

# Which autistic traits are related to depressive symptoms in Japanese workers?

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**Abstract:** Individuals with autism spectrum disorders are at a high risk of experiencing depressive symptoms. However, the relationship between autistic traits and depressive symptoms is unclear. This study aimed to identify which autistic traits are related to depressive symptoms in Japanese workers. The study participants included 2,049 workers from all areas of Japan. Autistic traits and depressive symptoms were measured using an abridged Japanese version of the Autism-Spectrum Quotient (AQ-Short) and the Japanese version of the K6 scale, respectively. The AQ-Short comprises five autistic trait subcomponents that assess fascination for numbers/patterns, difficulties with imagination, preference for routine, difficulties with social skills, and attention-switching difficulties. Linear regression analyses were performed to estimate the association between total and subcomponent autistic trait scores and depressive symptoms. Participants with higher total autistic trait scores were significantly more likely to have depressive symptoms ( $p < 0.001$ ). When scores on the five autistic trait subcomponents were entered simultaneously into the model, participants with higher scores on all subcomponents other than ‘difficulties with imagination’ were significantly more likely to report depressive symptoms. Total autistic traits and autistic trait subcomponents could be used for early detection of the risk of depressive symptoms.

**Key words:** Autism spectrum disorders, Autism-Spectrum Quotient, Autistic traits, Depressive symptoms, Imagination

## Introduction

Autism spectrum disorders (ASD) are neurodevelopmental disorders characterized by impairment of social interaction and communication and repetitive stereotyped behaviors<sup>1</sup>. The estimated prevalence of ASD is 1.7%

(95% CI: 1.4–2.0) in the United Kingdom<sup>2</sup> and 2.6% (95% CI: 1.9–3.4) in South Korea<sup>3</sup>. Research has indicated that ASD represent the extreme end of a continuous distribution of autistic traits in the population, although ASD vary in severity and/or degree of functional impairment<sup>4</sup>. Individuals with ASD are at a high risk of associated psychiatric disorders, particularly depression and anxiety<sup>5–8</sup>. Hofvander *et al.*<sup>9</sup> found that approximately 50% of a group of adults with ASD had a concurrent lifetime diagnosis of mood disorder. In addition, Sterling *et al.* reported that 43% of a group of adults with ASD reported significant frequency of depressive symptoms<sup>5</sup>.

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Studies of the general population have shown that autistic traits are continuously distributed with no natural boundary between normality and ASD<sup>10, 11</sup>. Kanne *et al.* suggested that young adults who report having strong autistic traits but without an ASD diagnosis experience more psychiatric and psychosocial problems, including depression and anxiety<sup>12</sup>. Kunihira *et al.*<sup>13</sup> reported there to be an association between autistic traits and depression in university students. Most previous studies have described autism-linked depression in adolescents or young adults, and have not investigated this link in workers of a broad age range. Matsuo *et al.* also reported that adult subjects diagnosed with major depressive disorder exhibited a stronger autistic-like traits or symptoms compared with healthy controls, but the sample size was relatively small<sup>14</sup>. It is therefore interesting to focus on working adults with high autistic traits scores and without a diagnosis of ASD.

Five autistic trait subcomponents have been identified, including fascination for numbers/patterns, difficulties with imagination, preference for routine, difficulties with social skills, and attention-switching difficulties. Some related concepts have been found to be associated with suicidality or general psychiatric disorder. For example, Dell’Osso *et al.*<sup>15</sup> reported that restricted interests and rumination domain scores on the Adult Autism Subthreshold Spectrum (AdAS) were associated with suicidality in patients with full-blown ASD and subjects with autistic traits, as well as in a healthy control group. Carpita *et al.*<sup>16</sup> found that AdAS nonverbal communication domain scores were a statistically predictive variable for the presence of psychiatric disorders among 120 parents of ASD children. Furthermore, Takara and Kondo<sup>17</sup> extracted four indicators (interpersonal friction, experience of being bullied, psychotic-like experiences, age under 32 yr) that distinguished people with ASD from depressive adults. Although the literature has suggested that individuals with high autistic trait scores and patients with ASD are at a higher risk of experiencing depressive symptoms, there has been insufficient research on which type of autistic traits are related to depressive symptoms among workers. This study aimed to identify which autistic traits are related to depressive symptoms in Japanese workers.

