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Relationship between sun exposure and seasonal affective disorder symptoms in rural older people with different personalities: a cross-sectional study

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Abstract

Objectives Evidence suggests that environmental support, personality traits, and psychological factors can influence seasonal changes in human mood and behavior, particularly in rural middle-aged women and older people. This study aimed to quantify the associations between personality traits, seasonal affective disorder symptoms, and sun exposure in rural older people.

Methods This study is a cross-sectional analytical study, the participants were 300 rural older persons from 12 natural villages and 5 geriatric service centers in 4 different cities in Jiangxi Province, China. The Eysenck Personality Questionnaire (EPQ), the Personal Inventory of Depression and Seasonal Affective Disorder (PIDS-SA-SimpChi), and the Sunlight Exposure Scale were used to conduct follow-up interviews throughout the year. Spatial analysis was performed using ArcGIS and Geodetic Probes. The data were analyzed using SPSS 21 and Amos 23.0 mediated models.

Results Rural older people with low sun exposure exhibited higher personality trait scores ($p < 0.001$). Personality traits were directly associated with seasonal affective disorder symptoms($p < 0.01$); Sun exposure mediated this effect in rural older people ($p < 0.05$).

Conclusion High-scoring personalities are more typical of rural older people with low sun exposure, and there is a greater risk of emotional and behavioral instability. Latitudinal differences are not a determinant of SAD. Increased sun exposure is associated with symptom relief. The promotion of light therapy devices in rural areas with low sunlight is warranted.

Keywords Personality traits, Seasonal affective disorder, Sun exposure, Rural older people, Quality of life

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Introduction

Population aging and mood disorders are two of the world's health challenges reported by the World Health Organization [1]. In recent years, the WHO reported that the incidence of depression in the elderly is significantly higher than the average level, the global prevalence of severe depression in the elderly is as high as 13.3%, and the prevalence of severe depression in elderly women is significantly higher than that in men [2]. Older people living in remote rural areas for long periods are at greater risk of depression and cognitive impairment due to reduced sense of social support by prolonged absence of children and widowhood and lack of adequate health service conditions [3, 4].However, most of our scientific studies tend to focus on urban and surrounding rural areas [5]. China, as one of the fastest aging populations in the world, has a large population base and a high degree of rural aging [6]. Depression in Chinese older adults is highly prevalent, and is the second most important factor leading to disability and death [7].

Seasonal affective disorder (SAD) is a subtype of major depressive disorder (MDD) that is generally seasonal in nature, and its primary etiology is light-induced disruption of the circadian rhythm [8]. During the onset of the disorder, affective disorders can significantly impair the patient's quality of life and physical and mental health, and may include symptoms such as lethargy, insomnia, agitation, decreased libido, slowed thinking, loss of appetite, and a preference for sweets or carbohydrates,etc. [9–12].Older adults are more vulnerable to changes in their environment, which can lead to a number of psychological problems and increase the risk of disability, death after illness, and even suicide [13–15], so it is important to study environmental adaptation and mental health in older people. Sun exposure (SE) is a direct and effective non-pharmacological intervention to regulate mood abnormalities in individuals, primarily through the synthesis of adequate amounts of vitamin D [16]. Additionally, studies have shown that older adults with more sun exposure time typically show a more optimistic and positive outlook on life, as they have more opportunities for socialization and physical activity to overcome the negative emotions associated with loneliness [17].However, personality traits (PT), as an intrinsic attribute of individuals, are directly related to health and behavior [18]. According to Eysenck's theory of personality, groups with extroverted personalities are less likely to be at risk for depression, whereas those with more pronounced psychotic or neurotic personalities are usually prone to emotional instability, withdrawn and impulsive, and are more likely to be at risk for erratic behavior [19]. Nevertheless, many studies have demonstrated the positive effects of light interventions on individual physiology and behavior [20, 21], but few studies have examined the effects of light interventions on mental health, using individual personality differences as the independent variable, examining personality differences that are important for geriatric health education and the development of targeted mental health interventions.

Taken together, the above studies suggest that difference in personality traits, and changes in natural light are all associated with seasonal changes in people's mood and behavior, particularly in rura older people, but the interaction between these factors remains to be investigated. This study aimed to investigate the personality and sunlight exposure status of rural older people, explore the relationship between personality traits and SAD symptoms in rural older people using structural equation modeling, and test the mediating moderating effect of sunlight exposure variable intervention on the link between personality and SAD symptoms.

Method

Study design and participants

Between April 2022 and April 2023, we conducted a cross-sectional survey of rural elderly people in 12 villages and 5 geriatric service centers in 4 different cities Jiangxi Province, China. (Fig. 1c, latitude not exceeding 1 degree). The primary industry in these areas is planting industry and is influenced by economic development, the local older people are less affected by modern light intervention patterns, maintain the routine of sunrise and sunset in agricultural societies, and do not use artificial time cues from watches or alarm clocks; therefore, in this study, their daily light patterns are qualitatively and quantitatively different from those of the general population living in modern light patterns, making this study's research sample more representative and reducing interference with results from other physical or external factors.

