analysis of effects of Autistic Traits on the relationship between Sleep Difficulties and Mental Well-being

Discussion

This study measured the cross-sectional relationship between autistic traits, loneliness, sleep difficulties and mental wellbeing. Former literature suggested the direction of the associations between the examined factors, which was discussed in the introduction of the paper, and this literature informed the correlational hypothesis and rationale for autistic traits as the mediator. However, to first establish that mediation was possible, sleep difficulties, autistic traits, loneliness, and mental wellbeing were required to be found to correlate (Hair et al., 2021). A positive relationship between sleep difficulties and autistic traits in adults had previously been found (Cox et al., 2022; Hochard et al., 2020; Stewart et al., 2020). Furthermore, prior research suggested that there would be a positive relationship between sleep difficulties and loneliness (Cacioppo et al 2002). In addition, sleep difficulties and mental well-being had been indicated previously to relate negatively (Graham et al., 2021; Trabelsi et al, 2021). Autistic traits were hypothesised to be a good candidate to mediate these factors, as they reflect a relatively stable variable, which had been found to be independently linked to sleep difficulties, mental well-being, and loneliness (Caruana et al., 2021; Hochard et al., 2020; Stewart et al., 2020, Stice & Lavner, 2019). Autistic traits were chosen as a *whole* construct to mediate these factors as Stimpson et al (2021) found one sub-scale predicted a significant amount of mental well-being, but could not explain all the variance, therefore, the total score on a measure of autistic traits was instead used, rather than its individual sub scales.

Therefore, the hypotheses for this piece of research were: i) Sleep difficulties will positively correlate with loneliness; ii) Sleep difficulties will negatively correlate with mental well-being; iii) Sleep difficulties will positively correlate with autistic traits; iv) Autistic traits will mediate the relationship between sleep difficulties and loneliness, and iv) Autistic traits will mediate the relationship between sleep difficulties and mental well-being.

The results of this study first indicated a positive relationship between sleep difficulties and loneliness, which meant that as sleep difficulties increased reports of loneliness also increased, which supported prior research findings (Cacioppo et al 2002). In addition, sleep difficulties and mental well-being were also found to be negatively related, meaning that as sleep difficulties increased, mental well-being reduced, which had also been previously indicated by former research (Graham et al., 2021; Trabelsi et al, 2021). As reported in a previous study with this population (Cox et al., 2022; Hochard et al., 2020; Stewart et al., 2020), sleep difficulties were also found to positively correlate with autistic traits, which meant that in this study it was found that increased level of sleep difficulties, were found alongside higher levels of autistic traits. This study consequently adds to the existing small pool of literature in this area (Hochard et al., 2020; Stewart et al., 2020). Sleep difficulties were further found to have a positive relationship with loneliness, replicating Cacioppo et al's (2002) findings, of an increase in sleep difficulties being found alongside higher levels of self-reported feelings of loneliness. Due to the relationships being found as expected from the literature and all constructs were found to be related, a mediation analysis was possible.

Autistic traits fully mediated the relationship between sleep difficulties and loneliness. This was as the direct path from sleep difficulties to loneliness was not significant, meaning that Sleep Difficulties did not have a significant impact on loneliness once autistic traits had been controlled for. This finding supports the prior research which indicated that autistic traits to be a good choice for a mediator, due to the relationships found between autistic traits, sleep difficulties (Hochard et al., 2020; Stewart et al., 2020) and loneliness (Caruana et al., 2021; Stice & Lavner, 2019). The reason why it is believed that autistic traits could fully explain the relationship between sleep difficulties and loneliness, is unclear, as this is a new research area. As, only a small number of recent studies have explored the relationship between autistic traits and sleep difficulties in adults (Cox et al., 2022; Hochard et al., 2020; Stewart et al., 2020),

therefore, a clear mechanism for why people with autistic traits experience higher number of sleep difficulties is not known. However, it is supposed that part of this mechanism may be explained by Bio-psycho-social factors which underly sleep difficulties in autistic people (Richdale & Schrek, 2009) also being experienced by people with autistic traits, due to the idea of the wider autism phenotype, which means that research conducted on people with autistic traits may be able to be applied to those who are neuro-diverse and who have ASD and vice versa (Posserud et al., 2006). The biological factors indicated to disrupt sleep in people with ASD include circadian rhythm disruption, melatonin uptake, and genetic factors that alter brain structure and biochemistry (Richdale & Schrek, 2009). In addition, psychological or behavioural characteristics such as anxiety and hyperactivity, which often commonly co-occur with ASD, are also negatively associated with sleep difficulties (Richdale & Schrek, 2009). Furthermore, social factors in the home such as bedtime routine, are also hypothesised to play a role in sleep difficulties experienced by autistic people, as autistic people are said to be less able to note social cues which indicate it being time to sleep (Richdale & Schrek, 2009). Therefore, although unclear and in its infancy, there is evolving evidence that it is autism itself which cause these bio-psycho-social issues which disrupt sleep and thus is it theorised that similar factors may also be causing the sleep difficulties experienced by people with autistic traits. Autistic traits were also believed to then be able to explain the relationship between sleep difficulties and loneliness, as people with autistic traits also experience difficulties with social communication and interaction (Caruana et al., 2021) and issues with social communication and interaction in turn can lead to people with autistic traits experiencing less social interaction than hoped for, thus leading to feelings of loneliness (Caruana et al., 2021). Thus, autistic traits would be theorised in this instance to explain/cause the sleep difficulties and the feelings of loneliness experienced by people with autistic traits and consequently explain/ underly this relationship.