## Methods

### *Participants*

The present study used data obtained from a survey conducted to examine social class and health in an oc-

cupational cohort, the Japanese study of Health, Occupation and Psychosocial factor related Equity (J-HOPE study)<sup>18, 19</sup>. The present analyses were conducted with the J-HOPE dataset of January 8, 2014. Workers in a major Japanese manufacturing company (with headquarters in Kyoto and 11 other main offices throughout Japan) were recruited as participants. All workers were invited to participate in the study, and 2,266 (response rate 90.1%, age range: 21–65 yr; 241 women and 2,025 men) agreed to participate during the first year (2010). The J-HOPE dataset collected longitudinal data four times between 2010 and 2014. Data from the fourth year (the autistic traits were assessed in 2013) were used in the present analyses. At that time, there were 2,187 participants, of which 138 were excluded from the analyses because of missing data (either autistic traits or depressive symptoms data), which left a total of 2,049 study participants (age range: 23–65 yr; 217 women and 1,832 men).

The J-HOPE study obtained ethical approval from the ethics committee of the University of Tokyo Graduate School of Medicine/Faculty of Medicine (No. 2772), Kitasato University School of Medicine/Hospital (B12-103), National Center for Global Health and Medicine (NCGM-A-000183-00), and University of Occupational and Environmental Health (10-004). All participants provided written informed consent prior to enrollment in the study.

### *Sociodemographic characteristics*

The participants were surveyed using a self-administered questionnaire. Sociodemographic characteristics included sex, age, socioeconomic status (SES, i.e. education, occupational position, and pre-tax annual household income), living status, and health-related behaviors (i.e. drinking habits, smoking habits, and leisure-time physical activity). Educational attainment was classified into 5 categories, as follows: junior high school [9 yr], high school [12 yr], junior college [14 yr], college [16 yr], or graduate school [18 yr]. Occupational position was classified into 2 categories, managerial and non-managerial. Pre-tax annual household income was classified into 6 categories, as follows: ≤2.99 million Yen, 3–4.99 million Yen, 5–7.99 million Yen, 8–9.99 million Yen, 10–14.99 million Yen, and ≥15 million Yen (Yen=Japanese Yen; 100 yen is approximately equal to 1 USD). Equivalent income (10,000 yen/yr) was divided by the median values of the annual household income in each category by the square root of the household number to adjust for household size. Living status was classified into 2 categories, alone and not alone. Drinking habits were classified into 2 categories, almost every day and

rarely (or sometimes). Smoking habits were classified into 2 categories, current smokers and non-current smokers (the latter comprising either individuals who smoked previously but did not smoke anymore and those who never smoked). Leisure-time physical activity was classified into 2 categories, including ‘yes’ (from light physical activity 1 or more times per week to intense physical activity 3 or more times a week) and ‘no activity’.

#### *Autistic traits*

The Abridged Version of the Autism-Spectrum Quotient (AQ-Short), which was used to evaluate autistic traits, is a self-administered test that measures the degree to which an adult with normal intelligence has ASD-associated traits<sup>20</sup>. The AQ-Short was developed based on the Autism-Spectrum Quotient (AQ) created by Baron-Cohen *et al.*<sup>10, 21</sup>, and is used worldwide. Two major Japanese versions of the AQ are currently in use<sup>22, 23</sup>. The AQ-Short includes 28 of the 50 original AQ items. The AQ-Short can also be used as a quick screening tool for autistic traits and yields scores in ASD and control samples that correlate strongly with those of the full AQ<sup>20</sup>. The AQ-Short total scores have shown accurate differences between control participants and individuals clinically diagnosed with Asperger’s syndrome, which is included in ASD<sup>20</sup>.