Each subject was interviewed one-on-one at home and followed up by telephone (at least once every three months) to collect relevant data. Prior to conducting the study, all the researchers (background in a medically related field or at least 1 year in a local health organization) received project training to standardize their survey process. Each participant signed an informed consent form in advance and was told that the data they provided would be strictly protected and used only for scientific research. During the survey, the researcher conducted a basic physical and psychological examination of each study participant to exclude individuals suffering from major depression and severe physical illnesses to avoid serious data bias. The study was approved by the ethics committee of Dalian Medical University. During the formal survey, a random sampling method was used to

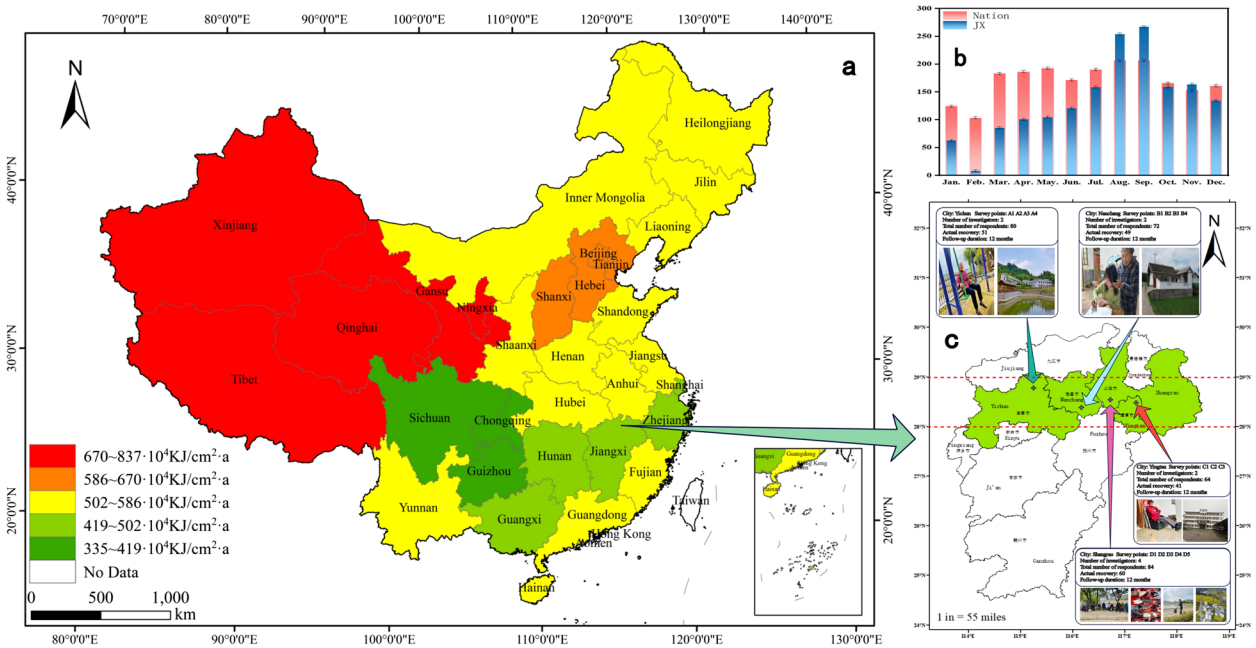

Fig. 1 Sunlight and research design

randomly recruit study sites(no less than 50% of the total number of compliant elderly people per survey site), 300 participants were eventually enrolled in the study participants ages< 60 or with severe neurological disease were initially excluded from the first round. Finally, 201 of whom met the study criteria, with a valid data return rate of 67%. The sample screening criteria are shown in Fig. 2.

Measures

ArcGIS and regional natural light statistics

By searching the database of the National Meteorological Center of China, light data for the last 30 years in the Chinese region were collected [25]; the average light statistics of Jiangxi Province and the country were derived by searching the China Statistical Yearbook 2022 [22].

Sociodemographic characteristics

Participants provided their demographic information, including name, sex, birth year, education level, occupation, marital status, smoking history, chronic disease history.The judgment of exercise intensity was mainly divided into three levels according to the participants' self-reported number of outside farming or physical exercise per week, 0–1 times a week was low, 2–4 times were medium, and 4–7 times were high.

Scales

The adult version of the Eysenck Personality Questionnaire Revised Chinese Rating Scale (EPQ-RSC) was used to measure the personality traits of the participant group.The EPQ-RSC consists of 88 questions divided into four personality trait subscales, including Extraversion (21 items), Psychoticism (23 items), Neuroticism (24 items), and LIE (20 items, measure of truthfulness of self-reported data). Scores for each subscale were calculated as crude scores based on the answers, which were computed into sample T-scores after a standardized formula, where the standardized formula:

$$T = 50 + \frac{X - \mu}{SD}$$

The Chinese version of the Personal Inventory of Depression and Seasonal Affective Disorders (PIDS-SA-SimpChi) from the Center for Environmental Therapy was used to analyze the bias and total symptom scores of seasonal affective disorder in the subject group. The measure consists of four dimensions: depression, seasonality of behavior, extreme behavior scores, and months of the year in which the extreme behavior occurs.

The Sun Exposure Assessment Scale was used to measure participants' sun exposure assessment, and scores were calculated for each dimension including factors related to sun exposure motivation, information, and behavior.

The correlation coefficients between each calculated dimension and the total scale ranged from 0.3 to 0.8 ($P < 0.01$), indicating that these questionnaires have good