However, autistic traits only partially mediated the relationship between sleep difficulties and mental well-being, as after accounting for the mediating role of autistic traits, sleep difficulties remained a significant predictor of mental well-being, not consistent with full mediation. Previous research has found that sleep difficulties and mental wellbeing are related (Graham et al., 2021; Trabelsi et al, 2021), therefore sleep difficulties themselves may have a stronger link with mental wellbeing and thus autistic traits cannot fully explain this relationship, as sleep difficulties themselves potentially explain the relationship without the need of a mediator. Alternatively, another unknown factor may also in part be required to explain this relationship. One proposed factor could be loneliness, as sleep difficulties have been found to impede the processing of negative emotions (such as loneliness), a key part of mental well-being (Baglioni et al., 2010). Therefore, loneliness could explain the relationship between sleep difficulties and mental wellbeing together with autistic traits, as loneliness has been found to also link to sleep difficulties (Cacioppo et al., 2002) and theorised to be a key part of mental well-being, due to the importance of positive relationships with others (Bond et al., 2012).

Furthermore, the descriptive data itself is also noteworthy as it indicated that 77.6% of the sample scored below the average UK population regarding mental wellbeing. In addition, 62.4% of the samples self-reported sleep scores suggest sleep difficulties, which indicates that these (mental well-being and sleep difficulties) are areas which the student population samples would benefit from intervention from.

Limitations and future research directions

This study focussed on understanding the relationship between sleep, autistic traits, mental well-being, and loneliness in a student population. Care should be taken in generalising the results of this study beyond this population. This is as firstly the population was composed

of a high number of females (89.8%). In addition, students as a population, are known to experience disproportionately poor sleep compared to the general population (Lund et al., 2010), which was seen in this study, with 62.4% of the sample found to experience sleep difficulties. Equally, this is a good reason to study this population, due to their known sleep difficulties (Lund et al., 2010), as sleep difficulties are also found to be more prevalent in people with higher levels of autistic traits (Merikanto et al., 2019; Hochard et al., 2020; Salmela et al., 2019; Stewart et al., 2020; Tsai et al., 2021). Choosing a population of students who experience higher levels of sleep difficulties (Lund et al., 2010) enabled the cross-sectional examination of these factors. Whilst this study carefully examined cross-sectional relationships, to my knowledge, no study has measured how loneliness, mental wellbeing, autistic traits, and sleep difficulties co-vary over time. Future longitudinal research may support inferences about causality, which have been theorised here. It would also be further important to triangulate the data, by understanding the lived experiences of these difficulties through conducting qualitative research.

In addition, the mediation analyses were run in one way due to prior literature informing directional hypotheses, it would be advised that future research is completed using structural equation modelling on the same variables i.e., sleep difficulties, autistic traits, mental well-being, and loneliness. This would be advised as structural equation modelling is a statistical technique used to measure and analyse the relationships of observed and latent variables (Beran & Vialato, 2010). It is more powerful than regression analyses, as it explores linear causal relationships among variables, at the same time as accounting for any error in measurement (Beran & Vialato, 2010). Therefore, this type of research could determine if the relationships supposed are causal in nature and are underpinned by the theorised construct autistic traits and are not influencing each other, which would be especially useful regarding autistic traits only partially mediating the relationship between sleep difficulties and mental

well-being. Structural equation modelling may also the be able to provide further statistical support to the conclusion found regarding autistic traits being found to fully mediate the relationship between sleep difficulties and loneliness.

In addition, it should be noted that this research was conducted during Covid-19, a unprecedented global pandemic. During this time day to day life changed for many people due to the government guidelines requesting people to distance themselves from others and at times to not leave their home unless necessary, in attempts to slow the spread of Covid-19 (Groarke et al., 2020). This led to many people including students (who this study was completed on), having a vast change to their lives, not being able to socialise with others or see their families, and young adults were found to be most affected by loneliness during COVID-19 (Groarke et al., 2020).Therefore, it is likely that the participants conducting this study during the pandemic may have had lower mental well-being and felt lonelier due to the Covid-19 restrictions. Thus, the context the study was completed within should be considered when considering its findings. Therefore, it is advised that a study using the same or similar procedure is conducted now the restrictions have lifted to ascertain if differences are found in students' loneliness and mental well-being scores, to ensure that Covid-19 did not impact on the study's findings.

An additional limitation of this study was that the timeframes for the questionnaires were difference, for example the UCLA-loneliness scale version 3 did not have a time frame, as it measures loneliness on a frequency level (Russell, 1996), the SRS-2 is to be rated on a six month period (Constantino, 2002), the PSLQI is to be rated on a month period (Buysee et al., 1998) and the WEMWBS ask participants to complete it based on a time period of two weeks (Tennant et al., 2007). The questionnaires were chosen due their reliability and validity with similar samples to that used by this study, but their differing time scales could present issues in comparability as ratings were taken across different time periods. Therefore, future research

should explore if there are other lesser-known scales which measure these factors across a common time period to determine if this affects the results.

A further limitation of using self-report measures within this research paper was that people may not have been truthful/ and or can be subjective in their ratings, for example what could be deemed as sleep difficulties to one person would be good quality sleep to another. Therefore, in future the application of direct measures of recording should be considered or taking measures at multiple time points, to check if the results change due to external factors. One method sleep difficulties can be more accurately measured is using wearable sleep trackers, which provide data on the persons sleep quality, which can provide a more ecologically valid measurement of sleep difficulties (Godfrey et al., 2008).

