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RESEARCH ARTICLE

Predictors of sleep quality for autistic people across adulthood

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Abstract

Poor sleep can have a significant impact on physical health and well-being. Sleep problems are common among autistic children, but less is known about sleep across the autistic adult lifespan. Autistic adults (n = 730, aged 18–78 years) were recruited via Simons Powering Autism Research for Knowledge Research Match. Participants completed online surveys asking about demographics, health problems, social support, symptoms of anxiety and depression, and overall and specific aspects of sleep quality. Regression analyses explored the variables associated with sleep quality. Physical health, assigned female sex at birth and self-reported anxiety symptoms significantly contributed to models for all aspects of sleep. Perceived stress contributed to models of overall and subjective sleep quality, and daytime dysfunction. Depression symptoms did not contribute significantly to any of the models of sleep quality. However, utilizing government support mechanisms (such as social security) contributed to the model of sleep efficiency. Age contributed little to models of sleep quality, whereas perceived stress and psychotropic medication use contributed to some but not all aspects of sleep. Sleep quality is poor for autistic people across the adult lifespan. Given known impacts of poor sleep on health, cognition and quality of life, attention should be paid to sleep and its possible everyday effects for autistic people of all ages.

Lay Summary

Sleep problems are known to negatively affect cognition, well-being and physical and mental health. Poor sleep is common among autistic children, but little is known about sleep among autistic adults. The few studies examining sleep among autistic adults have focused on young adults and suggest that sleep difficulties continue into adulthood. This study asked 730 autistic people (aged 18–78 years) to complete surveys asking about sleep quality, stress, anxiety and depression symptoms, and other aspects of health and social care. Autistic adults report poor quality sleep overall. Being female, having poor health and higher anxiety are significantly associated with all aspects of poor sleep for autistic people. Stress, psychiatric medication use, and receiving support from government agencies were important for some (but not all) aspects of sleep. It is important to raise awareness of the risk of poor sleep among autistic people of all ages, and of the impact that it can have on well-being.

KEYWORDS
adulthood, autism, mental health, sleep, social care

INTRODUCTION

Sleeping poorly has significant detrimental impacts on many aspects of health and well-being (Delahaye et al., 2014; Deserno et al., 2019; Lawson et al., 2020; Magee et al., 2017). Due to the importance of sleep for physical and psychological well-being, several theoretical models have been put forth to understand the processes involved with sleep problems. These include the neurocognitive (Goel et al., 2009), behavioral (Perlis et al., 1997), and the biopsychosocial. For brevity, we review the biopsychosocial model here, as it appears most relevant to conceptualizing sleep problems among autistic adults. Biopsychosocial models for sleep problems propose that biological and genetic predisposition for sleep problems, are reinforced by experience, environmental factors, and maladaptive coping (Perlis et al., 1997; Spielman et al., 1987). Presence of depression and/or anxiety can be viewed as not only a predisposing and environmental factor predicting sleep difficulties, but also a consequence of sleep problems (Gulia & Kumar, 2018; McHugh et al., 2011; Steptoe et al., 2008; Sutter et al., 2012). For example, rumination associated with anxiety and depression has been associated with the development and maintenance of sleep problems (Gosling et al., 2012). Biopsychosocial models further suggest that high arousal may lead to enhanced sensory processing around sleep, which increases risk of insomnia (Perlis et al., 1997). In contrast “optimal” sleep (considered to be between 6 and 8.5 h per night of restful sleep) is associated with low levels of anxiety and depression, and high levels of personal growth, purpose in life, and self-acceptance (Hamilton et al., 2007). Sleep patterns change across the lifespan, and older age (60+) is associated with longer sleep latency (time to fall asleep), more disrupted sleep, and less deep sleep (Carskadon & Dement, 2011; Gulia & Kumar, 2018). Although changes in sleep patterns across adulthood are well understood in the general population, little is known about age-related changes in sleep quality among autistic people.

Sleep difficulties are commonly reported for autistic children, and there is growing evidence of sleep problems continuing into adulthood (Baker & Richdale, 2015; Hohn et al., 2019; Jovevska et al., 2020; Morgan et al., 2020; Oyane & Bjorvatn, 2005). The most commonly reported sleep difficulties in autistic individuals relate to insomnia and include difficulty falling asleep, poor sleep efficiency, and problems with sleep maintenance (Baker & Richdale, 2015; Hare et al., 2006; Jovevska et al., 2020; Lawson et al., 2020; Limoges et al., 2005; Morgan et al., 2020; Oyane & Bjorvatn, 2005). High rates of risk factors identified in biopsychosocial models of sleep, which are also common among autistic people (such as anxiety, depression and associated rumination, and enhanced sensory processing) may explain the common sleep difficulties (Gosling et al., 2012; Richdale & Schreck, 2009). The association between sleep and age is not yet clear across the lifespan for autistic people, with studies including different age ranges, measures of sleep and analytic approaches. In one study spanning adulthood (15–80 years), young (20–39 years) and middle-aged (40–59 years) autistic adults reported poorer sleep quality (using the Pittsburgh Sleep Quality Index) compared to same-age non-autistic comparison groups, whereas group differences were not observed in adolescent (15–19 years) or older (60+ years) age groups (Jovevska et al., 2020). Note that autistic people in the older age group (60+ years) reported relatively better sleep (on the Insomnia Severity Index) than younger autistic people. A similar pattern was observed in a different sample, where older age was significantly associated with better sleep quality among 45–65 year olds but not in younger age groups (18–25 years and 25–45 years; Hohn et al., 2019). Although note the difference in the maximum age of these two studies. These results are in contrast to a study of people with high autistic traits in the general population, in which middle-aged and older people (50–81 years) with high autistic traits reported more sleep difficulties (measured using the St Mary's Hospital Sleep questionnaire) than those with low autistic traits (Stewart et al., 2020).

Across the lifespan, poor sleep quality among autistic people has been associated with a range of demographic and mental health factors. Two studies from Australia and the Netherlands suggest that autistic females have poorer sleep quality than autistic males (Hohn et al., 2019; Jovevska et al., 2020). As observed within the general population (Newman et al., 1997), poorer sleep quality has also been associated with current medication use among autistic people (Jovevska et al., 2020). Although physical health is associated with sleep in the general population (Gadie et al., 2017), we are not aware of studies examining this association in autistic people. Among young and middle-aged autistic adults, sleep difficulties have also been associated with the presence of co-occurring mental health conditions (Baker & Richdale, 2015; Jovevska et al., 2020; Limoges et al., 2005) and stress (McLean et al., 2021), showing similar patterns to those observed in the general population (Han et al., 2012; Steptoe et al., 2008). Among autistic people, presence of a co-occurring mental health condition (a range of different conditions were included) was linked with sleep quality and sleep latency, but not total sleep time (Jovevska et al., 2020). In a study incorporating sleep diaries, autistic people with co-occurring diagnoses of anxiety and/or depression reported more time sleeping than autistic people without co-occurring conditions (note that both over and under sleeping are considered detrimental); no other differences between the groups were observed (Baker & Richdale, 2015). As yet, studies have not examined the effect of individual mental health conditions or symptoms, and their unique associations with sleep quality in autistic adults. Less commonly explored are social factors, such as employment and the