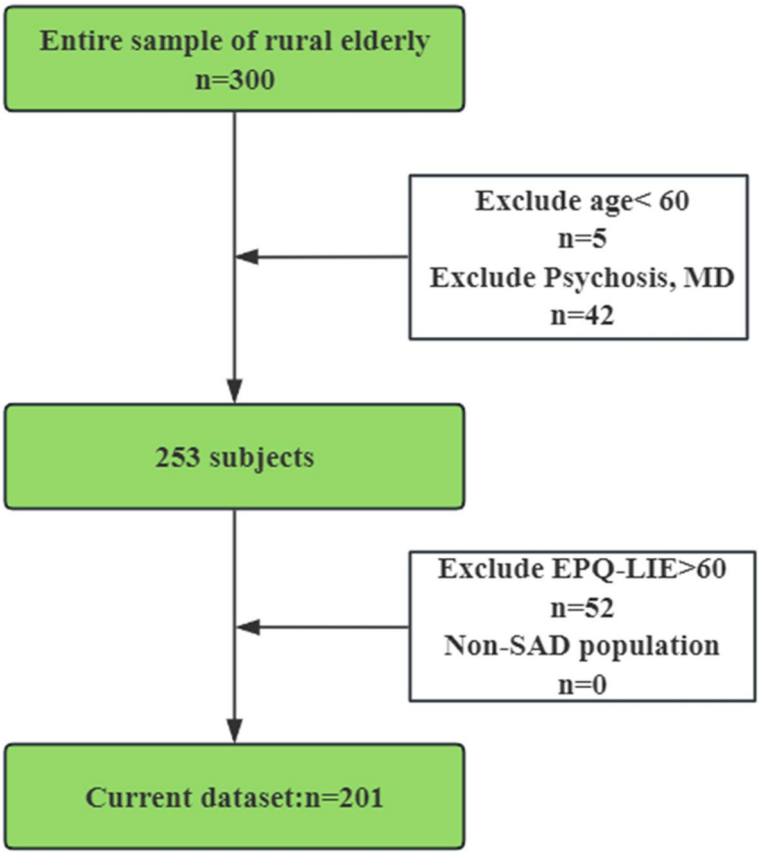

Fig. 2 Data selection flow chart. Psychosis (a sample with a depression scale score > 5)

reliability and validity. Table 1 gives the subscales and reliability analysis of the different scales.

Statistical analysis

We used ArcGIS 10.8 for data visualization of the light data, combined with Origin Pro2022 to plot a histogram of annual light hours at the study site compared to mainland China; a one-sample t-test in SPSS 21.0 was used to assess whether there was a difference between the participants and the general population of the same age, with the significance set at $p < 0.05$. AMOS 23.0's Structural Equation Modeling (SEM) to assess the direct and

Table 1 Scale reliability and validity analysis

Scale	Dimension	Cronbach's Alpha	*p value*
Eysenck Personality Questionnaire (EPQ-RSC) [23]	Extraversion (21 items)	α = 0.949	$p < 0.001$
	Psychoticism (23 items)		
	Neuroticism (24 items)		
	LIE (20 items)		
PIDS-SA-SimpChi [24]	Depressive (9 items)	α = 0.885	$p < 0.001$
	Seasonal Tendency (6 items)		
	Extreme Behavior (12 items)		
	Symptom (9 items)		
Sun Exposure Assessment Scale (SEM-Q) [25]	Motivation (5 items)	α = 0.839	$p < 0.001$
	Information (8 items)		
	Behavior (2 items)		

indirect relationships between personality traits, SAD symptoms, and sun exposure.Before running the SEM, we conducted multidimensional reliability and validity tests and Pearson's two-tailed correlation test for measuring reliability and multicollinearity between variables. The absolute value of the correlation coefficients between the six research variables included in this study is < 0.8, which indicates that the probability of multicollinearity between the variables in the model is small and the bias on the model regression results is negligible.Initially, we constructed a hypothetical model incorporating regression of all variables based on previous findings and expertise, but final correlation analyses showed that the correlations between age (p=0.06) and gender (p=0.46) of the participants included in this study and the final measured symptoms of Seasonal Affective Disorder (SAD1, SAD2) did not reach a statistically significant difference, and that the model incorporating both variables was overfitted (CMMIN/df > 5 , RMSE > 0.08) and was not absolutely representative. In addition, for the other confounders either the data differences were small or not confirmed by previous studies, so we retained paths between highly correlated variables as much as possible. Based on this, we constructed the final SEM to test the hypothesized model (Fig. 3), including the one mediation effect test involved.

Results

Regional natural light comparison

According to the light data in the database of the China National Meteorological Center, the total annual average light hours and solar radiation in Jiangxi Province over the last 30 years are mainly concentrated in the fourth echelon of total light in China. (Fig. 1a). Another result of the duration of sunlight exposure showed that the total monthly sunlight exposure in Jiangxi Province in winter and spring, and even in early summer and late autumn, did not reach the national average. In particular, the total amount of sunshine in February fell to the lowest level in the country, at only 8.8 hours, and although the amount of sunshine increased after that, it still did not reach the national average before the summer. Only August, September, and November exceeded mainland China's monthly sunshine average (Fig. 1b).

According to follow up data reported by the Institute, the superiority or inferiority of natural light conditions may influence the formation of seasonal moods and behaviors in rural older people. In winter, when natural light conditions are lowest, there is a greater frequency of negative moods and behaviors, including chronic bad moods, abnormal weight gain or loss, low socialization levels, low vitality, drowsiness, and other adverse symptoms. Conversely, as light conditions continue to improve, these negative phenomena change. Between March and early May and between September and October, more rural seniors can demonstrate better mental and behavioral habits, including good mood, high socialization, high vitality, and a good diet. After June, the increase in light hours, with the fewest categories of abnormalities in mood or behavior among older adults, continued until early October, but during that time participants mostly reported symptoms of insomnia, which for the most part may have been caused by the short summer nights or the high temperatures. Even though, we did not completely exclude the effect of temperature on the above phenomena, the effect of light on SAD tropism and symptoms has been fully discussed, so the overall correlation trend between the two can be inferred. Figure 4 shows the details.

Participant characteristics

A total data sample of 201 rural older people was included in this study. The subjects were 115 (57.2%) aged 65 years or older and 86 (42.8%) aged 60–65 years. Most participants were female (n=131; 65.2%), had a relatively balanced birth season (spring: n=75, 37.3% summer: n=52, 25.9% fall: n=40, 19.9% winter: n=34, 16.9%), had elementary school or less education (n=146, 72.6%), were married (n=167, 83.1%), and agricultural name (n=145, 72.1%) and having a history of chronic diseases (n=115, 57.2%). The demographic characteristics and personality traits according to longitudinal statistics of the participants are shown in Table 2.

Comparison of the personality traits of rural older people with normative norms

The statistical results showed that, excluding the Lie dimension, rural older people's mean personality trait scores were greater than the normative norms of older people of the same age for both males and females. Rural older people had higher extraversion, psychoticism, and neuroticism scores. The t test results showed that the differences were statistically significant (p<0.01). See Tables 3 and 4 for details.