A previous study that compared AQ data from the original UK study with those obtained in a Japanese study indicated strong similarities between the two datasets, although mean AQ scores were higher in the Japanese sample than in the British sample<sup>23</sup>. In general, the UK results were replicated in every respect in Japan, as follows: (1) The ASD group had a similar high AQ score; (2) A sex difference (male > female participants) was found in both general populations and student populations, but not among individuals with ASD; (3) Science students scored significantly higher than non-science students in both countries; and (4) mathematics and physical science students scored higher than medical students in both countries<sup>23</sup>. These results suggest that autistic conditions are expressed in very similar ways across widely differing cultures.

The AQ-Short subcomponent scores were used as a measurement for specific autistic traits in the present study. The AQ-Short comprises two higher-order subcomponents that assess fascination for numbers and patterns and social behavioral difficulties. The social behavioral difficulties trait subcomponent comprises four lower-order subcomponents that assess difficulties with imagination, a preference for routine, difficulties with social skills, and

attention switching difficulties<sup>20</sup>. Participants respond to each statement using a 4-point Likert scale, as follows: 1=definitely agree; 2=slightly agree; 3=slightly disagree, and 4=definitely disagree. Scoring is reversed for items in which an “agree” response reflects the presence of a characteristic of autism. Scores are summed, resulting in a minimum AQ-Short score of 28 (indicative of no autistic traits), and a maximum score of 112 (full endorsement of all autistic traits). We used a Japanese version of the AQ-Short form, which was translated into Japanese by the authors and independently back-translated by a native English speaker. Although there are no studies that have confirmed the validity of the Japanese version of the AQ-Short, validity for the Japanese version of the AQ has been demonstrated<sup>22, 23</sup>.

#### *Depressive symptoms*

Depressive symptoms were measured using the Japanese version of the K6 scale<sup>24, 25</sup>, which consists of six items concerning the frequency with which respondents had experienced symptoms of psychological distress (e.g., “feeling so sad that nothing can cheer you up”) during the preceding 30 d. The response options ranged from 0 (none of the time) to 4 (all of the time), with total possible scores ranging from 0 to 24. The reliability and validity of the original versions have been demonstrated repeatedly in the USA and Australia<sup>26, 27</sup>. The K6 scale was translated into Japanese, and its validity has been demonstrated in mood and anxiety disorders diagnosed by a lay interviewer in a community sample<sup>24</sup>. This version demonstrated a screening performance that was equivalent to that of the original English version<sup>28</sup>.

#### *Statistical analysis*

Continuous variables are presented as the mean  $\pm$  SD, and categorical variables are presented as percentages. We calculated Cronbach’s  $\alpha$  and the pairwise correlation between total and subcomponent autistic trait scores and depressive symptoms scores. Linear regression analyses were performed to estimate the association between total and subcomponent autistic trait scores and depressive symptoms scores. To check if the traits were independently associated with depressive symptoms, the subcomponent scores were entered into the regression models in two ways: each subcomponent was entered (Table 3), or all subcomponents were entered simultaneously (Table 4). We confirmed that high correlations (i.e.,  $p > 0.7$ ) did not exist among the five autistic trait subcomponents before entering these variables into the model (Table 2). Concerning

the adjustment method, the first model was adjusted only for age and sex (Tables 3 and 4). The second model was further adjusted for SES (education level [yr], job position [managerial job or not], equivalent income [10,000 yen/yr]), living status (alone or not alone), and health-related behaviors (drinking habits [almost every day or rarely/sometimes], smoking habits [current smoking or non-current smoking], and physical activity [yes or no]) (Tables 3 and 4). We drew a residual plot by putting the standardized residuals on the vertical axis and the participant number on the horizontal axis. The plot showed a random pattern, indicating a good fit for a linear model (Supplementary Fig. 1). Statistical significance was set at a two-tail value of  $p < 0.05$ . All analyses were conducted using SPSS (version 20 for Windows, IBM Inc., New York, USA).