TABLE 1 Descriptive characteristics of participants

	Mean (range)	SD
Age	39.87 (18–78)	13.61
AQ-28 scores	84.91 (47–112)	11.46
Perceived stress	23.07 (0–40)	7.30
Anxiety symptoms	10.23 (0–21)	6.19
Depression symptoms	10.57 (0–27)	7.03
Global PSQI score	9.49 (0–21)	4.48
PSQI—Sleep quality	1.53 (0–3)	0.84
PSQI—Sleep latency	1.79 (0–3)	1.04
PSQI—Sleep duration	0.80 (0–3)	0.98
PSQI—Sleep efficiency	1.02 (0–3)	1.16
PSQI—Sleep disturbance	1.64 (0–3)	0.69
PSQI—Sleep medication use	1.25 (0–3)	1.36
PSQI—Daytime dysfunction	1.49 (0–3)	0.92
	Frequency	**% Frequency**
Sex assigned at birth (m, f)	292, 437	40%, 60%
Race, count (White, African-American, Asian, Native American/Alaska Native, Multiracial, Other)[a]	603, 16, 12, 6, 74, 16	83%, 2%, 2%, 1%, 10%, 2%
Ethnicity, count (Latinx, Not Latinx, Unknown, Missing)	60, 655, 10, 5	90%, 8%, 1%, 1%
Education, count		
No high school, Some high school	2, 18	0.5%, 3%
GED diploma, High school graduate	26, 96	4%, 13%
Trade/vocational school	45	6%
Associate's degree, Some college	72, 143	10%, 20%
Baccalaureate degree	183	25%
Graduate/professional degree	142	20%
[b]Measure of needs indicators[a] (none, 1, 2, 3, 4)	430, 129, 97, 41, 4	61%, 18%, 14%, 6%, 1%
Number of health conditions affecting daily life[c] (none, 1, 2 or more)	235, 229, 259	32%, 32%, 36%
Psychotropic medication use[d] (no, yes, prefer not to say)	183, 441, 7	29%, 70%, 1%

[a]Data available for $n = 701$ individuals.
[b]Needs indicators made up of Medicaid, Social Security Disability Insurance, Supplemental Security Income, and Section 8 housing vouchers.
[c]Data available for $n = 723$ individuals.
[d]Data available for $n = 631$ individuals.

need for government financial support, that are associated with sleep. One study has included employment as a variable of interest, where being employed was associated with better overall sleep quality in the comparison group but not in the autistic group, and being employed was associated with increased sleep duration among autistic people only (Jovevska et al., 2020).

Although there is growing evidence for sleep issues among autistic people across the lifespan, more studies are needed, particularly those focused on adulthood. Biopsychosocial models of sleep suggest that autistic people may be at particular risk for sleep difficulties, due to high rates of anxiety, depression, a ruminative cognitive style, and sensory sensitivities (Perlis et al., 1997; Richdale & Schreck, 2009). A better understanding of the factors that precipitate and maintain various sleep difficulties among autistic people is needed in order to begin to develop interventions. In this study we examine the demographic, health and social factors associated with different aspects of sleep quality, in a large sample of autistic adults across a wide age range. We include measures of physical health, medication use and receipt of American government social support mechanisms, as well as self-reported anxiety and depression symptoms as well as perceived stress. We hypothesized that demographic, health and social factors, as well as autistic traits will contribute to statistical models explaining sleep quality.

METHODS

Participants

Participants were recruited online via Simons Foundation Powering Autism Research for Knowledge (SPARK; Feliciano et al., 2018) Research Match. All participants were required to be aged 18 or older. Participants took part in a broader online study of adult development and were compensated $25 for their time. The study was approved by the local institutional review board and followed procedures in accordance with the Declaration of Helsinki. Accordingly, all participants provided informed consent.

The survey was begun by 899 individuals, with demographic information provided by 876 (97.4%) of these individuals. The overall score on the self-reported Pittsburgh Sleep Quality Index (PSQI) was available for 730 individuals (83.3% of autistic adults who completed demographic information). We used listwise deletion for individuals who did not complete the PSQI, and analyses were conducted on participants with an overall score on the PSQI available. The final analytic sample in the current study represented 730 autistic individuals aged 18–78 years (Mean = 39.87, SD = 13.61). For sample demographic details see Table 1.

The sample was composed of "independent" autistic adults (who were able to provide their own informed consent) as designated by SPARK. None of the participants in the current study reported intellectual disability as a prior medical diagnosis on their health history questionnaire. In order to be included in the SPARK registry, participants were required to have self-disclosed an autism spectrum diagnosis given by medical/clinical professionals. Although SPARK does not independently confirm diagnoses, they partner with expert clinical sites to ensure that enrolled participants possess a community-based clinical diagnosis. Cross-validation has been completed in a proportion of the SPARK sample using electronic health records (where 98.8% had a confirmed autism diagnosis, Fombonne et al., 2022). To further validate the clinical diagnosis, 729 of the 730 participants completed the 28-item self-report Autism spectrum Quotient-28 (AQ28; Hoekstra et al., 2011). Scores >65 are considered to be above the cut-off indicating a positive screen for ASD. 95.2% (n = 695) of participants in the current sample scored >65.

Measures

Demographic information, health, and social need

Participants provided detailed demographic information including age, race, ethnicity, and sex assigned at birth, and they listed any existing physical health conditions (including hypertension, history of cancer, arthritis, etc). Number of physical health conditions (reported as open text) was summed and coded on a three-point scale as none, one, or two or more health conditions to be used as a variable in analyses (dummy variables in the analyses as 0, 1, 2). Note that sleep-related conditions were not included in this physical health condition coding. Furthermore, participants were asked to report any current psychotropic medication use (e.g., antidepressants, antipsychotics), which was recorded and coded (yes/no). Participants also reported whether they used various means-tested government anti-poverty and disability benefit programs, namely Medicaid, Social Security Disability Insurance (SSDI), Supplemental Security Income (SSI), and Section 8 housing vouchers (rental payment assistance for low income households). The number of programs utilized was summed and the total number was used as an indicator of need in analyses.

Sleep

The Pittsburgh Sleep Quality Index (PSQI; Buysse et al., 1989) was used to assess overall sleep quality and sub-components of sleep such as latency, duration and disturbance. The PSQI comprises 19-items, 18 of which are included in the total score (range 0–21). Usual bedtime, sleep latency and sleep duration were provided via open-field text while items evaluating sleep disturbance were rated on four-point scales. A single overall sleep quality score is calculated as well as seven sub-components of sleep (1-subjective sleep quality, 2-sleep latency, 3-sleep duration, 4-sleep efficiency, 5-sleep disturbance, 6-sleep medication use, and 7-daytime dysfunction). A total overall sleep quality score higher than 5 indicates poor sleep quality either with severe difficulties in at least two areas or moderate difficulties in at least three areas. The internal consistency of the PSQI is very good in samples in the general population (Cronbach's alpha = 0.83; Buysse et al., 1989) and adequate in prior studies of autistic adults (Cronbach's alpha = 0.68; Baker & Richdale, 2015; McLean et al., 2021), indicating that this measure is suitable for use with autistic people. In the current sample the internal consistency was good (Cronbach's alpha = 0.75).

Perceived stress, anxiety, and depression symptomatology

Self-reported perceived stress, anxiety and depression symptomatology were measured. The Perceived Stress Scale (PSS: Cohen et al., 1983) quantified individual stress levels.