Correlation analysis of personality trait variables, SAD, and sun exposure in rural older people

Analysis of the correlation results revealed that sun exposure in rural older people was associated with three personality traits—psychoticism, neuroticism, and extraversion (p<0.05 or p<0.01)—and with seasonal mood and behavioral tendencies and seasonal mood disorder symptoms (p<0.01). Scores on the three dimensions of personality traits were positively correlated with two dimensions of the variable measuring SAD (p<0.01). This suggests that there may be an interaction or interaction

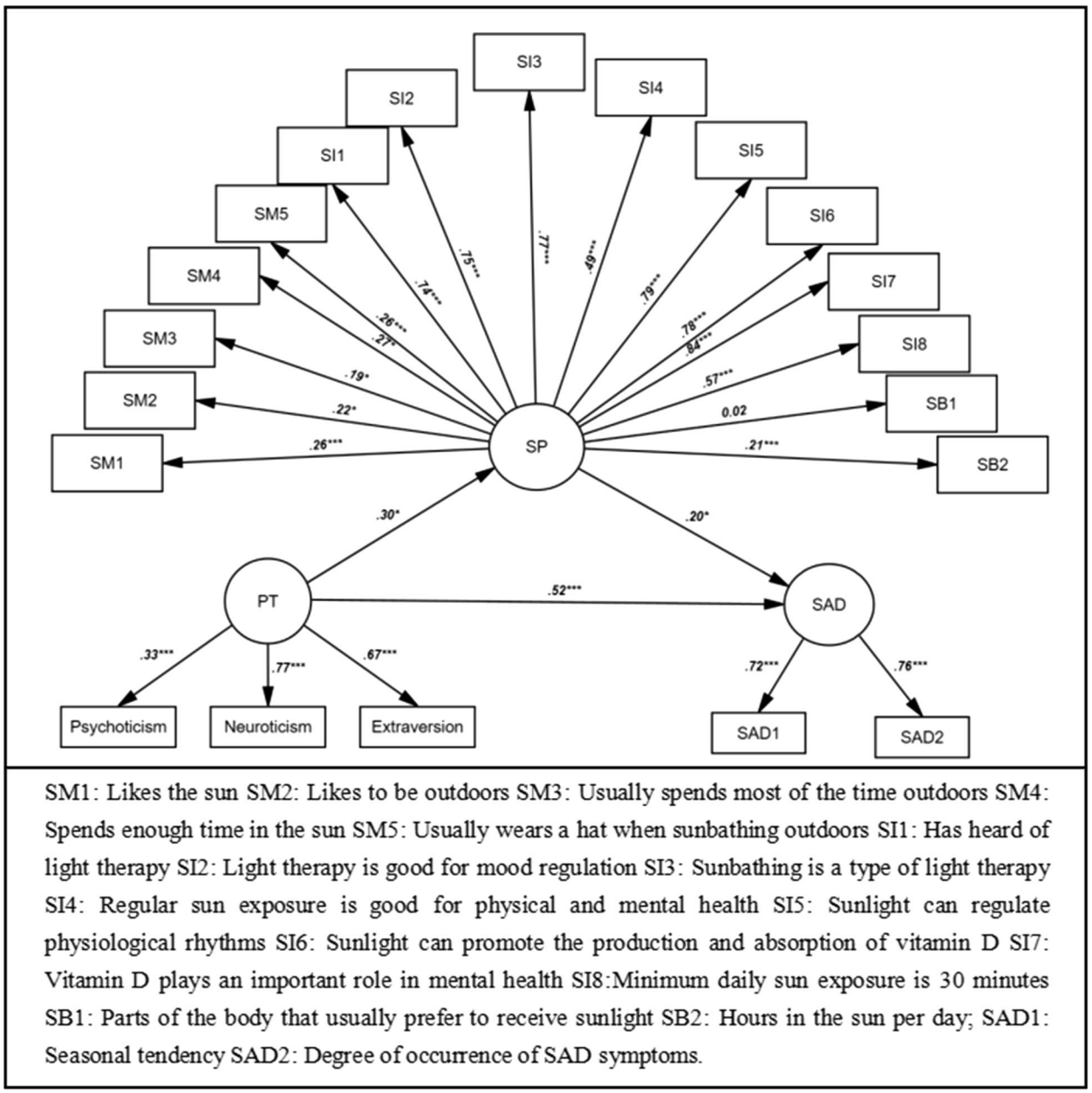

Fig. 3 Test of the relationships among sun exposure, personality traits, and SAD

between personality traits, SAD, and sun exposure in rural older people. The specific data are presented in Table 5.

Structural equation modeling and mediating effect tests

Structural equation modeling

This model had good goodness-of-fit (CMIN/DF = 1.595, NFI = 0.701, CFI = 0.912 and RMSEA = 0.055). The results of SEM data analysis showed that personality traits of rural older adults had a significant positive effect on SAD ($\beta = 0.52$, $p < 0.01$) and sun exposure ($\beta = 0.30$, $p < 0.05$), and that sun exposure had a significant positive effect on SAD ($\beta = 0.20$, $p < 0.05$). In addition, personality traits had a greater effect on SAD than sun exposure in rural older adults.