Furthermore, the Neurodiversity movement which aims to change societies thinking about autism (Den Houting, 2019) requires consideration and discussion due to its links to this topic (i.e., autistic traits). The Neurodiversity movement does not wish society to view ASD as a disorder but hopes that in time society will come to see ASD as a neurological difference, which leads people with ASD to view the world differently (Den Houting). One of the arguments which has been led by this movement is the double empathy problem, which argues that the neurotypical population (people without ASD) misperceives those who are neurodiverse (people with ASD, ADD or other neurodevelopmental disorders) and it is the lack of understanding of the neurodiverse person (by the neurotypical person), which leads to social isolation and loneliness experienced by the people with ASD, not the difficulties of ASD themselves (Mitchell et al., 2021). Autistic traits are viewed as contentious within the neurodiverse movement, as autistic traits are found in people who are neurotypical and raises the idea of the “broader autism phenotype” which is seen as controversial by many people within and who support the neurodiversity movement (Posserud et al., 2006). The wider autism phenotype if it is true does however mean that research conducted on people with

autistic traits may be able to be applied to those who are neuro-diverse and who have ASD (Posserud et al., 2006) and that theories such as double empathy may apply (Mitchell et al., 2021), but research has yet to indicate the double empathy theory can be applied to people with autistic traits and it is not conclusive if autistic traits research can be related to research or theories which apply to people with ASD (Mitchell et al., 2021). Therefore, this paper when considered from the neurodiverse movement perspective and in lieu of the broader autism phenotype theory cannot and should not draw similarities between people with ASD and those with autistic traits. Therefore, this argument is a potential limitation of the research and should be considered when reading this paper.

Clinical application

There are several potential clinical implications from the findings outlined here. Firstly, the high prevalence of identified sleep difficulties and low level of mental well-being in the psychology student sample studied, indicates the importance of providing sleep and mental well-being interventions to this population. Providing sleep interventions is particularly important due to the relationship between sleep difficulties and mental health difficulties, alcohol abuse, lower mental well-being, and higher risk of suicide (Graham et al., 2021; Hertenstein, 2019; Liu et al., 2020). Additionally, the findings of autistic traits mediating the relationship between sleep difficulties and loneliness add to the existing research which demonstrates the myriad difficulties associated with high levels of autistic traits, including sleep difficulties (Hochard et al., 2020; Stewart et al., 2020), mental health difficulties (Beck et al., 2020; Geurts et al., 2016; Lundström et al., 2011; Oshima et al., 2014), reduced mental well-being (Stimpson et al., 2021) and increased loneliness (Caruana et al., 2021; Stice & Lavner, 2019). Thus, screening for high levels of autistic traits in the student population could enable more timely intervention with the associated difficulties, taking pressure of an already overburdened NHS (O'Dowd, 2023). Screening of autistic traits could be completed using

measures such as SRS-2 (Constantino & Gruber, 2012) used in this study, or the AQ (Baron-Cohen et al., 2001).

Conclusion

Self-reports of sleep problems, autistic traits, mental well-being, and loneliness replicated previous findings and added to this under-researched topic area. The mediation analyses, indicates the importance of autistic traits in the relationship between sleep and both loneliness and mental well-being in this population. Understanding people's differences and difficulties in the social world appears key in understanding a range of negative outcomes in their everyday lives. This study proposes potential clinical implications, including the importance and likely benefits of developing interventions for poor sleep, mental well-being for students, and the importance of screening for autistic traits.

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Chapter 3

Public Dissemination Documents

Meta-analysis Press Release

Headline: *Female Children are being diagnosed later than Males with Autism Spectrum Disorder*

Background

Autism Spectrum Disorder (ASD), is a lifelong difference in the construction/wiring of the brain, that is present from birth, which makes social interaction and communication difficult (American Psychological Association, 2013). Early diagnosis is important as it helps the child and their family understand the child's difficulties (Baker-Ericzn, Brookman-Frazee & Stahmer, 2005), can enable access to services and financial support (National Institute for Health & Care Excellence, 2013) and to early, and therefore more effective intervention for these difficulties (Landa, 2018). Two former meta-analysis (Loubersac et al., 2021; Van't Hof et al., 2021) did not find that sex or gender impacted on the age of ASD diagnosis, but both had limitations in their search strategy's, which meant they likely missed several papers. Therefore, this paper aimed to conclude if gender or sex do impact on the age of ASD diagnosis in children.

What did the study do?

This study was a meta-analysis. A meta-analysis begins by searching several research databases, in this case on the 14th of December 2021 four databases were searched; Medline, PsycInfo, Embase and Psycarticles, using search terms which together, aim to find all the research which has previously been completed on this topic. The search terms for this paper were taken from the two previous meta-analysis (Loubersac et al., 2021; Van't Hof et al., 2021) and from the wider literature. The initial search conducted on papers which had been released since 2013 to December 2021, 3627 papers were found to have been completed on this topic area. Then an inclusion and exclusion criteria was applied, to ensure the papers found had the

data required, which left 29 papers for review, which was more papers than used in previous meta-analysis (Loubersac et al., 2021; Van't Hof et al., 2021). The quality of the papers was then reviewed, and was deemed acceptable, but it was noted that the reporting of these papers was a main difficulty, and the main reporting failure was that they often used the terms sex and gender interchangeably. Despite these issues, 147,885 participants data from previous papers was able to be used for analysis, via statistical methods, to determine if sex or gender impacted on age of diagnosis.

What did the meta-analysis find?

The meta-analysis found that boys were being diagnosed before girls. This was as girls were found to on average across the papers to be diagnosed at 5.6 compared to 4.8 years of age for boys. It could also not be determined if the difference in age of diagnosis found between boys and girls was due to sex or gender. This was believed to be due to the interchangeable use of terms by the research papers. It was also noted that there were no transgender or non-binary children mentioned across the papers, despite this group being shown by prior literature to be more likely to be diagnosed with ASD (Strang et al., 2018).