The PSS probes the extent to which everyday experiences are perceived as stressful on 10 items utilizing a 5-point Likert scale ("Never," "Almost Never," "Sometimes," "Fairly often," "Very often"). Total scores range from 0 to 40, with scores 14–26 indicating moderate stress and scores greater than 27 indicating severe stress. The internal consistency of the PSS has been reported as very good in non-autistic (Cronbach's alpha = 0.84–0.87; Baik et al., 2019; Cohen et al., 1983) and autistic (Cronbach's alpha = 0.87; Bishop-Fitzpatrick et al., 2017; McQuaid et al., 2022) populations. In the current study's sample (partially overlapping with McQuaid et al., 2022) the internal consistency of the PSS was very good (Cronbach's alpha = 0.87).

The 7-item Generalized Anxiety Disorder scale (GAD-7; Spitzer et al., 2006) was used to quantify anxiety symptomatology. The GAD-7 probes the presence and severity of anxiety symptoms on a 4-point Likert scale ("Not at all," "Several days," "More than half the days," "Nearly every day"). Total scores range from 0 to 21, with scores ≥10 indicating moderate or severe anxiety. Using a cut-off of ≥10 the GAD-7 has shown good sensitivity (89%) and specificity (82%). The internal consistency of the GAD-7 is generally excellent (Cronbach's alpha = 0.92; Spitzer et al., 2006). The internal consistency of the GAD-7 in the current study was excellent (Cronbach's alpha = 0.92).

Depression symptomatology was assessed using the 9-item Patient Health Questionnaire (PHQ-9; Arnold et al., 2020; Kroenke et al., 2001). Participants reported on the presence/frequency of depressive symptomatology on a 4-point Likert scale ("Not at all," "Several days," "More than half the days," "Nearly every day"), and scores range from 0 to 27. The PHQ-9 has been shown to have 88% sensitivity and specificity for major depressive disorder (Kroenke et al., 2001). In the current sample internal consistency of the PHQ-9 was very good (Cronbach's alpha = 0.90). Two items on the PHQ-9 were considered to overlap with items on the PSQI, namely item 3 "Trouble falling/staying asleep, sleeping too much" and item 4 "Feeling tired or having little energy." In order to avoid analyses being impacted by these overlapping items (i.e., inflating relationships), the PHQ-9 was recalculated excluding items 3 and 4, and the abbreviated version of the PHQ-9 was included in the regression analyses described below.

Community involvement: This study was not designed or carried out with involvement from the autistic community, although the broader SPARK cohort includes stakeholders throughout the design process.

Data analysis

In order to assure that the participants included in these analyses are representative of the sample as a whole, *t* tests and Chi-Square analyses compared the demographic information for those included versus excluded from the analyses (due to missing data on the PSQI). Spearman's Rho correlations explored associations between variables of interest. A stepwise linear regression analysis examined which variables were associated with overall sleep quality. Ordinal regression analyses were employed to identify the variables that were associated with each sleep sub-component in turn (1-subjective sleep quality, 2-sleep latency, 3-sleep duration, 4-sleep efficiency, 5-sleep disturbance, 6-sleep medication use, and 7-daytime dysfunction). Two models were run for each regression analysis: Model 1 included demographic, health and social factors (specifically age, sex assigned at birth, needs indicators [government assistance programs], physical health conditions, psychotropic medication use, and AQ-28 score); Model 2 included perceived stress, anxiety, and depression variables in a second block. Alpha was at 0.05; therefore, $p < 0.05$ was the threshold for statistical significance. Effect sizes are available in the reported r and R^2 statistics. False discovery rate (FDR) was used to correct for multiple comparisons on the sleep sub-component scores.

RESULTS

Included/excluded participants

Independent samples *t* tests were performed to assess whether participants included in the analyses differed from those excluded due to missing PSQI data on demographic variables. The groups differed on both age and AQ-28 scores, with participants who did not complete the PSQI and who were thus excluded from the analyses being older and having lower AQ-28 scores, compared to included participants. The groups did not differ in sex assigned at birth, race or ethnicity. See Table S1.

Overall sleep quality

Using the PSQI, the number of people who scored above the cut-off indicating poor overall sleep quality was calculated. In this sample 85.5% ($n = 624$) of autistic adults met the criteria for poor sleep.

Correlation analyses

Spearman's rho correlations were performed to explore associations between variables of interest (see Table 2). All sub-scales on the PSQI correlated significantly with each other. Older age was associated with more health problems and higher autistic traits, and with access to fewer government support programs (needs indicators), shorter sleep latency and more sleep disturbance. Age was not significantly associated with scores on anxiety and depression measures. Greater autistic traits were associated with higher levels of perceived stress, anxiety and depression symptoms, and poorer quality sleep