**Results**

The characteristics of participants are presented in Table 1. Table 2 shows the means, SD, Cronbach’s alpha coefficients, and pairwise correlations between the total and subcomponent autistic trait scores and depressive symptoms scores. We assessed the internal consistency of the Japanese AQ-Short as autistic traits and obtained a Cronbach’s  $\alpha$  coefficient of 0.79, which indicates an acceptable internal consistency. The Cronbach’s  $\alpha$  values of the AQ-Short subcomponents, namely, fascination for numbers and patterns trait, difficulties with imagination trait, and difficulties with social skills trait, were all moderate to high. The internal consistency for a preference for routine trait and attention-switching difficulties trait were 0.55 and 0.41, respectively. Assessment of the internal consistency of the Japanese K6 scale as depressive symptoms yielded a Cronbach’s  $\alpha$  coefficient of 0.90, which indicates acceptable internal consistency.

**Table 1. Participant sociodemographic characteristics (n=2,049)**

Age (yr)	44.5 ± 9.4
Sex, Male, n (%)	1,832 (89.4)
Depressive symptoms, K6 score	4.7 ± 4.6
Autistic traits, AQ-Short score	69.1 ± 8.1
Educational level (yr)	14.8 ± 2.3
Occupational position (manager), n (%)	533 (26.2)
Equivalent income (10,000 yen/yr)	469.4 ± 205.9
Living status (alone), n (%)	425 (20.8)
Drinking habits (almost every day), n (%)	727 (35.5)
Smoking habits (current smoking), n (%)	574 (28.0)
Leisure-time physical activity (no), n (%)	1,101 (53.9)

Mean ± SD.

AQ-Short, An Abridged Version of the Autism-Spectrum Quotient; Equivalent income, annual household income divided by the square root of the household number.

The depressive symptoms score was significantly positively associated with higher values for the total and subcomponent autistic trait scores. Among the subcomponents, the association of depressive symptoms with fascination for numbers and patterns trait was relatively weak, albeit statistically significant. The correlations between all pairs of autistic trait subcomponents were not strong. Again, only the fascination for numbers and patterns trait subcomponents were negatively associated with other subcomponents (difficulties with imagination, a preference for routine, difficulties with social skills, and attention switching difficulties).

Linear regression analyses of the total and subcomponent autistic traits (AQ-Short) that were associated with depressive symptoms (K6) are shown in Table 3. Participants with higher total autistic trait scores were significantly more likely to have depressive symptoms (standardized regression coefficient [ $\beta$ ]=0.327, 95% CI of

**Table 2. Mean, SD, internal consistencies (Cronbach’s  $\alpha$ ), and pairwise correlation between total and subcomponent autistic traits score and depressive symptoms score (n=2,049)**

	n	Mean ± SD	Cronbach’s $\alpha$	1	2	3	4	5	6	7
1. Depressive symptoms, K6 score	6	4.7 ± 4.6	0.90	1	0.32***	0.06**	0.16***	0.29***	0.24***	0.28***
2. Autistic traits, AQ-Short score (Autistic trait subcomponent)	28	69.1 ± 8.1	0.79		1	0.21***	0.72***	0.66***	0.78***	0.66***
3. Fascination for numbers and patterns trait	5	11.6 ± 2.6	0.68			1	-0.15***	-0.05*	-0.07**	-0.05*
4. Difficulties with imagination trait	8	19.4 ± 3.2	0.66				1	0.40***	0.41***	0.43***
5. A preference for routine trait	4	10.0 ± 1.9	0.55					1	0.41***	0.45***
6. Difficulties with social skills trait	7	17.7 ± 3.6	0.80						1	0.41***
7. Attention switching difficulties trait	4	10.4 ± 1.8	0.41							1

n: number of items in each scale; \*\*\* $p < 0.001$ , \*\* $p < 0.01$ , \* $p < 0.05$ .