In addition, the results of this study revealed several pathways, such as liking the sun ($\beta = 0.26$, $p < 0.001$), liking outdoor sports ($\beta = 0.22$, $p < 0.05$), usually spending most of the time outdoors ($\beta = 0.19$, $p < 0.05$), spending enough time in the sun ($\beta = 0.27$, $p < 0.01$), usually wearing a hat

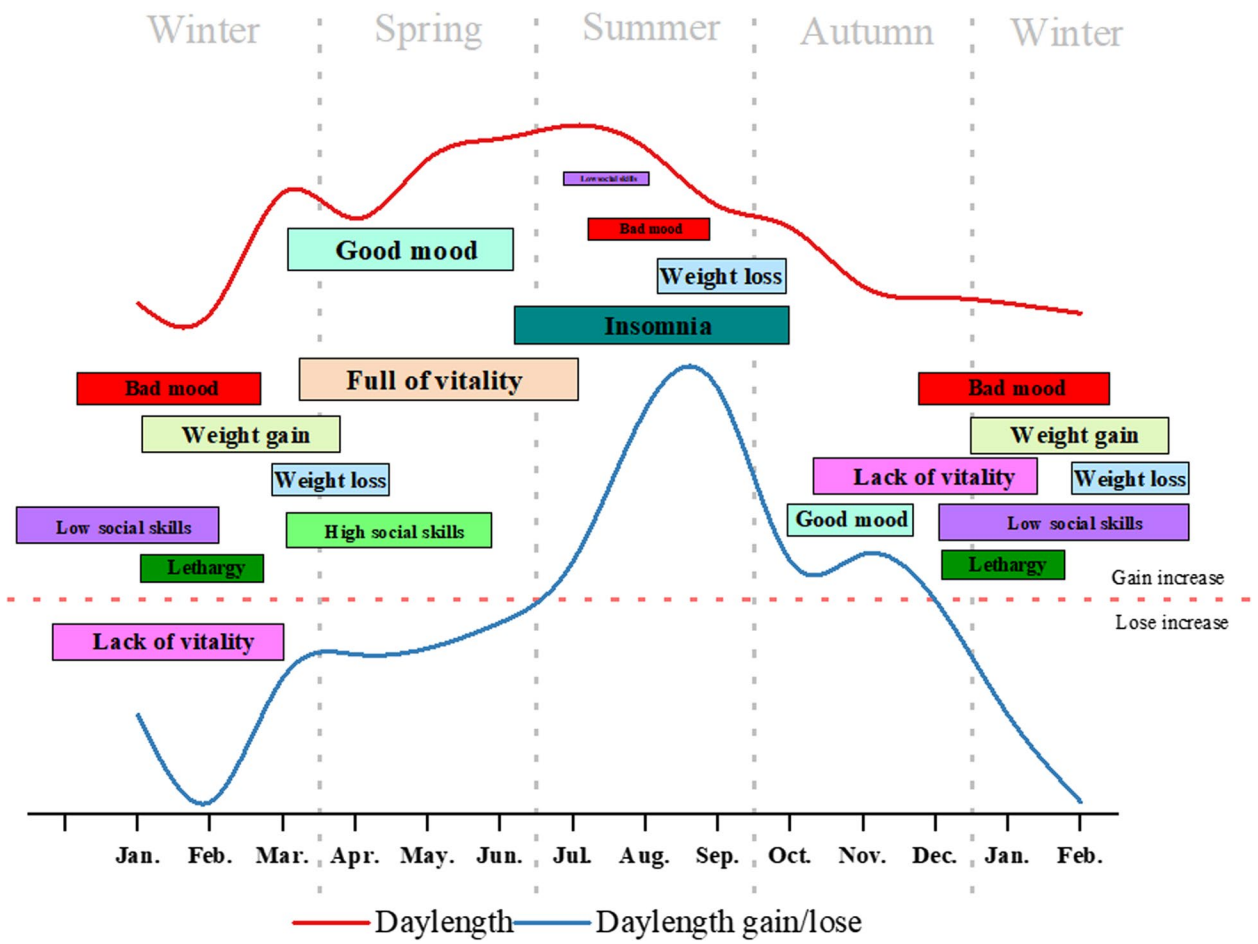

Fig. 4 Distribution curve of seasonal changes in geriatric behavior

when sunbathing outdoors (β = 0.26, $p < 0.05$), hearing about light therapy (β = 0.74, $p < 0.001$), light therapy is good for mood regulation (β = 0.75, $p < 0.001$), sunbathing is a type of light therapy (β = 0.77, $p < 0.001$), regular sunbathing is good for physical and mental health (β = 0.49, $p < 0.01$), sunlight can regulate physiological rhythms (β = 0.79, $p < 0.001$), sunlight can promote the production and absorption of vitamin D (β = 0.78, $p < 0.001$), vitamin D is important for mental health (β = 0.84, $p < 0.001$), and the minimum duration Among them, the usual site of preferred exposure to sunlight (β = 0.02, $p = 0.75$) was the least important sunlight exposure factor and was not statistically significant (Table 6).

Sun exposure intermediary utility test

Based on the Bootstrap 2000 algorithm with 95% CI set, the results showed a direct effect of personality traits on seasonal affective disorder = 0.079 with a 95% CI of [0.048, 0.116], which does not contain 0, indicating the presence of a direct effect ($p < 0.05$); a total effect = 0.089 with a 95% CI of [0.062, 0.128], which does not contain 0, indicating the presence of a total effect ($p < 0.01$); and an indirect effect = 0.009 with a 95% CI of [0.003, 0.023], which does not contain 0, indicating the presence of an indirect effect ($p < 0.05$), as shown in Fig. 5. This evidence suggests that the sun exposure variable is significantly different as a mediating moderator of the effect of personality traits on seasonal affective disorders in rural older people.

Discussion

This study provides the first comprehensive description of the objective associations between seasonal mood disorders and personality in rural older people in a low-light environment. To our knowledge, the current cross-sectional study is the first to add personality factors to the light environment and SAD mechanisms in rural older people. With a growing number of studies documenting the effects of different populations regarding light exposure patterns on SAD tendencies related to symptoms [26–29], light intervention is one of the most important means of regulating the effects of SAD on individuals

Table 2 Demographic characteristics of the sample and personality traits according to longitudinal statistics