TABLE 2 Spearman's rho correlations between variables of interest

	Age	Needs indicators	Health problems	AQ score	Perceived stress	Anxiety symptoms	Depressive symptoms	Global sleep	1-Sleep quality	2-Sleep latency	3-Sleep duration	4-Sleep efficiency	5-Sleep disturbance	6-Sleep medication use
Needs indicators	$r = -0.091$, $p = 0.016$	-												
Health problems	$r = 0.380$, $p < 0.001$	$r = 0.074$, $p = 0.050$	-											
AQ score	$r = 0.215$, $p < 0.001$	$r < 0.001$, $p = 0.991$	$r = 0.141$, $p < 0.001$	-										
Perceived stress	$r = -0.001$, $p = 0.970$	$r = 0.109$, $p = 0.004$	$r = 0.110$, $p = 0.003$	$r = 0.277$, $p < 0.001$	-									
Anxiety symptoms	$r = -0.070$, $p = 0.057$	$r = 0.088$, $p = 0.019$	$r = 0.105$, $p = 0.005$	$r = 0.250$, $p < 0.001$	$r = 0.730$, $p < 0.001$	-								
Depressive symptoms	$r = -0.068$, $p = 0.066$	$r = 0.080$, $p = 0.034$	$r = 0.150$, $p < 0.001$	$r = 0.189$, $p < 0.001$	$r = -0.688$, $p < 0.001$	$r = 0.713$, $p < 0.001$	-							
Global sleep	$r = -0.008$, $p = 0.825$	$r = 0.156$, $p < 0.001$	$r = 0.198$, $p < 0.001$	$r = 0.213$, $p < 0.001$	$r = 0.496$, $p < 0.001$	$r = 0.541$, $p < 0.001$	$r = 0.541$, $p < 0.001$	-						
1-Sleep quality	$r = -0.029$, $p = 0.435$	$r = 0.059$, $p = 0.118$	$r = 0.162$, $p < 0.001$	$r = 0.192$, $p < 0.001$	$r = 0.421$, $p < 0.001$	$r = 0.429$, $p < 0.001$	$r = 0.429$, $p < 0.001$	$r = 0.739$, $p < 0.001$	-					
2-Sleep latency	$r = -0.078$, $p = 0.035$	$r = 0.115$, $p = 0.002$	$r = 0.131$, $p < 0.001$	$r = 0.132$, $p = 0.001$	$r = 0.274$, $p < 0.001$	$r = 0.298$, $p < 0.001$	$r = 0.298$, $p < 0.001$	$r = 0.660$, $p < 0.001$	$r = 0.449$, $p < 0.001$	-				
3-Sleep duration	$r = 0.038$, $p = 0.301$	$r = 0.064$, $p = 0.090$	$r = 0.108$, $p = 0.004$	$r = 0.163$, $p < 0.001$	$r = 0.288$, $p < 0.001$	$r = 0.366$, $p < 0.001$	$r = 0.366$, $p < 0.001$	$r = 0.630$, $p < 0.001$	$r = 0.523$, $p < 0.001$	$r = 0.263$, $p < 0.001$	-			
4-Sleep efficiency	$r = -0.032$, $p = 390$	$r = 0.156$, $p < 001$	$r = 0.094$, $p = 0.012$	$r = 0.143$, $p < 0.001$	$r = 0.319$, $p < 0.001$	$r = 0.342$, $p < 0.001$	$r = 0.342$, $p < 0.001$	$r = 0.735$, $p < 0.001$	$r = 0.487$, $p < 0.001$	$r = 0.466$, $p < 0.001$	$r = 0.537$, $p < 0.001$	-		
5-Sleep disturbance	$r = 0.094$, $p = 012$	$r = 0.139$, $p < 0.001$	$r = 0.246$, $p < 0.001$	$r = 0.126$, $p = 0.001$	$r = 0.403$, $p < 0.001$	$r = 0.438$, $p < 0.001$	$r = 0.438$, $p < 0.001$	$r = 0.640$, $p < 0.001$	$r = 0.499$, $p < 0.001$	$r = 0.388$, $p < 0.001$	$r = 0.324$, $p < 0.001$	$r = 0.344$, $p < 0.001$	-	
6-Sleep medication use	$r = -0.013$, $p = 0.717$	$r = 0.093$, $p = 0.014$	$r = 0.066$, $p = 0.074$	$r = 0.073$, $p = 0.048$	$r = 0.163$, $p < 0.001$	$r = 0.221$, $p < 0.001$	$r = 0.221$, $p < 0.001$	$r = 0.519$, $p < 0.001$	$r = 0.154$, $p < 0.001$	$r = 0.225$, $p < 0.001$	$r = 0.056$, $p = 0.134$	$r = 0.174$, $p < 0.001$	$r = 0.244$, $p < 0.001$	-
7-Daytime dysfunction	$r = 0.039$, $p = 0.294$	$r = -0.018$, $p = 0.635$	$r = 0.177$, $p < 0.001$	$r = 0.175$, $p < 0.001$	$r = 0.488$, $p < 0.001$	$r = 0.446$, $p < 0.001$	$r = -0.446$, $p < 0.001$	$r = 0.583$, $p < 0.001$	$r = 0.417$, $p < 0.001$	$r = 0.208$, $p < 0.001$	$r = 0.286$, $p < 0.001$	$r = 0.279$, $p < 0.001$	$r = 0.376$, $p < 0.001$	$r = 0.216$, $p < 0.001$

TABLE 3 Stepwise linear regression results for global sleep quality

	Model 1				
	Step 1	**Step 2**	**Step 3**	**Step 4**	**Step 5**
AQ	$\beta = 0.232$, $p < 0.001$	$\beta = 0.220$, $p < 0.001$	$\beta = 0.193$, $p < 0.001$	$\beta = 0.194$, $p < 0.001$	$\beta = 0.195$, $p < 0.001$
Sex assigned at birth	-	$\beta = 0.155$ $p = 0.002$	$\beta = 0.164$, $p < 0.001$	$\beta = 0.156$, $p < 0.001$	$\beta = 0.148$, $p < 0.001$
Physical health	-	-	$\beta = 0.144$, $p < 0.001$	$\beta = 0.142$, $p < 0.001$	$\beta = 0.138$, $p = 0.001$
Psychotropic meds	-	-	-	$\beta = 0.118$, $p = 0.003$	$\beta = 0.110$, $p = 0.005$
Needs indicators	-	-	-	-	$\beta = 0.090$, $p = 0.022$
R^2 Change	$R^2 = 0.054$	Delta $R^2 = 0.024$	Delta $R^2 = 0.020$	Delta $R^2 = 0.014$	Delta $R^2 = 0.008$
Model summary	$F = 33.55$, $R^2 = 0.054$, $p < 0.001$	$F = 24.75$, $R^2 = 0.078$, $p < 0.001$	$F = 21.16$, $R^2 = 0.098$, $p < 0.001$	$F = 18.39$, $R^2 = 0.112$, $p < 0.001$	$F = 15.56$, $R^2 = 0.119$, $p < 0.001$
	Variables not included in final model: Age ($\beta = -0.082$, $p = 0.057$).				
	Model 2				
	Step 1	**Step 2**	**Step 3**	**Step 4**	**Step 5**
Anxiety symptoms	$\beta = 0.550$, $p < 0.001$	$\beta = 0.409$, $p < 0.001$	$\beta = 0.406$, $p < 0.001$	$\beta = 0.402$, $p < 0.001$	$\beta = 0.392$, $p < 0.001$
Perceived stress	-	$\beta = 0.196$, $p < 0.001$	$\beta = 0.185$, $p < 0.001$	$\beta = 0.173$, $p < 0.001$	$\beta = 0.177$, $p < 0.001$
Physical health	-	-	$\beta = 0.111$, $p < 0.001$	$\beta = 0.118$, $p < 0.001$	$\beta = 0.118$, $p = 0.001$
Sex assigned at birth	-	-	-	$\beta = 0.110$, $p = 0.001$	$\beta = 0.106$, $p = 0.002$
Psychotropic meds	-	-	-	-	$\beta = 0.071$, $p = 0.036$
R^2 Change	$R^2 = 0.302$	Delta $R^2 = 0.019$	Delta $R^2 = 0.012$	Delta $R^2 = 0.012$	Delta $R^2 = 0.005$
Model summary	$F = 255.12$, $R^2 = 0.302$, $p < 0.001$	$F = 138.85$, $R^2 = 0.321$, $p < 0.001$	$F = 97.65$, $R^2 = 0.333$, $p < 0.001$	$F = 77.10$, $R^2 = 0.345$, $p < 0.001$	$F = 62.93$, $R^2 = 0.350$, $p < 0.001$
	Variables not included in final model: Age ($\beta = -0.003$, $p = 0.944$), Needs indicator ($\beta = 0.048$, $p = 0.155$), AQ ($\beta = 0.047$, $p = 0.189$), Depression ($\beta = -0.008$, $p = 0.806$).				

Note: For all variables high scores indicate greater need, mental health difficulties or worse sleep. Sex assigned at birth is coded male = 1, 2 = female.

(on all metrics). More physical health problems were associated with greater stress, anxiety and depression symptoms, and poorer sleep quality.

Regression analyses

Overall sleep quality, stepwise linear regression

In model 1, all the demographic, health, and social metrics except age contributed significantly to the model ($F = 15.56$, $R^2 = 0.119$, $p < 0.001$). In model 2, higher anxiety symptoms ($\beta = 0.392$, $p < 0.001$), perceived stress ($\beta = 0.177$, $p < 0.001$), a higher number of physical health conditions ($\beta = 0.118$, $p = 0.001$), female sex assigned at birth ($\beta = 0.106$, $p = 0.002$) and use of psychotropic medication ($\beta = 0.071$, $p = 0.036$) were associated with poorer sleep quality ($F = 62.93$, $R^2 = 0.350$, $p < 0.001$). Other demographic variables and depression symptoms were not significantly associated with overall sleep quality. See Table 3 for full details of results.