**Table 3. Linear regression analyses of the total and subcomponent autistic traits (AQ-Short) associated with depressive symptoms (K6) (n=2,049)**

	Age- and Sex-adjusted				Multivariate-adjusted			
	$\beta$	(95% CI)	<i>p</i>	Adjusted R <sup>2</sup>	$\beta$	(95% CI)	<i>p</i>	Adjusted R <sup>2</sup>
Total autistic trait	0.327	(0.286 to 0.368)	<0.001	0.115	0.320	(0.277 to 0.362)	<0.001	0.113
Fascination for numbers and patterns trait	0.059	(0.016 to 0.103)	0.007	0.013	0.071	(0.026 to 0.115)	0.002	0.022
Difficulties with imagination trait	0.167	(0.124 to 0.210)	<0.001	0.037	0.155	(0.111 to 0.199)	<0.001	0.040
A preference for routine trait	0.282	(0.241 to 0.324)	<0.001	0.089	0.272	(0.228 to 0.314)	<0.001	0.087
Difficulties with social skills trait	0.251	(0.209 to 0.293)	<0.001	0.072	0.243	(0.199 to 0.286)	<0.001	0.073
Attention switching difficulties trait	0.278	(0.236 to 0.320)	<0.001	0.085	0.264	(0.222 to 0.308)	<0.001	0.084

$\beta$ : standardized regression coefficient; CI: confidence interval; AQ-Short: An Abridged Version of the Autism-Spectrum Quotient.

Linear regression analysis was performed to estimate the association between K6 and AQ-Short total and subcomponent scores.

The multivariate-adjusted model was adjusted for age, sex, education level (yr), job position (managerial job or not), equivalent income (10,000 yen/yr), living status (alone vs. not alone), drinking habits (almost every day vs. rarely or sometimes), smoking habits (current smoking vs. non-current smoking), and leisure-time physical activity (no vs. yes).

**Table 4. Linear regression analyses of the autistic trait subcomponent (AQ-Short subcomponent) associated with depressive symptoms (K6), considering all autistic trait subcomponents (n=2,049)**

	Age- and Sex-adjusted				Multivariate-adjusted			
	$\beta$	(95% CI)	<i>p</i>	Adjusted R <sup>2</sup>	$\beta$	(95% CI)	<i>p</i>	Adjusted R <sup>2</sup>
Fascination for numbers and patterns trait	0.086	(0.045 to 0.127)	<0.001	0.134	0.088	(0.046 to 0.131)	<0.001	0.130
Difficulties with imagination trait	-0.009	(-0.057 to 0.040)	0.728		-0.008	(-0.057 to 0.041)	0.752	
A preference for routine trait	0.168	(0.120 to 0.216)	<0.001		0.163	(0.114 to 0.211)	<0.001	
Difficulties with social skills trait	0.126	(0.079 to 0.173)	<0.001		0.127	(0.079 to 0.176)	<0.001	
Attention switching difficulties trait	0.160	(0.111 to 0.209)	<0.001		0.153	(0.104 to 0.204)	<0.001	

$\beta$ : standardized regression coefficient; CI: confidence interval; AQ-Short: An Abridged Version of the Autism-Spectrum Quotient.

Linear regression analysis was performed to estimate the association between K6 and AQ-Short subcomponent scores.

Five AQ-Short subcomponents were entered simultaneously.

The multivariate-adjusted model was adjusted for age, sex, education level (yr), job position (managerial job or not), equivalent income (10,000 yen/yr), living status (alone vs. not alone), drinking habits (almost every day vs. rarely or sometimes), smoking habits (current smoking vs. non-current smoking), and leisure-time physical activity (no vs. yes).

the  $\beta$ : 0.286 to 0.368). Participants with a higher score on any autistic trait subcomponent were significantly more likely to report depressive symptoms. Adjustment for possible confounding factors did not affect these associations between total and subcomponent autistic traits and depressive symptoms.