Characteristics ($n=201$)		Personality Traits		
	N (%)	*E* (μ ± SD)	*P* (μ ± SD)	*N* (μ ± SD)
Sex				
Male	70 (34.8)	9.49 ± 4.12	5.86 ± 3.63	10.34 ± 7.14
Female	131 (65.2)	9.12 ± 3.54	4.73 ± 3.00	9.97 ± 6.63
age(years)				
60–65	86 (42.8)	9.02 ± 3.73	5.09 ± 3.00	9.37 ± 6.45
Over 65	115 (57.2)	9.42 ± 3.77	5.12 ± 3.47	10.64 ± 7.02
Birth season				
Spring	75 (37.3)	9.52 ± 3.76	5.07 ± 3.24	9.52 ± 3.76
Summer	52 (25.9)	8.81 ± 3.80	5.27 ± 3.45	11.08 ± 6.99
Autumn	40 (19.9)	8.55 ± 3.45	4.45 ± 2.80	9.45 ± 6.05
Winter	34 (16.9)	10.14 ± 3.89	5.79 ± 3.54	9.71 ± 7.33
Educational attainment				
Primary and below	146 (72.6)	9.32 ± 3.70	5.24 ± 3.30	10.51 ± 6.88
Junior High	27 (13.4)	8.52 ± 3.68	5.04 ± 3.11	8.78 ± 6.35
High School	14 (7)	11.14 ± 4.90	5.50 ± 4.15	10.14 ± 8.19
University and above	14 (7)	8.00 ± 2.39	3.64 ± 1.95	8.29 ± 5.03
Occupation				
Farmer	145 (72.1)	9.08 ± 3.75	5.20 ± 3.31	10.48 ± 7.01
Worker	21 (10.4)	9.62 ± 3.90	5.52 ± 3.54	10.05 ± 6.79
Teacher	6 (3)	8.83 ± 4.07	4.67 ± 3.93	10.17 ± 7.65
Medical worker	5 (2.5)	10.60 ± 4.51	2.80 ± 2.59	11.40 ± 7.33
Civil servants	2 (1)	12.00 ± 2.83	8.5 ± 3.54	11.00 ± 8.49
Self-employed	3 (1.5)	8.67 ± 2.31	3.00 ± 2.65	10.33 ± 7.64
Other	19 (9.5)	9.68 ± 3.77	4.79 ± 2.51	6.79 ± 4.10
Marital status				
Married	167 (83.1)	9.34 ± 3.87	5.22 ± 3.35	10.15 ± 6.88
Single	34 (16.9)	8.79 ± 2.97	4.65 ± 2.84	9.85 ± 6.44
History of smoking				
Yes	59 (29.4)	9.48 ± 3.91	5.77 ± 3.70	10.32 ± 7.07
NO	142 (70.6)	9.16 ± 3.67	4.93 ± 3.07	10.01 ± 6.70
History of chronic disease				
Yes	115 (57.2)	9.11 ± 3.72	5.06 ± 3.09	9.99 ± 6.57
NO	86 (42.8)	9.43 ± 3.79	5.20 ± 3.52	10.24 ± 7.12
Physical activity				
Low	107 (53.2)	9.11 ± 3.83	4.95 ± 3.22	10.24 ± 6.73
Medium	69 (34.3)	9.46 ± 3.65	5.15 ± 3.41	10.36 ± 7.05
High	25 (12.4)	9.24 ± 3.79	5.76 ± 3.17	8.76 ± 6.46

Table 3 Comparison of EPQ results obtained by male sex and Chinese sex (score, $\bar{x} \pm SD$)

	Male ($n=70$)	Chinese norm ($n=300$)	*t*	*P*
Extraversion	9.49 ± 4.12	7.08 ± 3.01	19.28	0.00
Psychoticism	5.86 ± 3.63	2.68 ± 2.31	13.49	0.00
Neuroticism	10.34 ± 7.14	3.70 ± 3.00	12.12	0.00

Table 4 Comparison of EPQ results obtained for females and Chinese individuals (scores, $\bar{x} \pm SDs$)

	Female ($n=131$)	Chinese norm ($n=206$)	*t*	*P*
Extraversion	9.12 ± 3.54	7.28 ± 2.95	29.47	0.00
Psychoticism	4.73 ± 3.00	2.51 ± 1.98	18.01	< 0.01
Neuroticism	9.97 ± 6.63	4.44 ± 3.12	17.21	0.00

[30–32]. However, few studies have examined the overall impact of an individual's personality differences and changes in the degree of adaptation to the environment on the seasonality of mood and behavior, and the results of this study bridge the current gap and suggest new thinking about the environment and the mechanisms of SAD occurrence. As sun exposure is influenced by various factors, we believe that structural equation modeling (SEM) is an appropriate solution for achieving the study objectives.

The results of the light analysis suggest that rural older people in low-light environments are more likely to exhibit seasonal changes in a range of emotions and behaviors. The advantages of natural light conditions may influence the seasonal moods and behaviors of rural older people [33]. In the winter season, when natural light conditions are lowest, individuals exhibit a greater frequency of negative moods and behaviors, including chronic bad moods, abnormal weight gain or loss, low socialization levels, low vitality, and sleepiness. Conversely, these negative phenomena change as light conditions continue to improve. This finding is in line with previous findings conducted in extreme areas on seasonal sensitivity in different populations [34–37]. Furthermore, temperature may affect some physiological conditions in the population, but it is not critical for SAD patients [38] so the mental health status of older people living in low-latitude areas with poor light conditions needs to be given high priority.