What do the results mean?

The results of this meta-analysis not being found by previous research (Loubersac et al., 2021; Van't Hof et al., 2021), was likely due to this papers' more robust search strategy. This meta-analysis, however, could not determine whether boys are diagnosed before girls due to sex or gender reasons, and this question requires further research. It is however, hypothesised that this may be due to the interchangeable use of the terms sex and gender in research, which does need to be addressed.

The results of this paper also suggest that due to finding that no transgender and non-binary children were cited in the literature, suggests that more attention needs to be paid by

research to this group. Equally, due to the later diagnosis age of girls found by this meta-analysis, it is suggested that local level service evaluations are conducted to determine why girls are being diagnosed later than boys. In addition, teachers, clinicians, and parents are advised to receive training on the identification of ASD in girls, to ensure that girls do not continue to be diagnosed at a later age than boys in the future, to enable girls to also have access to the benefits that early diagnosis can provide.

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Empirical Press Release

Headline: *Screening for Autistic Traits and Sleep Interventions required for University Students*

Background

Sleep difficulties have been found to link with depression, anxiety, psychosis, alcohol abuse (Hertenstein, 2019), lower mental well-being (Graham et al., 2021), and loneliness (Cacioppo & Cacioppo, 2014). Two groups who particularly experience sleep difficulties are university students (Lund et al., 2010) and people with higher levels of autistic traits (Hochard et al., 2020). Autistic traits are defined as difficulties with social interaction and communication, which do not meet clinical criteria for Autism Spectrum Disorder, as classified by the Diagnostic and Statistical Manual fifth edition ([DSM-V], American Psychiatric Association, 2013) or the International Classification of Diseases tenth edition ([ICD-11], World Health Organisation, 2019)**.**

What did the study do?

This study therefore aimed to explore sleep difficulties in university students and to determine if autistic traits could explain the relationship between university students sleep difficulties, loneliness, and mental well-being. This study began by recruiting 205 university students studying psychology and asking them to complete self-report online questionnaires, which explored if they had any sleep difficulties, the level of autistic traits they experienced, and their level of loneliness and mental well-being. The questionnaires were then scored. The total scores for sleep difficulties were first compared to loneliness, mental well-being, and autistic traits, using a statistical test called a correlation analysis. Then a second statistical test called a mediation analysis, was applied. The first meditation analysis analysed if autistic traits

could explain the relationships found between sleep difficulties and loneliness. Whilst the second mediation analysis aimed to determine if autistic traits could explain the relationship between sleep difficulties and mental well-being.

What did the study find?

The results showed that 77.6% of the students scored below the average UK population regarding mental wellbeing. Further 62.4% of the samples self-reported sleep scores suggest sleep difficulties, which indicates that these are areas which the student population samples would benefit in intervention from.

The correlation tests found that there was a positive relationship between sleep difficulties, loneliness, and autistic traits, meaning that students who reported more sleep difficulties, also scored higher on the scale measuring autistic traits and loneliness. In comparison, sleep difficulties were found to be negatively related to mental well-being, meaning that students who described higher levels of sleep difficulties also reported lower levels of mental well-being.

The first mediation analysis found that autistic traits completely explained the relationship between sleep difficulties and loneliness, while the second mediation analysis found that autistic traits partially explained the relationship between sleep difficulties and mental well-being.

What do the results mean?

The finding of autistic traits mediating the relationship between sleep difficulties and loneliness adds to the existing research, which has shown the different issues linked to high levels of autistic traits, including sleep difficulties (Hochard et al., 2020), mental health difficulties (Beck et al., 2020), reduced mental well-being (Stimpson et al., 2021) and increased loneliness (Caruana et al., 2021). Thus, it is advised that screening for high levels of autistic

traits in the student population would be useful, to enable more timely intervention with the associated difficulties. In addition, due to the high levels of difficulties with mental well-being and sleep difficulties, interventions for student populations to improve mental well-being and tackle sleep difficulties is advised.

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Appendices

Appendix A

Table A1

Quality Index Table

Study Name	Selection Bias	Detection Bias	Reporting Bias	Generalisability	Study Design Score	ROB Score	Overall Quality Score	Overall Quality Index Score
Begeer et al., 2013	Unclear	High	Unclear	Unclear	20	3	23	82%
Bent et al., 2015	Unclear	Low	Unclear	Unclear	20	5	25	89%
Brett et al., 2016	Unclear	High	Unclear	Unclear	20	3	23	82%
Cawthorpe, 2018	Unclear	Low	Unclear	Unclear	10	5	15	54%
Daniels & Mandell, 2013	Unclear	Unclear	Unclear	Unclear	10	4	14	50%
Gabis et al., 2020	Unclear	Low	Unclear	Unclear	10	5	15	54%
Gabis et al., 2021	Unclear	Low	Unclear	Unclear	10	5	15	54%
Gibbs et al., 2019	Unclear	Unclear	Low	High	20	4	24	86%
Harrop et al., 2021	Low	Low	Low	Low	20	8	28	100%
Hiller et al., 2016	Unclear	High	Unclear	Unclear	20	3	23	82%
Höfer et al., 2019	Low	Low	Unclear	High	10	5	15	54%
Jensen et al., 2014	Low	Low	Unclear	Low	20	7	27	96%
Kavanaugh et al., 2021	Unclear	High	Unclear	Unclear	20	3	23	82%
Kentrou et al., 2019	Unclear	High	Unclear	Unclear	20	4	24	86%
Kurasawa et al., 2018	Low	Low	Unclear	Low	20	7	27	96%
McCormick et al., 2020	Unclear	High	Unclear	Unclear	10	3	13	46%