Table 4 shows the results of the linear regression analyses of the autistic trait subcomponents (AQ-Short subcomponent) that were associated with depressive symptoms (K6), considering all autistic trait subcomponents by entering five autistic trait subcomponents simultaneously. In the age- and sex-adjusted model, participants whose responses were higher on all subcomponents except one (difficulties with imagination) were significantly more likely to report depressive symptoms. The results of the multivariate-

adjusted model were essentially the same. There were significant associations between all subcomponents except one (difficulties with imagination) and depressive symptoms.

## Discussion

We examined the associations between autistic traits/autistic trait subcomponents and depressive symptoms in a sample of 2,049 workers who were engaged in their normal work across Japan. Workers with higher total autistic trait scores were significantly more likely to experience depressive symptoms. Additionally, four of the five subcomponents (fascination for numbers and patterns trait, a preference for routine trait, difficulties with social

skills trait, and attention-switching difficulties trait) were independently associated with depressive symptoms. The only subcomponent that was not associated with depressive symptoms was difficulty with imagination.

Our results are congruent with results from previous studies, as autistic traits/ASD have often been associated with depression and depressive symptoms<sup>5-7, 9, 12-14, 17, 29, 30</sup>. Depression appears to be common among individuals with ASD<sup>5-7, 9, 30</sup>, although most individuals with ASD do not have sufficient language skills to verbalize changes in mood and feelings of depression<sup>6</sup>. Previous reports on adults have mainly targeted college students or patients with ASD/depression; University students with high autistic traits were found to report more difficulties in most areas, including depression<sup>12, 13</sup>. Depressed patients have been reported to exhibit high levels of autistic traits or ASD<sup>14, 17, 29</sup>. The target of this study was individuals who were actively working. The findings revealed that even individuals who were able to work were more likely to experience depressive symptoms if they had high autistic traits.

The link between autistic traits and depressive symptoms could stem from the fact that many people do not understand autistic traits; this lack of understanding could contribute to greater difficulties in everyday life in individuals with strong autistic traits, such as reduced ability to perform daily tasks, and this may in turn increase distress and depressive symptoms. A further mechanism includes the possible mediating role of other factors in this relationship. A previous study by Pelton and Cassidy<sup>31</sup> suggests that people with high autistic traits are more likely to feel that they do not belong in the world (thwarted belonging) and to view themselves as a burden on others (burdensomeness), which increases their likelihood of attempting suicide. Another study showed a significant relationship between autistic traits and the mood spectrum, which is partially mediated by ruminations and trauma/stressor-related symptomatology<sup>32</sup>.

We found that most subcomponents of the autistic trait (fascination for numbers and patterns, preference for routine, difficulties with social skills, and attention-switching difficulties) were independently associated with depressive symptoms. These results concerning difficulties with social skills are similar to those of a previous study by Domes *et al*<sup>29</sup>. The authors found that chronically depressed individuals with ASD reported significantly higher impairments in social skills and higher levels of personal distress in social interactions than patients with episodic depression. This suggests that patients with ASD who have more difficulties with social skills are more likely to have

chronic depression. Conversely, Sterling *et al.*<sup>5</sup> reported that individuals with ASD with lower social impairment and higher cognitive ability were more likely to report depressive symptoms via the semi-structured observation and an interview administered directly to the participant. The authors suggested that higher functioning individuals with ASD are aware of their social difficulties and that this awareness may lead to increased distress and the development of associated psychiatric conditions. This means that the more often an individual with ASD is aware of difficulties with social skills, the less social impairment was evaluated by others.