1-Subjective sleep quality, ordinal regression

In model 1, the following variables contributed significantly to the model—age, sex assigned at birth, number of physical health conditions and autistic traits ($X^2 = 47.77$, Pseudo $R^2 = 0.085$, $p < 0.001$; see Table 4). In model 2, female sex assigned at birth ($\beta = 0.437$, $p = 0.010$), a higher number of physical health conditions ($\beta = 0.258$, $p = 0.016$) and psychotropic medication use ($\beta = 0.498$, $p = 0.005$) were significantly associated with poorer subjective sleep quality. Higher levels of anxiety symptoms ($\beta = 0.104$, $p < 0.001$) and perceived stress ($\beta = 0.056$, $p < 0.001$) were significantly associated with poorer sleep quality ($X^2 = 168.25$, Pseudo $R^2 = 0.272$, $p < 0.001$).

2-Sleep latency, ordinal regression

Age, sex assigned at birth, number of physical health conditions and autistic traits contributed to model 1 for sleep latency ($X^2 = 40.44$, Pseudo $R^2 = 0.072$, $p < 0.001$, see Table 4). In model 2, female sex assigned at birth ($\beta = -0.419$, $p = 0.010$), a higher number of physical

TABLE 4 Ordinal Regression results by sleep domain including confidence intervals (CI)

	1-Subjective sleep quality		2-Sleep latency		3-Sleep duration		4-Sleep efficiency		5-Sleep disturbance		6-Sleep medication use		7-Daytime dysfunction	
	Model 1	**Model 2**	**Model 1**	**Model 2**	**Model 1**	**Model 2**	**Model 1**	**Model 2**	**Model 1**	**Model 2**	**Model 1**	**Model 2**	**Model 1**	**Model 2**
Age	$\beta = -0.017$, $p = 0.007$ CI = −0.03 to −0.005	$\beta = -0.010$, $p = 0.137$ CI = −0.02 to 0.003	$\beta = -0.016$, $p = 0.010$ CI = −0.03 to −0.004	$\beta = -0.011$, $p = 0.077$ CI = −0.02 to 0.001	$\beta = -0.008$, $p = 0.221$ CI = −0.02 to 0.005	$\beta < 0.001$, $p = 0.985$ CI = −0.01 to 0.01	$\beta = -0.009$, $p = 0.146$ CI = −0.02 to 0.003	$\beta = -0.005$, $p = 0.478$ CI = −0.02 to 0.008	$\beta = -0.001$, $p = 0.914$ CI = −0.01 to 0.01	$\beta = 0.012$, $p = 0.098$ CI = −0.002 to 0.03	$\beta = -0.003$, $p = 0.628$ CI = −0.01 to 0.009	$\beta = 0.003$, $p = 0.566$ CI = −0.008 to 0.02	$\beta = -0.006$, $p = 0.346$ CI = −0.02 to 0.006	$\beta = 0.002$, $p = 0.783$ CI = −0.01 to 0.02
Sex assigned at birth	$\beta = -0.508$, $p = 0.002$ CI = −0.83 to −0.19	$\beta = -0.437$, $p = 0.010$ CI = −0.77 to −0.11	$\beta = -0.481$, $p = 0.003$ CI = −0.79 to −0.17	$\beta = -0.419$, $p = 0.010$ CI = −0.74 to −0.10	$\beta = -0.113$, $p = 0.498$ CI = −0.44 to 0.21	$\beta = -0.049$, $p = 0.778$ CI = −0.39 to 0.29	$\beta = -0.428$, $p = 0.010$ CI = −0.76 to −0.10	$\beta = -0.398$, $p = 0.020$ CI = −0.73 to −0.06	$\beta = -0.626$, $p < 0.001$ CI = −0.96 to −0.29	$\beta = -0.578$, $p = 0.001$ CI = −0.93 to −0.22	$\beta = -0.418$, $p = 0.006$ CI = −0.72 to −0.12	$\beta = -0.409$, $p = 0.009$ CI = −0.72 to −0.10	$\beta = -0.194$, $p = 0.229$ CI = −0.51 to 0.12	$\beta = -0.024$, $p = 0.885$ CI = −0.35 to 0.30
Needs indicators	$\beta = 0.028$, $p = 0.724$ CI = −0.13 to 0.18	$\beta = -0.026$, $p = 0.752$ CI = −0.19 to 0.14	$\beta = 0.099$, $p = 0.205$ CI = −0.05 to 0.25	$\beta = 0.066$, $p = 0.403$ CI = −0.09 to 0.22	$\beta = 0.110$, $p = 0.170$ CI = −0.05 to 0.27	$\beta = 0.088$, $p = 0.287$ CI = −0.07 to 0.25	$\beta = 0.262$, $p = 0.001$ CI = 0.11 to 0.42	$\beta = 0.217$, $p = 0.007$ CI = 0.06 to 0.38	$\beta = 0.173$, $p = 0.037$ CI = 0.01 to 0.34	$\beta = 0.136$, $p = 0.117$ CI = −0.03 to 0.31	$\beta = 0.152$, $p = 0.047$ CI = 0.002 to 0.30	$\beta = 0.131$, $p = 0.091$ CI = −0.02 to 0.28	$\beta = -0.061$, $p = 0.438$ CI = −0.22 to 0.09	$\beta = -0.156$, $p = 0.055$ CI = −0.32 to 0.003
Physical health	$\beta = 0.361$, $p = 0.001$ CI = 0.16 to 0.57	$\beta = 0.258$, $p = 0.016$ CI = 0.05 to 0.47	$\beta = 0.348$, $p = 0.001$ CI = 0.15 to 0.55	$\beta = 0.298$, $p = 0.004$ CI = 0.10 to 0.50	$\beta = 0.208$, $p = 0.048$ CI = 0.002 to 0.41	$\beta = 0.121$, $p = 0.262$ CI = −0.09 to 0.33	$\beta = 0.189$, $p = 0.071$ CI = −0.02 to 0.39	$\beta = 0.125$, $p = 0.243$ CI = −0.09 to 0.33	$\beta = 0.570$, $p < 0.001$ CI = 0.36 to 0.79	$\beta = 0.492$, $p < 0.001$ CI = 0.27 to 0.72	$\beta = 0.155$, $p = 0.105$ CI = −0.03 to 0.34	$\beta = 0.071$, $p = 0.471$ CI = −0.12 to 0.26	$\beta = 0.351$, $p = 0.001$ CI = 0.15 to 0.55	$\beta = 0.296$, $p = 0.005$ CI = 0.09 to 0.50
Psycho-tropic meds	$\beta = 0.304$, $p = 0.077$ CI = −0.03 to 0.64	$\beta = 0.498$, $p = 0.005$ CI = 0.15 to 0.85	$\beta = -0.193$, $p = 0.249$ CI = −0.52 to 0.14	$\beta = -0.168$, $p = 0.321$ CI = −0.50 to 0.16	$\beta = 0.277$, $p = 0.110$ CI = −0.06 to 0.62	$\beta = 0.429$, $p = 0.016$ CI = 0.08 to 0.78	$\beta = -0.329$, $p = 0.062$ CI = −0.67 to 0.02	$\beta = -0.251$, $p = 0.162$ CI = −0.60 to 0.10	$\beta = 0.083$, $p = 0.643$ CI = −0.27 to 0.43	$\beta = 0.231$, $p = 0.217$ CI = −0.14 to 0.60	Not in model	Not in model	$\beta = -0.348$, $p = 0.040$ CI = −0.68 to −0.02	$\beta = -0.246$, $p = 0.159$ CI = −0.59 to 0.10
AQ	$\beta = 0.031$, $p < 0.001$ CI = 0.02 to 0.05	$\beta = 0.011$, $p = 0.157$ CI = −0.004 to 0.03	$\beta = 0.021$, $p = 0.003$ CI = 0.007 to 0.04	$\beta = 0.007$, $p = 0.348$ CI = −0.008 to 0.02	$\beta = 0.026$, $p < 0.001$ CI = 0.01 to 0.04	$\beta = 0.010$, $p = 0.195$ CI = −0.005 to 0.03	$\beta = 0.031$, $p < 0.001$ CI = 0.02 to 0.05	$\beta = 0.016$, $p = 0.041$ CI = 0.001 to 0.03	$\beta = 0.015$, $p = 0.050$ CI = <0.001 to 0.03	$\beta = -0.011$, $p = 0.177$ CI = −0.03 to 0.005	$\beta = 0.010$, $p = 0.628$ CI = −0.003 to 0.02	$\beta = 0.002$, $p = 0.800$ CI = −0.01 to 0.02	$\beta = 0.034$, $p < 0.001$ CI = 0.02 to 0.05	$\beta = 0.008$, $p = 0.288$ CI = −0.007 to 0.02
Model summary	$X^2 = 47.77$ Pseudo $R^2 = 0.085$, $p < 0.001$		$X^2 = 40.77$ Pseudo $R^2 = 0.072$, $p < 0.001$		$X^2 = 23.06$ Pseudo $R^2 = 0.042$, $p < 0.001$		$X^2 = 51.31$ Pseudo $R^2 = 0.091$, $p < 0.001$		$X^2 = 57.91$ Pseudo $R^2 = 0.107$, $p < 0.001$		$X^2 = 20.38$ Pseudo $R^2 = 0.032$, $p = 0.001$		$X^2 = 47.12$ Pseudo $R^2 = 0.083$, $p < 0.001$	
Anxiety symptoms		$\beta = 0.104$, $p < 0.001$ CI = 0.07 to 0.14		$\beta = 0.059$, $p = 0.006$ CI = 0.02 to 0.10		$\beta = 0.115$, $p < 0.001$ CI = 0.07 to 0.16		$\beta = 0.060$, $p = 0.006$ CI = 0.02 to 0.10		$\beta = 0.129$, $p < 0.001$ CI = 0.09 to 0.17		$\beta = 0.051$, $p = 0.010$ CI = 0.01 to 0.09		$\beta = 0.081$, $p < 0.001$ CI = 0.04 to 0.12