The results of the personality survey revealed that rural older people who survived in low natural light conditions scored significantly higher on the latitudes of extraversion, psychoticism, and neuroticism than did the general peer group. According to Eysenck's theory on the

Table 5 Correlation analysis of personality traits, SAD, and total sunshine exposure score (r, correlation coefficient)

Variables	SP	Psychoticism	Neuroticism	Extraversion	SAD1	SAD2
SP	1					
Psychoticism	0.152*	1				
Neuroticism	0.234**	0.256**	1			
Extraversion	0.194*	0.199**	0.522**	1		
SAD1	0.334**	0.261**	0.324**	0.243**	1	
SAD2	0.316**	0.193**	0.304**	0.322**	0.543**	1

* $P < 0.05$, ** $P < 0.01$, SP is the total sun exposure score

Table 6 Total effect of correlation between variables in the model

Variables			β	S.E.[a]	C.R	P^{**}
PT	→	**SE**	**0.30**	**0.01**	**1.957**	**0.02**
PT	→	SAD	0.20	0.02	3.241	< 0.001
SP	→	SAD	0.52	0.82	1.807	0.04
PT	→	Neuroticism	0.77	0.17	3.795	< 0.001
PT	→	Extraversion	0.67	0.15	3.826	< 0.001
PT	→	Psychoticism	0.33	0.11	3.125	< 0.001
SE	→	SM1	0.26	0.27	2.243	< 0.001
SE	→	SM2	0.22	0.33	2.091	0.02
SE	→	SM3	0.19	0.33	1.921	0.03
SE	→	SM4	0.27	0.39	2.270	< 0.01
SE	→	SM5	0.26	0.39	2.242	0.01
SE	→	SI1	0.74	0.68	2.794	< 0.001
SE	→	SI2	0.75	0.79	2.798	< 0.001
SE	→	SI3	0.77	0.73	2.802	< 0.001
SE	→	SI4	0.49	0.57	2.661	< 0.01
SE	→	SI5	0.79	0.80	2.807	< 0.001
SE	→	SI6	0.78	0.80	2.803	< 0.001
SE	→	SI7	0.84	0.78	2.818	< 0.001
SE	→	SI8	0.57	0.57	2.721	< 0.001
SE	→	SB1	0.02	0.64	0.310	0.75
SE	→	SB2	0.21	0.74	2.156	0.02
SAD	→	SAD2	0.76	0.89	5.676	< 0.001
SAD	→	SAD1	0.72	0.14	5.859	< 0.001

[a] *S.E.* Standard error, $P^{**} < 0.05$ was considered to indicate statistical significance

biological basis of personalit [30], individuals with higher extraversion scores usually show more extroversion and impulsiveness. Individuals with high psychoticism scores may have difficulty adapting to external environments and tend to be emotionally unstable. The higher the neuroticism score is, the more typical the emotional instability, the more serious the tendency toward depression, and often suffer from a variety of physical and mental disorders. The results also show that there is a direct link between the personalities of rural older adults and the seasonal variations in mood and behavior they exhibit, especially Neuroticism. A previous meta-analysis of personality and mental health by Malouff et al. also found a significant relationship between personality and psychological symptoms, with high levels of neuroticism leading to more psychological symptoms [20]. Nonetheless, the level of control over self-behavior varies considerably across extraversion and psychoticism, especially among older adults living alone with a sense of isolation [39], A portion of rural older adults, even if they maintain normal levels on neuroticism tests, have difficulty adapting to external environments due to excessive extroversion, aggressiveness, or difficulty adapting to external environments as demonstrated by high scores

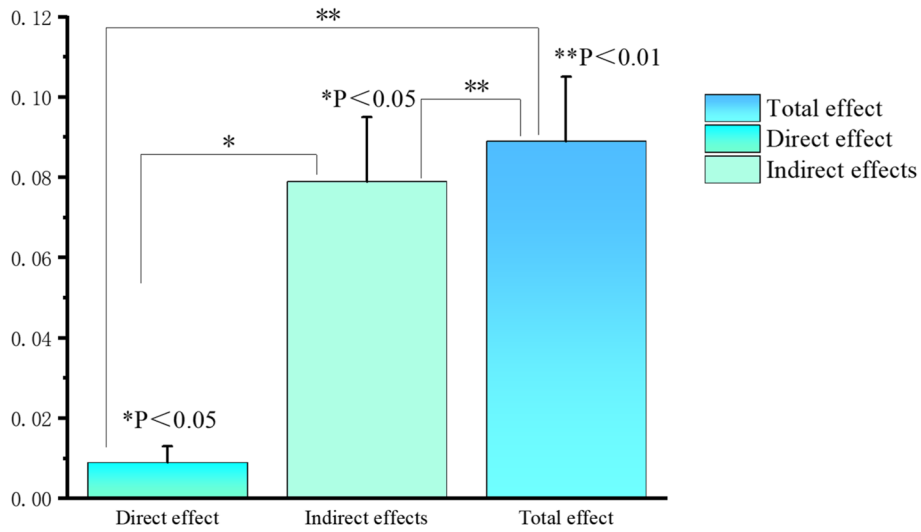

Fig. 5 Effect of personality traits on SAD mediated by sun exposure

on neuroticism, making it difficult to adapt behavioral and emotional disorders with changes in light. Therefore, future cohort studies could be conducted based on personality subgroups to further explore the potential interactions between these traits and how they collectively affect seasonal affective disorder symptoms. Personality may be an important factor influencing mood disorders in rural older adults and should receive more attention in daily care or health education.

The results of structural equation modeling confirmed the positive relationship between the personality traits of rural older people with seasonal affective disorder and sun exposure. First, personality traits directly influence the occurrence of seasonal affective disorder in rural older people, with neuroticism and extraversion being the main influencing factors with high standardized path coefficients. Emotional instability is often subject to environmental changes [40, 41], and the more depressed people are, the more they will try to self-mitigate their negative psychological effects due to the environment by venting their emotions or adopting more aggressive behaviors [42], such as sadness, crying, abnormal eating, sleepiness, refusal or excessive socialization [43]. Common SAD tends to be more pronounced in terms of the individual's emotional loss of control [44]. Individuals with impulsive and adventurous personalities are more likely to disrupt the relatively stable rhythm of life [45], and although they tend to be extroverted in personality, they tend to experience periods of high social activity followed by phases of low socialization and are prone to experience extremes of bingeing and isolation [46, 47]. Second, rural older people score higher on personality traits and tend to have higher levels of sun-exposed environments. Prolonged exposure to poor environments is an important factor affecting the mental health of older people [48], and more humid spaces increase the risk of various chronic diseases in older people, who in turn are more likely to experience depression due to physical and psychological stress [19]. In addition, studies have shown that the more extroverted rural older people are, the more willing they are to believe that good sunlight exposure promotes good health. Rural older people with typically high scores of psychoticism often appear to be lonely and uncaring, but they seem to prefer to mitigate their lack of control over their emotions and behaviors by receiving as much sunlight as possible or by socializing in groups in front of doors in the sun. Combined with the results of the mediated utility test, these findings indicate that sunlight exposure intervention is significantly associated with the control and modulation of personality and SAD associations in rural older people. This finding is similar to the results of a previous study on the relationship between cognition and sunlight exposure in older people in northeastern China [49], where long-term high sunlight exposure was positively associated with better cognitive function.