McDonnell et al., 2020	Low	Low	Unclear	Low	20	7	27	96%
Mishaal et al., 2014	Low	Low	Unclear	Low	20	7	27	46%
Mussey et al., 2017	Low	Low	Unclear	Low	20	7	27	96%
Petrou et al., 2018	Unclear	High	Low	Unclear	20	4	24	86%
Rutherford et al., 2016	Unclear	Unclear	Unclear	Unclear	20	4	24	86%
Salomone et al., 2016	Unclear	High	Unclear	Unclear	20	3	23	82%
Shaw et al., 2020	Unclear	Unclear	Unclear	Unclear	20	4	24	86%
Shrestha et al., 2019	Unclear	Low	Low	Unclear	20	6	26	93%
Tang et al., 2021	Low	Low	Unclear	High	20	5	25	89%
Tanidir & Mukaddes, 2014	Unclear	Low	Unclear	High	20	4	24	86%
Wang et al., 2018	Unclear	High	Unclear	Unclear	20	3	23	82%
Wu et al., 2016	Unclear	Low	Unclear	Unclear	10	5	15	54%
Zeleke et al., 2018	Unclear	Unclear	Unclear	High	20	3	23	82%

Appendix B

Table B1

Table of Study Characteristics

Study Name	Total Number of Participants	Percentage of Sample Male	Was the Study Completed in Europe?	Reported Exploring Sex or Gender?	Type of Diagnosis	Average Age of ASD Diagnosis Male (years)	Average Age of ASD Diagnosis Female (years)
Begeer et al., 2013	1354	84.9%	European country	Sex	Variety ASD diagnosis	6.5	7.1
Bent et al., 2015	15074	80.8%	Not a European country	Sex	Variety ASD diagnosis	4.1	4
Brett et al., 2016	2134	82.7%	European country	Sex	Variety ASD diagnosis	-	-
Cawthorpe, 2018	720	84.6%	Not a European country	Sex	Single diagnosis (ASD)	7.8	7.5
Daniels & Mandell, 2013	1475	81.8%	Not a European country	Sex	Single diagnosis (ASD)	3.1	3.1
Gabis et al., 2020	467	76.2%	Not a European country	Unclear	Single diagnosis (ASD)	3.55	3.0
Gabis et al., 2021	1182	80.6%	Not a European country	Unclear	Single diagnosis (ASD)	4.4	3.8
Gibbs et al., 2019	215	77.6%	Not a European country	Gender	Single diagnosis (ASD)	4.1	6.5
Harrop et al., 2021	195	53.8%	Not a European country	Sex	Single diagnosis (ASD)	5.3	6.3
Hiller et al., 2016	152	60.5%	Not a European country	Unclear	Single diagnosis (ASD)	8.5	9.2

Höfer et al., 2019	203	83.7%	European country	Sex	Variety ASD diagnosis	6.5	6.6
Jensen et al., 2014	14997	79.4%	European country	Sex	Variety ASD diagnosis	-	-
Kavanaugh et al., 2021	87651	76.9%	Not a European country	Sex	Single diagnosis (ASD)	4.6	5.7
Kentrou et al., 2019	443	79.9%	European country	Gender	Single diagnosis (ASD)	5.5	6.3
Kurasawa et al., 2019	8264	76.0%	Not a European country	Sex	Variety ASD diagnosis	7.2	7.42
McCormick et al., 2020	851	79.0%	Not a European country	Sex	Variety ASD diagnosis	5.7	7.0
McDonell et al., 2020	365	80.3%	Not a European country	Sex	Single Diagnosis (ASD)	5.09	6.8
Mishaal et al., 2014	551	87.3%	Not a European Country	Unclear	Single Diagnosis	2.55	2.7
Mussey et al., 2017	679	83.4%	Not a European Country	Gender	Single Diagnosis (ASD)	10.1	10.6
Petrou et al., 2018	830	84.7%	European Country	Gender	Single Diagnosis (ASD)	5.61	6.8
Rutherford et al., 2016	830	84.7%	European Country	Gender	Single Diagnosis (ASD)	5.61	6.8
Salomone et al., 2016	1245	92.6%	European Country	Gender	Single Diagnosis (ASD)	-	-
Shaw et al., 2020	798	77.9%	Not a European Country	Sex	Single Diagnosis (ASD)	5.84	6.1
Shrestha et al., 2019	246	76.0%	Not a European Country	Gender	Single Diagnosis (ASD)	4.82	4.8
Tang et al., 2021	195	74.4%	Not a European country	Gender	Single Diagnosis (ASD)	7.21	8.3

Tanidir & Mukaddes, 2014	61	91.8%	European Country	Unclear	Single Diagnosis (ASD)	10	8.5
Wang et al., 2018a	492	78.5%	European Country	Gender	Single Diagnosis (ASD)	4.9	5.6
Wang et al., 2018b	433	82.5%	European Country	Gender	Single Diagnosis (ASD)	3.3	3.4
Wu et al., 2016	8564	82.6%	Not a European country	Sex	Single Diagnosis (ASD)	4.8	4.7
Zeleke et al., 2018	97	80.4%	Not a European Country	Unclear	Single Diagnosis (ASD)	3.9	2.3

Note. the table shows the number of participants, percentage of males, country of origin, method of diagnosis is it given, and whether a clinical or non-clinical diagnosis of autism provided. The figures in the table are rounded to one decimal point.