(Continues)

TABLE 4 (Continued)

	1-Subjective sleep quality		2-Sleep latency		3-Sleep duration		4-Sleep efficiency		5-Sleep disturbance		6-Sleep medication use		7-Daytime dysfunction	
	Model 1	**Model 2**	**Model 1**	**Model 2**	**Model 1**	**Model 2**	**Model 1**	**Model 2**	**Model 1**	**Model 2**	**Model 1**	**Model 2**	**Model 1**	**Model 2**
Perceived stress		$\beta = 0.056$, $p < 0.001$ CI = 0.03 to 0.09		$\beta = 0.022$, $p = 0.171$ CI = −0.01 to 0.05		$\beta = 0.016$, $p = 0.355$ CI = −0.02 to 0.05		$\beta = 0.029$, $p = 0.083$ CI = −0.004 to 0.06		$\beta = 0.047$, $p = 0.007$ CI = 0.01 to 0.08		$\beta = -0.017$, $p = 0.285$ CI = −0.05 to 0.01		$\beta = 0.099$, $p < 0.001$ CI = 0.07 to 0.13
Depression symptoms		$\beta = -0.007$, $p = 0.433$ CI = −0.03 to 0.01		$\beta = -0.065$, $p = 0.637$ CI = −0.24 to 0.36		$\beta = -0.046$, $p = 0.770$ CI = −0.35 to 0.26		$\beta = 0.168$, $p = 0.278$ CI = −0.14 to 0.47		$\beta = -0.001$, $p = 0.469$ CI = −0.005 to 0.003		$\beta = 0.273$, $p = 0.055$ CI = −0.006 to 0.55		$\beta = -0.001$, $p = 0.641$ CI = −0.005 to 0.003
Model summary		$X^2 = 168.25$ Pseudo $R^2 = 0.272$, $p < 0.001$[a]		$X^2 = 83.17$ Pseudo $R^2 = 0.141$, $p < 0.001$[a]		$X^2 = 103.46$ Pseudo $R^2 = 0.177$, $p < 0.001$[a]		$X^2 = 107.71$ Pseudo $R^2 = 0.183$, $p < 0.001$[a]		$X^2 = 181.25$ Pseudo $R^2 = 0.303$, $p < 0.001$[a]		$X^2 = 49.70$ Pseudo $R^2 = 0.077$, $p < 0.001$[a]		$X^2 = 204.84$ Pseudo $R^2 = 0.317$, $p < 0.001$[a]

Note: For all variables high scores indicate greater need, mental health difficulties, or worse sleep. Sex assigned at birth is coded male = 1, 2 = female.

[a]Regression model remains significant after FDR correction.

health conditions ($\beta = 0.298$, $p = 0.004$), and more anxiety symptoms ($\beta = 0.059$, $p = 0.006$) were associated with greater sleep latency ($X^2 = 83.17$, Pseudo $R^2 = 0.141$, $p < 0.001$). Depression and perceived stress were not significantly associated with sleep latency.

3-Sleep duration, ordinal regression

In model 1, more physical health problems and higher levels of autistic traits, as measured by the AQ-28, were significantly associated with longer sleep duration ($X^2 = 40.44$, Pseudo $R^2 = 0.072$, $p < 0.001$). In model 2, higher levels of anxiety symptoms ($\beta = 0.115$, $p < 0.001$) and psychotropic medication use ($\beta = 0.429$, $p = 0.016$) were associated with longer sleep duration ($X^2 = 103.46$, Pseudo $R^2 = 0.177$, $p < 0.001$).

4-Sleep efficiency, ordinal regression

Sex assigned at birth, presence of needs indicators and autistic trait scores contributed significantly to model 1 for sleep efficiency ($X^2 = 51.31$, Pseudo $R^2 = 0.091$, $p < 0.001$, see Table 4). In model 2, these demographic variables (female sex assigned at birth, $\beta = -0.398$, $p = 0.020$; higher levels of needs indicators: $\beta = 0.217$, $p = 0.007$; and more autistic traits as measured by AQ-28 score: $\beta = 0.016$, $p = 0.041$), and higher levels of anxiety symptoms ($\beta = 0.060$, $p = 0.006$) were associated with poorer sleep efficiency ($X^2 = 107.71$, Pseudo $R^2 = 0.183$, $p < 0.001$).