The formation of personality is determined by the interaction of biogenetic and environmental factors with a certain degree of continuity and stability [50]. The present study revealed that the occurrence of SAD in rural older people is related to individual personality, changes in their natural environment and adaptability and that sunlight, as a mediating moderating variable, can play a predictive and moderating role in inducing SAD in rural older people with high personality scores.

Additionally, negative emotions and undesirable behaviors in older adults are more likely to occur during seasons with shorter light hours, such as winter or early spring. The predictive and moderating role is consistent with the findings of a study on daily and seasonal variation in light exposure among the Old Order Amish [27].

The adverse effects of SAD have long been well discussed [11, 12, 28, 34, 51] Older people who have lived in rural areas for a long time often lack adequate social support and experience greater damage from physical and psychological factors [5]. Illnesses reported by rural older people in long-term adverse environments involve longer pathological processes, both psychologically and physically, than in areas with superior medical conditions and friendly environments [15, 18, 28], however, our studies tend to be willingly biased only toward towns or surrounding rural areas [1]. The risk of SAD in older people is not only the comorbidity of various physical disorders caused by their loss of emotional and behavioral control; it may even affect group emotional disorders and social support, including family relationships, and thus reduce the self-perception of dignity in older people [52]. The high risk of depression induced by SAD may lead to social public problems such as reduced well-being and lower life expectancy in older people. Light intervention, as the most direct and effective way to regulate SAD, has good generalizability [10, 34, 53]. This study demonstrated that personality and SAD play important mediating roles in moderating the relationship between these variables in rural older people. Previous studies have shown that rationally organized environmental interventions can be effective in improving the mental health of older people [54] According to Stephen Stansfeld [55], well-organized interventions targeting environmental risk factors are important for the primary prevention of mental illness. According to the study, the variables included sunlight exposure information about light therapy, the benefits of light therapy for mood regulation, sun exposure as a type of light therapy, the physical and mental health benefits of regular sun exposure, the minimum daily sun exposure of 30 min, the fact that sunlight regulates physiological rhythms, the fact that sunlight promotes the production and absorption of vitamin D, and the fact that vitamin D has an important role in mental health have a high impact on the regulation of SAD. These variables have a high impact on the regulation of SAD and can provide a reference for the development of mental health education programs for SAD prevention. In addition, the factors of length of sunlight exposure and preference for outdoor activities can be used as predictors of whether rural older people have seasonal tendencies for mood and behavior.

Therefore, it is crucial to provide regular and timely personalized mental health education and health interventions for rural older adults with different personalities based on environmental changes. For example, for the elderly who are dominated by high scores of neuroticism, they usually have the greatest possibility of suffering from multiple physical and mental disorders, and the instability of their emotions and behaviors is also more obvious, the local government and the relevant medical institutions need to increase the health care and medical support for this part of the population, and actively carry out activities to promote the acceptance of sunlight-exposed communities to reduce the sense of loneliness; for the population with more psychoticism and extraversion, we should actively pay attention to their perception of environmental changes, improve poor housing, and provide early warning of the negative impacts of extreme weather. For people with more prominent mental qualities and extroversion, we should actively pay attention to their perception of environmental changes, improve poor housing conditions, provide early warning of the negative impacts of extreme weather, and, if necessary, take light intervention to prevent the physical and mental burdens of local elderly people due to their bad moods and behaviors, and so on.

Limitations

This study has several limitations. When considering the influence of environmental conditions on participants' SAD symptoms, we considered the effect of sun exposure and did not analyze the effects of temperature or other natural factors, such as "green space", air quality, etc., on the mental health of rural older people. Future studies should investigate more rural older people in similar or different regions using controlled variables for cross-sectional comparisons to make them more representative and comprehensive. Nevertheless, some of the findings in this study are consistent with those of previous research, which provides additional support for our data. For example, personality traits, as inherent attributes possessed by individuals, are directly and indirectly related to the occurrence of depression [27, 50].

Conclusions

In this study, personality traits and sunlight had direct effects on SAD symptoms in rural older people, and sun exposure had a mediating role in the relationship between personality traits and SAD symptoms in rural older people. Latitudinal differences were not a major factor in the production of SAD symptoms. Rural older people in low-light conditions were significantly more at risk of developing seasonal mood and behavior than older people in the general area, and individuals with greater sun exposure were more likely to experience mitigated seasonal adverse symptoms. Therefore, there is a

need for major personality censuses, and when providing mental health education to older people in rural areas at all levels of care, changes in the light environment in the area should be fully considered to enhance the effectiveness of self-health management for rural older people.

Supplementary Information

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Supplementary Material 1.

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Author's contributions
XFH participated in the design, investigation, data analysis, and writing of the manuscript. RRW, QYK, XXW, YYL, YTH, YQW, and CYG participated in data collection and analysis. XWW participated in the investigation and evaluation of the study. YYZ participated in the design, investigation, and evaluation of the study and contributed to critical revision.

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Availability of data and materials
The data that support the findings of this study are available from the corresponding authors (YYZ) upon reasonable request.

Declarations

Ethics approval and consent to participate
The study was approved by the Dalian Medical University Ethics Committee. This study was conducted in accordance with the Declaration of Helsinki. All participants or their guardians provided signatures of informed consent, on paper questionnaires.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

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