Appendix C

Participant Information Sheet

Before taking part in this study, it is important for you to understand why it's being conducted and what it will involve.

What will my participation involve if I agree to take part?
You are being invited to take part in an online research study that aims to help us better understand the relationship between sleep quality, well-being and social cognition. You will be asked to answer questions about the quality of your sleep, your well-being and how you interact in social situations, across six questionnaires. Participation in the study typically takes around 40 minutes. You will be rewarded 0.7 credits on completion of this study.

Anyone aged 18-65 can take part, as long as they don't meet either of the following criteria: – A diagnosed mental health condition – A neurodevelopmental disorder (such as autism).

Participation is voluntary and you are free to withdraw at any point should you choose to do so, by exiting the questionnaire. Withdrawal will not incur any penalty. You will receive credit for the proportion of questions you have completed.

What will happen to my responses?
Your responses to the questions will be stored in an electronic database alongside the answers of other participants in this study. You will be known by your Participation ID only, and your data will not be stored with any personally identifiable data about you. You have the right to ask that any data you have contributed be withdrawn within two weeks after completing this study. To do so, please contact the research team with your RPS ID number. Anonymised data will be stored for up to 10 years before being destroyed, in accordance with the University of Birmingham policy. You maintain the right to refuse to respond to any question that is asked of you by exiting the questionnaire.

What are the potential benefits and risks of me taking part?
By taking part in research studies, you gain valuable experience of being a participant and understanding of how psychological research takes place. There are no known risks for you in this study. Questions in the study will be related to anxiety, sleep and social cognition. We do not expect this to cause distress in any participants. On the chance that it does, support can be sought from Birmingham Healthy Minds (https://www.bsmhft.nhs.uk/ourservices/birmingham-healthy-minds/self-referral/), Birmingham Nightline (https://www.guildofstudents.com/studentgroups/societies/nightline/) or from your General Practitioner (doctor). This project follows protocols approved by the University of Birmingham Research Ethics Committee.

If you have any questions as a result of reading this information sheet, please feel free to contact the lead researcher via email: Dr Andrew Surtees (Lecturer in Psychology): [redacted]. If you have any concerns about this study, you can contact the head of the School of Psychology, Professor Ed Wilding [redacted].

Appendix D

Consent Form

By signing below, you agree that:

- I have read and understood the Participant Information Sheet.
- I understand that I maintain the right to withdraw at any point in the study and can refuse to answer any question without any consequence.
- I understand that I can request for my data to be withdrawn and destroyed within two weeks after completing the study.
- I understand the purpose and nature of the study. I have had the opportunity to ask questions and have had them answered.
- I understand that all personal information will remain confidential and data will be anonymised.
- I understand that I am free to contact any of the researchers or the Principal Investigator for further clarification and information.
- I do not have a mental health condition or a neurodevelopmental disorder.
- Having read the above, I consent to taking part in this study.

Appendix E

Demographic Questions

1. What is your age? If you'd prefer not to answer, please type 'prefer not to say'.
2. What gender do you identify with?
    a. Male
    b. Female
    c. Non-binary
    d. Other
    e. Prefer not to say
3. Please specify your ethnicity.
    a. White
    b. Asian/Asian British
    c. Black/African/Caribbean/Black British
    d. Mixed/multiple ethnic groups
    e. Other ethnic group, please specify:
    f. Prefer not to say

Appendix F

The Warwick–Edinburgh Mental Well-being Scale (WEMWBS)

Instructions: Below are some statements about feelings and thoughts.
Please tick the box that best describes your experience of each over the last 2 weeks.

1. I've been feeling optimistic about the future.
2. I've been feeling useful
3. I've been feeling relaxed.
4. I've been feeling interested in other people.
5. I've had energy to spare.
6. I've been dealing with problems well
7. I've been thinking clearly
8. I've been feeling good about myself
9. I've been feeling close to other people
10. I've been feeling confident
11. I've been able to make up my own mind about things
12. I've been feeling loved
13. I've been interested in new things
14. I've been feeling cheerful

Appendix G

Loneliness Scale

Instructions: Indicate how often you feel the way described in each of the following statements.

1. I feel in tune with the people around me
2. I lack companionship
3. There is no one I can turn to
4. I do not feel alone
5. I feel part of a group of friends
6. I have a lot in common with the people around me
7. I am no longer close to anyone
8. My interests and ideas are not shared by those around me
9. I am an outgoing person
10. There are people I feel close to
11. I feel left out
12. My social relationships are superficial
13. No one really knows me well
14. I feel isolated from others
15. I can find companionship when I want it
16. There are people who really understand me
17. I am unhappy being so withdrawn
18. People are around me but not with me
19. There are people I can talk to
20. There are people I can turn to

Appendix H

Pittsburgh Sleep Quality Index (PSQI)

Buysse, D. J., Reynolds III, C. F., Monk, T. H., Berman, S. R., & Kupfer, D. J. (1988). The Pittsburgh Sleep Quality Index: A New Instrument for Psychiatric Practice and Research. *Psychiatry Research, 28,* 193-213.

Instructions: The following questions relate to your usual sleep habits during the past month only. Your answers should indicate the most accurate reply for the majority of days and nights in the past month.

Requiring written responses.

1. During the past month, what time have you usually gone to bed at night?
2. During the past month, how long (in minutes) has it usually taken you to fall asleep?
3. During the past month, what time have you usually gotten up in the morning?
4. During the past month, how many hours of actual sleep did you get at night? (This may be different than the number of hours you spent in bed.)

Scale: Not during the past month; less than once a week; once or twice a week; three or more times a week.