These results concerning preference for routine and attention-switching difficulties are similar to those of a previous study by Dell'Osso *et al*<sup>15</sup>. They reported that the strongest predictors of suicidality score were restricted interests and the rumination domain score of autistic traits. Carpita *et al.*<sup>16</sup> reported that the effect of autistic traits on social and occupational functioning was totally mediated by the presence of ruminative thinking, and indicated that mental rumination involves perseverative thoughts that revolve around a negative emotion or situation.

We found that the "difficulties with the imagination" trait was not independently associated with depressive symptoms. Impairment of imagination as a symptom of the autism spectrum involves an impairment of the ability to imagine others' thoughts, or to identify appropriate behavior in a situation<sup>1</sup>. Individuals who lack such concerns might be free from interpersonal conflicts and/or relationship stress, which are major stressors that can induce depressive symptoms. Changes of the direction of the association between difficulties with imagination and depressive symptoms (from positive association to negative association) suggests that multi-collinearity could have contributed to this result. Although the correlations between all pairs of autistic trait subcomponents were not very strong, we checked the variance inflation factor and found that there was no large effect of multicollinearity in the variables of autistic trait subcomponents (variance inflating factors of the variables were between 1.057 and 1.449).

We found that the fascination for numbers and patterns trait had a weak effect size compared with the other trait subcomponents regarding their association with depressive symptoms. The association between this trait and depressive symptoms could be of a different from the associations between the other subcomponents and depressive symptoms; the fascination for numbers and patterns trait is not included in the social behavioral difficulties trait subcomponents, but the other trait subcomponents

are included in social behavioral difficulties trait subcomponents<sup>20</sup>). The fascination for numbers and patterns trait is prevalent among workers with a high SES<sup>18</sup>), while autistic traits/ASD are generally more prevalent among workers with a low SES<sup>18, 33</sup>). Thus, the fascination for numbers and patterns trait may be an advantage for having a high SES. The more prevalent autistic traits/ASD in workers with a low SES may be because individuals with high autistic traits scores or with ASD are likely to exhibit poor academic performance at school owing to difficulties caused by their autistic traits and comorbid psychiatric disorders, including depressive symptoms<sup>34</sup>).

#### Limitations

Our study was conducted using a relatively large working sample who were engaged in a normal working life, and many possible confounding factors were controlled for. However, this study has several limitations. First, the AQ-Short instrument may not be appropriate for use with participants with a low intelligence quotient, as it requires reading comprehension skills<sup>10</sup>). Therefore, our results may only be applicable to people with normal intelligence. Second, participants were workers from a single company, which may limit the generalizability of the findings; however, they were recruited from 12 of the company's offices located throughout Japan (from Hokkaido in the far north to Kyushu in the south), reflecting numerous types of employment and various job positions. Third, our results may be more applicable to men because of the relatively small number of female participants. However, the outcome analyses were performed with adjustments for covariates, including sex. Fourth, the internal consistency for the preference for routine trait and attention-switching difficulties trait was low, but this is probably due to the small number of items in both subcomponents, and the results are consistent with previous reports<sup>20, 35</sup>).

In conclusion, our results indicated that workers with higher total autistic trait scores were significantly more likely to experience depressive symptoms. Additionally, our results suggest that four autistic trait subcomponents (fascination for numbers and patterns, a preference for routine, difficulties with social skills, and attention-switching difficulties), and not for the difficulties with imagination trait, were independently associated with depressive symptoms when considering all five subcomponents and adjusting for SES, living status, and health-related behaviors. Total autistic traits and autistic trait subcomponents could be used for early detection of the risk of depressive symptoms.

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## Conflict of Interest

The authors have no conflicts of interest to declare.

## Author Contributions

K.M. and A.T. conceived of the original study concept and developed the study design. K.M. and A.T. collected the data. T.S. performed the statistical analyses. K.M. and A.T. supervised the overall research project. T.S. wrote the first draft of the manuscript, and all authors contributed to the critical revision of the manuscript. All authors have read and approved the final manuscript.

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