5-Sleep disturbance, ordinal regression

In model 1, sex assigned at birth, presence of needs indicators, number of physical health conditions and autistic traits scores contributed significantly to the model ($X^2 = 57.91$, Pseudo $R^2 = 0.107$, $p < 0.001$, see Table 4). In model 2, female sex assigned at birth ($\beta = -0.578$, $p = 0.001$) and more physical health problems ($\beta = 0.492$, $p < 0.001$), higher levels of anxiety symptoms ($\beta = 0.129$, $p < 0.001$) and greater perceived stress ($\beta = 0.047$, $p = 0.007$), were associated with greater sleep disturbance ($X^2 = 181.25$, Pseudo $R^2 = 0.303$, $p < 0.001$).

6-Sleep medication use, ordinal regression

For the regression analyses with sleep medication use as the dependent variable, psychotropic medication was not included as an independent variable. Sex assigned at birth and higher levels of needs indicators contributed significantly to model 1 ($X^2 = 20.38$, Pseudo $R^2 = 0.032$, $p = 0.001$, see Table 4). Model 2 included female sex assigned at birth ($\beta = -0.409$, $p = 0.009$) and higher levels of anxiety symptoms ($\beta = 0.051$, $p = 0.010$) associated with use of sleep medications ($X^2 = 49.70$, Pseudo $R^2 = 0.077$, $p < 0.001$).

7-Daytime dysfunction, ordinal regression

In model 1, female sex assigned at birth, number of physical health conditions, psychotropic medication use and autistic traits significantly contributed to the model ($X^2 = 47.12$, Pseudo $R^2 = 0.083$, $p < 0.001$, see Table 4). In model 2, a higher number of physical health conditions ($\beta = 0.296$, $p = 0.005$), and higher anxiety symptoms ($\beta = 0.081$, $p < 0.001$) and higher levels of perceived stress ($\beta = 0.099$, $p < 0.001$) were significantly associated with greater levels of daytime dysfunction ($X^2 = 204.84$, Pseudo $R^2 = 0.317$, $p < 0.001$).

FDR correction was applied to the seven regression analyses examining sub-components of sleep quality. All statistical models remained significant after FDR correction ($q < 0.05$).

DISCUSSION

In this paper we describe demographic, physical health, social, and mental health variables associated with various aspects of sleep in a large sample of autistic individuals varying in age from young to older adulthood. Sleep difficulties were common with 85% of autistic people in this study reporting overall poor sleep quality according to the PSQI recommended cut-off. The proportion of autistic people reporting poor sleep and the mean score on the PSQI (Mean = 9.49) are higher in the current sample compared to other studies of autistic adults that have also used the PSQI (Mean = 7.45, 64% above cut-off, Jovevska et al., 2020; Mean = 6.21, proportion above cut-off not reported, McLean et al., 2021). This difference may be related in part to the inclusion of more older autistic people (McLean et al., 2021 age range 18–55, Mean = 24.2 $n = 40$; Jovevska et al., 2020 age range 15–80, Mean = 34.36, $n = 297$; current sample, age-range 18–78, Mean = 39.87, $n = 730$), although note a similar age-range in Jovevska et al., or more females (McLean et al., 2021, 10% female; Jovevska et al., 2020, 52% female; current sample, 60% female) in the current sample. Regression analyses demonstrate that demographic, physical health, and social variables were significantly associated with sleep quality, but that statistical models are improved further by accounting for mental health variables. Different patterns of associations were observed for different aspects of sleep. For example, physical health contributed to statistical models explaining sleep quality, sleep latency, sleep disturbance, and daytime dysfunction but not sleep duration, sleep efficiency or daytime dysfunction. Anxiety symptoms contributed to statistical models examining all aspects of sleep, but perceived stress contributed only to statistical models of sleep quality, sleep disturbance and daytime dysfunction. Overall, sleep quality was significantly associated with all the demographic, physical health and social variables entered in model 1, except age. After adding mental health variables in model 2, higher levels of anxiety symptoms, perceived stress, presence of physical health problems, psychotropic medication use, and female sex assigned at birth, were significantly associated with poorer sleep quality, with anxiety symptoms and perceived stress being particularly important.

Presence of physical health difficulties and female sex assigned at birth accounted for a small but significant amount of variance in most of the regression models for sleep difficulties. Female sex assigned at birth was associated with all aspects of sleep except sleep duration (models 1 and 2) and daytime dysfunction (model 2). Results indicate that those assigned female at birth generally reported poorer sleep quality than those assigned male at birth. Although few studies have explored sex differences in sleep among autistic adults, this finding aligns with two recent studies demonstrating poorer sleep quality among autistic women than autistic men (Hohn et al., 2019; Jovevska et al., 2020). This pattern is also observed in the general population where women tend to report more sleep difficulties than men (Mallampalli & Carter, 2014; but see also Zhu et al., 2019). In contrast, no sex differences in sleep quality were noted in a study of older people reporting high (compared to low) autistic traits (Stewart et al., 2020). Overall, research suggests that women may report poorer sleep quality than men, and the same pattern seems to be observed among autistic people.

In correlational analyses older age was negatively associated with sleep latency and positively associated with sleep disturbance. The current finding that older age was associated with shorter (i.e., better) sleep latency for autistic people is in contrast to studies of non-autistic people, where older age is associated with longer (i.e., poorer) sleep latency. These results align with one of the few studies considering age and sleep among autistic people, where older autistic people reported fewer sleep problems than young and middle aged autistic people (Jovevska et al., 2020). This is, however, in contrast to cross-sectional studies in the general population that largely report poorer sleep (longer sleep latency, more disrupted sleep) associated with older age (Carskadon & Dement, 2011; Gulia & Kumar, 2018). It is important to note that age did not significantly contribute to the regression models. Studies examining longitudinal changes in sleep latency and differences between autistic and non-autistic older people are required to explore whether this different pattern in age-related sleep trajectories is replicated.

A greater number of physical health difficulties were significantly associated with poorer subjective sleep quality, sleep latency, sleep disturbance and daytime dysfunction, even after accounting for mental health variables. Although participants did not describe sleep conditions in the current study, it is possible that physical health problems may be associated with sleep conditions. Psychotropic medication use was significantly associated with overall poorer sleep quality and daytime dysfunction (in model 1), but no longer remained significant once mental health measures were added in model 2. This may reflect shared variance between psychotropic medication and mental health difficulties. These findings are in keeping with studies among both autistic adults and the general population. Presence of physical health conditions and prescription medication use (linked to either/both physical and mental health conditions) are associated with poorer sleep quality (Gadie et al., 2017; Jovevska et al., 2020; Magee et al., 2011; Newman et al., 1997).

A further important social variable for sleep quality was presence of needs indicators. Results demonstrate that those relying more on external support from means-tested anti-poverty and disability benefit programs had poorer sleep efficiency. Utilization of means-tested anti-poverty and disability benefit programs is both an indicator of poverty and federally defined disability severity among autistic adults. Although we are not aware of previous research examining the association between means-tested anti-poverty and disability benefit program utilization and sleep among autistic people, such relationships have been examined in the general population. There is strong evidence for associations between poor sleep and lower socioeconomic status, poor neighborhood quality and financial strain in the general population (Anders et al., 2014; Hale et al., 2013; Patel et al., 2010; Ruff et al., 2018; Steptoe et al., 2008). Although this was not tested in our study, there is evidence in the general population that suggests that utilization of means-tested anti-poverty and disability benefit programs may also be associated with stressful neighborhood environments and ill health, which may interact to have a negative effect on sleep quality (Arber et al., 2009; Chambers et al., 2016; Hale et al., 2013).