5. During the past month, how often have you had trouble sleeping because you…
    a. Cannot get to sleep within 30 minutes
    b. Wake up in the middle of the night or early morning
    c. Have to get up to use the bathroom
    d. Cannot breathe comfortably
    e. Cough or snore loudly
    f. Feel too cold
    g. Feel too hot
    h. Have bad dreams
    i. Have pain
    j. Other reason(s), please describe
6. During the past month how often have you taken medicine to help you sleep (prescribed or "over the counter")?
7. During the past month, how often have you had trouble staying awake while driving, eating meals, or engaging in social activity?

Scale: No problem at all; only a very slight problem; somewhat of a problem; a very big problem.

8. During the past month, how much of a problem has it been for you to keep up enough enthusiasm to get things done?

Scale: Very good; fairly good; fairly bad; very bad.

9. During the past month, how would you rate your sleep quality overall?

Appendix I

Debrief form

This study aimed to investigate the relationship between sleep quality, well-being and social cognition. Differences in social cognition can be associated with Autism Spectrum Disorder.

Participation in this study involved the completion of some questionnaires that can be used during preliminary screening for clinical conditions, including anxiety, depression and autistic traits. Scores from these tests would not be a sufficient basis for clinical diagnosis, and they do not serve those purposes in this study. You will not receive feedback on your individual scores for this reason. However, they may still have made you think about difficulties or differences you experience. If you wish to seek further information, you might consider the following outlets, or speak with your General Practitioner (doctor).

Birmingham Healthy Minds
Birmingham Healthy Minds is an NHS primary care psychological therapies service that works closely with Birmingham GPs (https://www.bsmhft.nhs.uk/our-services/birminghamhealthy-minds/self-referral/)). BHM offers advice, information and brief psychological talking therapies for people aged 16 and over, who are often feeling anxious, low in mood or depressed.

Birmingham Nightline
Birmingham Nightline is a confidential, non-judgemental and non-directive listening and information service run by students for students. You can contact Nightline from 8pm-8am every night of term for email, phone and instant messaging services, and from 6pm-12am every night of term for face-to-face contact at the Chaplaincy. Emails are also checked regularly throughout vacation periods. Contact details can be found on the back of student ID cards for students at both University of Birmingham and Aston University, or on online portals (my.bham)

Mind
Mind offers confidential help on a range of mental health problems by providing highquality information, including on anxiety and sleep deprivation. Helpline: 0300 123 3393

National Autistic Society The Autism helpline provides impartial, confidential information and advice concerning Autism. Helpline: 0808 800 4104

If you wish to withdraw your data, or have any questions concerning this research, please contact the researchers via email: Komal: [redacted], Lottie: CDC862@alumni.bham.ac.uk, or the Principal Investigator, Dr. Andrew Surtees: [redacted].

If you have any concerns about this study, you can contact the head of the School of Psychology, Professor Ed Wilding ([redacted]

Appendix J

Licence for the use of WEMWBS

Thank you for completing the registration for a Licence to use WEMWBS for non-commercial purposes. You now have access to the scales and the associated resources here on our website: https://warwick.ac.uk/wemwbs/using/register/resources
We suggest you bookmark this page for future reference.
The information declared on your Registration Form is documented below. Please retain a copy of this email as a record of your Licence together with the Terms and Conditions you have accepted. https://warwick.ac.uk/wemwbs/using/non-commercial-licence-registration/shrink-wrap_licence_-wemwbs_non-_commercial_v3_8.9.20.pdf.
If you have any questions please contact us via email: [redacted]

Question: Type of use Answer: Survey

Question: If other, please specify Answer: Doctoral research

Question: Type of intervention (if applicable) Tick all that apply
Answer: Other doctoral thesis.

Question: Field of Use: University or college

Question: Preferred version of
(Note – both versions of can be used under a single licence)
Answer:
WEMWBS - 14 item scale

Question: Age of Participants (Tick all that apply)
Answer: 18-64

Question: How many participants are you planning to use with? (Scale of use)
Answer: 101-250

Question: Start Date
Answer: 01/11/2021

Question: End Date
Answer: 30/11/2021

Question: Territories of Use: In which geographical areas will you be using ? (tick all that apply)
Answer: United Kingdom

Question: In which language(s) are you planning to use ?
Tick all that apply Please note that we may not be able to offer a translation into every language you require: Answer: English

Question: If other, please specify: Answer:

Question: Organisation name: Answer: University of Birmingham

Question: Type of organisation
Answer:
University

Question: If other, please specify
Answer:

Question: Size of Organisation (no. of employees)
Answer: 51-500

Question: Organisation Address: University of Birmingham, Edgbaston, Birmingham B15 2TT

Question: Country of Organisation: Answer: UK

Question: Website: Answer: https://www.birmingham.ac.uk/contact/index.aspx

Question: Contact Name
Answer: Simone Ellen Jade Kendall

Question: Job Title Answer: Trainee Clinical Psychologist/ Doctorate student

Question: If other, please specific. Answer:

Question: Email Answer: [redacted]

Question: I have read and agreed to the terms of the Non-Commercial Licence Please print and retain a copy for your reference
Answer:
Yes

Question: I agree to my contact details being shared with third parties for the purposes of product development of
Answer:
Yes

Appendix K

WEMWBS Scoring

The WEMWBS is scored by summing the responses to each of the 14 test items on a 1 to 5 Likert scale (1 = None of the time to 5 + All of the time). All questions are equally weighted. Scores can range from a minimum of 14 to a maximum of 70 points. Higher scores are associated with higher levels of mental well-being. The scale is a self-administered. No cut-off score is associated with the scale because the scale is not designed to identify persons with exceptionally high or low positive mental health. In a population sample comprised of adults ranging in age from 16 to 75 plus years, the mean score was 50.7/70. The mean score for a sub sample of adults aged between 65 and 74 years was 52.4 while the mean score was 51.2 for a sub sample of adults > 75 years

Appendix L

UCLA Version three scoring Instructions

INSTRUCTIONS: Indicate how often each of the statements below is descriptive of you.

Statement Never Rarely Sometimes Often

1. I feel in tune with the people around me 1 2 3 4

2. I lack companionship 1 2 3 4

3. There is no one I can turn to 1 2 3 4

4. I do not feel alone 1 2 3 4

5. I feel part of a group of friends 1 2 3 4

6. I have a lot in common with the people around me 1 2 3 4

7. I am no longer close to anyone 1 2 3 4

8. My interests and ideas are not shared by those around me 1 2 3 4

9. I am an outgoing person 1 2 3 4

10. There arc people I feel close to 1 2 3 4

11. I feel left out 1 2 3 4

12. My social relationships arc superficial 1 2 3 4

13. No one really knows me well 1 2 3 4

14. I feel isolated from others 1 2 3 4

15. I can find companionship when I want it 1 2 3 4

16. There are people who really understand me 1 2 3 4

17. I am unhappy being so withdrawn 1 2 3 4

18. People are around me but not with me 1 2 3 4

19. There are people I can talk to 1 2 3 4

20. There are people I can turn to 1 2 3 4

Scoring: Items 1, 5, 6, 9, 10, 15, 16, 19, 20 are all reverse scored.

Appendix M

PSQI Scoring Instructions

Buysse, D. J., Reynolds III, C. F., Monk, T. H., Berman, S. R., & Kupfer, D. J. (1988). The Pittsburgh Sleep Quality Index: A New Instrument for Psychiatric Practice and Research. *Psychiatry Research, 28*, 193-213.

In scoring the PSQI, seven component scores are derived, each scored 0 (no difficulty) to 3 (severe difficulty). The component scores are summed to produce a global score (range 0 to 21).

Component 1: Subjective sleep quality–question 9

Response to Q9	Component 1 score
Very good	0
Fairly good	1
Fairly bad	2
Very bad	3

Component 2: Sleep latency–questions 2 and 5a

Response to Q2	Component 2/Q2 subscore
□ 15 minutes	0
16-30 minutes	1
31-60 minutes	2
> 60 minutes	3

Response to Q5a	Component 2/Q5a subscore
Not during the past month	0
Less than once a week	1
Once or twice a week	2
Three or more times a week	3

Sum of Q2 and Q5a subscores	Component 2 score
0	0
1-2	1
3-4	2
5-6	3

Component 3: Sleep duration–question 4

Response to Q4	Component 3 score
> 7 hours	0
6-7 hours	1
5-6 hours	2
< 5 hours	3

Component 4: Sleep efficiency–questions 1, 3, and 4

Sleep efficiency = (□ hours slept/ □ hours in bed) X 100%

- hours slept – question 4
- hours in bed – calculated from responses to questions 1 and 3

Sleep efficiency	Component 4 score
> 85%	0
75-84%	1
65-74%	2
< 65%	3

Component 5: Sleep disturbance–questions 5b-5j

Questions 5b to 5j should be scored as follows:

Not during past month	0
Less than once a week	1
Once or twice a week	2
Three or more times a week	3

Sum of 5b to 5j scores	Component 5 score
0	0
1-9	1
10-18	2
19-27	3

Component 6: Use of sleep medication–question 6

Response to Q6	Component 6 score
Not during past month	0
Less than once a week	1
Once or twice a week	2
Three or more times a week	3

Component 7: Daytime dysfunction–questions 7 and 8

Response to Q7	Component 7/Q7 subscore
Not during past month	0
Less than once a week	1
Once or twice a week	2
Three or more times a week	3

Response to Q8	Component 7/Q8 subscore
No problem at all	0
Only a very slight problem	1
Somewhat of a problem	2
A very big problem	3

Sum of Q7 and Q8 subscores	Component 7 score
0	0
1-2	1
3-4	2
5-6	3

Appendix N

Approval letter

Dear Dr Surtees

Re: "The relationship between sleep, well-being and social cognition"
Ethics Application ERN_09-719AP28

Thank you for the above application to use Programme of Work ERN_09-719P. This has now been considered by the Science, Mathematics, Engineering and Technology Ethical Review Committee.

On behalf of the Committee, I can confirm a favourable ethical opinion for this application.

I would like to remind you that any substantive changes to the nature of the study as described in the Application for Ethical Review, and/or any adverse events occurring during the study should be promptly brought to the Committee's attention by the Principal Investigator and may necessitate further ethical review.

Please be aware that whilst Health and Safety (H&S) issues may be considered during the ethical review process, you are still required to follow the University's guidance on H&S and to ensure that H&S risk assessments have been carried out as appropriate. For further information about this, please contact your School H&S representative or the University's H&S Unit at healthandsafety@contacts.bham.ac.uk.

If you require a hard copy of this correspondence, please let me know.

Kind regards

Mrs Susan Cottam
Research Ethics Manager
Research Support Group
University of Birmingham
Email: [redacted]
Video/phone: If you would like to arrange a Teams/Zoom/telephone call, please email me and I will get in touch with you as soon as possible.
Web: https://intranet.birmingham.ac.uk/finance/RSS/Research-Support-Group/Research-Ethics/index.aspx
Postal address: [redacted]