Among autistic people, there are likely to be unique stressors associated with being autistic in a neurotypical world (Botha & Frost, 2020), which may contribute to poorer sleep quality. In the current study, self-reported autistic traits were significantly associated with all aspects of sleep quality in correlational analyses. In regression analyses autistic traits contributed to model 1 for all aspects of sleep quality (except sleep medication use) but were no longer significant contributors when mental health variables were added in model 2. The exception was for sleep efficiency, where autistic traits continued to contribute significantly to the model after mental health variables had been added. The correlation results show a similar pattern to a previous study of autistic adults, where autistic traits correlated significantly with overall sleep quality and sleep duration (Jovevska et al., 2020). Higher autistic traits have also been associated with poorer sleep quality in a study of older people with high autistic traits (Stewart et al., 2020). Further studies are required to clarify whether it is autistic traits themselves that are associated with sleep quality, or whether these measures of autistic traits reflect other risk factors described in biopsychosocial models of sleep such anxiety, depression, rumination and sensory processing differences (Gosling et al., 2012; Perlis et al., 1997).

Although demographic, physical health, and social factors contributed significantly to the models explaining sleep quality, the strongest associations were between sleep quality and mental health. Self-reported anxiety symptoms were particularly important, and were significantly associated with overall sleep quality and every aspect of sleep. Higher perceived stress contributed significantly to overall sleep quality, subjective sleep quality, sleep disturbance, and daytime dysfunction. Depression symptoms did not contribute significantly to any of the models. Results are somewhat consistent with prior studies (Anders et al., 2014; Jovevska et al., 2020; McLean et al., 2021). Previous studies of autistic people have found that mental health conditions or presence of anxiety and/or depression contribute to models of sleep quality (Baker & Richdale, 2015; Jovevska et al., 2020). However, these studies have collapsed various mental health difficulties into a single dichotomous variable (i.e., presence/absence), and therefore it has not been possible to disentangle the specific associations of anxiety or depression with sleep. Although an association between anxiety and sleep is well established (Ramsawh et al., 2009), few studies have examined associations between specific mental health symptoms and sleep for autistic people across the adult lifespan. Biopsychosocial theories of sleep suggest that stress and anxiety may act to maintain sleep difficulties (Spielman et al., 1987), and there is strong evidence for the association between poor sleep and both anxiety and rumination among non-autistic people (Gosling et al., 2012; McHugh et al., 2011). The results of this study highlight the importance of considering interactions between mental health, physical health, socioeconomic factors and sleep quality. Future work should also consider the influence of other common co-occurring conditions with autism such as attention deficit hyperactivity disorder, which are also associated with sleep disturbance.

A unique feature of the current study is the exploration of different components of sleep quality. The individual components of sleep correlated significantly with each other but at varying levels (correlation between $r = 0.174$ and $r = 0.537$), suggesting that individuals may experience different symptoms of sleep difficulties despite sleep problems overall being common. Each component of sleep difficulties correlated significantly with all measures of mental health symptomatology, autistic traits and presence of physical health problems (with the exception of sleep medication use), consistent with patterns of results from non-autistic people (Gosling et al., 2012; McHugh et al., 2011). In the regression models, the only measure associated with all of the sleep components was anxiety symptomatology. Other variables that were commonly included in the regression models were female sex assigned at birth (for five of seven models) and physical health difficulties (for four of seven models). Results suggest that although sleep difficulties are common, how they manifest differs across individuals. Better understanding of which factors explain certain patterns of sleep problems may contribute to developing individualized approaches to manage sleep difficulties in autistic adults.

Results from the current study should be considered alongside certain limitations. Data was collected at a single timepoint (cross-sectional data) and therefore should not be interpreted as measuring "change." Although the cognitive demands of this study and the participants' high education levels suggest that participants have cognitive abilities within the average range or higher, intellectual ability was not measured. Therefore, participants do not reflect the experiences of the whole population of autistic people (e.g., those with co-occurring intellectual disability). However, one advantage of this study is that it includes understudied portions of the autistic community, such as middle-aged and older adults as well as those assigned female at birth. It is worth noting that those individuals who were excluded from the current analysis (due to missing PSQI scores) tended to be older and report fewer autistic traits (on the AQ) than those participants in the broader study who did not complete the PSQI. The differences between included and excluded groups were small (3.39 difference in years for age; 3.28 points difference for AQ scores) but statistically significant. Whether these variables are specifically related to likelihood of completing sleep questionnaires, a reflection of fatigue or effort (the PSQI was at the end of a longer survey), or due to sample characteristics is not yet clear. A further limitation is related to the coding of health conditions and needs indicators. These variables were represented as the summed counts or number of reported occurrences, which assumes that all occurrences (e.g., all health conditions) have the same impact on the individual. This is unlikely to be the case as a single profound health condition may have more impact than several relatively minor health conditions. Future studies should ensure that health conditions and needs indicators are measured with greater precision. Another caveat to consider is that the measure of sleep quality employed here relied on self-report ratings. Although self-report scales are a valid approach to measuring sleep quality and they permit assessment of perceived dysfunction associated with sleep difficulties, studies often find discrepancies between self-report and objective measures of sleep (Difrancesco et al., 2019; Young et al., 2003). Therefore, in order to capture the whole picture, studies that utilize objective measures are needed to complement the current study, and others like it, that rely primarily on self-report scales. There are also several strengths to the current study. The sample utilizes a large age-range which includes older autistic people (aged 65–78) who are highly underrepresented in the research literature (Mason et al., 2022). Additionally, the current study considers the severity of symptoms in common mental health conditions separately (rather than simply presence/absence of mental health difficulties), in order to observe their shared and distinct associations with sleep. Finally, to our knowledge this is the first study to consider how physical health and use of government support reflecting social needs, are associated with sleep quality in autistic adults.

In conclusion, in this study we demonstrate that demographic, physical health and mental health variables are significantly associated with sleep quality in a large sample of autistic adults. In particular, being assigned female at birth, having more physical health problems, and having higher levels of anxiety symptoms were associated with poorer sleep quality overall and across a range of components of sleep difficulties. The presence of conditions that commonly co-occur with autism, such as anxiety and an associated ruminative cognitive style may increase the risk of autistic people experiencing poor sleep (Gosling et al., 2012; Richdale & Schreck, 2009). Few age effects were observed, despite the sample including autistic adults who were relatively evenly distributed across a wide age-range. Although anxiety is consistently associated with sleep, different combinations of other variables are associated with specific sleep components. We do not yet fully understand the plethora of possible contributors to various sleep difficulties experienced by autistic adults. Poor sleep quality is a significant risk factor for many aspects of health and well-being (Delahaye et al., 2014; Deserno et al., 2019; Lawson et al., 2020; Magee et al., 2017) and autistic people may be at particular risk for sleep difficulties. Therefore, it is vital to increase our understanding of the variables that precipitate and maintain sleep difficulties in order to inform the development of effective individualized treatments for autistic people.

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CONFLICT OF INTEREST

We have no known conflict of interest to declare.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from Simons Foundation Powering Autism Research. Restrictions apply to the availability of these data, which were used under license for this study. Data are available from https://www.sfari.org/resource/spark/ with the permission of Simons Foundation Powering Autism Research.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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