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ORIGINAL RESEARCH

Mood and Sleep Status and Mental Disorders During Prolonged Winter-Over Residence in Two Korean Antarctic Stations

Jae Myeong Kang[1,*], Seong-Jin Cho[1,*], Seo-Eun Cho[1], Taemo Bang[2], Byung Do Chae[3], Eojin Yi[4], Seung Min Bae[1], Kyoung-Sae Na[1], Jaehun Jung[5], Seung-Gul Kang[1]

[1]Department of Psychiatry, Gil Medical Center, Gachon University College of Medicine, Incheon, Republic of Korea; [2]Artificial Intelligence and Big-Data Convergence Center, Gil Medical Center, Gachon University College of Medicine, Incheon, Republic of Korea; [3]Unit of Frontier Exploration, Korea Polar Research Institute, Incheon, Republic of Korea; [4]Department of Plastic and Reconstructive Surgery, Yonsei University College of Medicine, Seoul, Republic of Korea; [5]Department of Preventive Medicine, Gachon University College of Medicine, Incheon, Republic of Korea

*These authors contributed equally to this work

Correspondence: Seung-Gul Kang, Department of Psychiatry, Gil Medical Center, Gachon University, College of Medicine, 21, Namdong-daero 774 beon-gil, Namdong-gu, Incheon, 21565, Republic of Korea, Tel +82-32-468-9932, Fax +82-32-468-9962, Email kangsg@gachon.ac.kr

Purpose: Antarctica is a region with extreme climate, characterized by extreme cold and photoperiod. No research has been conducted on the mental health of Korean Antarctic dispatchers. The aim of this study was to investigate the status of mental illness and changes in mood and sleep among Korean crew members staying for a long-term period in the Antarctic station.

Methods: From 2017 to 2020, crew members who were dispatched from South Korea to two Antarctic stations for a one-year period participated in this study. The crew were evaluated for mood and sleep status and mental illness through psychological tests and interviews by board-certified psychiatrists once before departure and twice during their stay in Antarctica. The incidence of mental illness was confirmed and changes in sleep and depression were analyzed.

Results: A total of 88 participants were included in the final analysis, and 7 of them (8.0%) were diagnosed with mental disorders such as insomnia in early winter. The total Beck Depression Inventory (BDI) score increased significantly in the early winter period, and the total Insomnia Severity Index (ISI) and Pittsburgh Sleep Quality Inventory (PSQI) scores increased in both early and late winter. The difference in changes in mood and sleep symptoms before, during, and after dispatch between the two stations was not significant.

Conclusion: This is the first study to investigate the mental illness and mood and sleep status of Korean crews dispatched to Antarctica. In early winter, there were significant increases in mental illness and depressive symptoms, and a worsening of sleep status.

Keywords: Antarctic, depression, insomnia, mental illness, sleep, winter-over

Introduction

The Antarctic Treaty (1959) defined the area south of 60 degrees south latitude as Antarctica, which is a region with climatic characteristics such as extreme coldness, unusual lengths of day and night, polar days and polar nights, severe storms, and low humidity.[1] Although it is one of the seven continents and is vast enough to account for 10% of the Earth's land area, 98% of the entire surface of Antarctica is covered with perennial ice, and the temperature can drop to - 70 °C in winter, making it unsuitable for human habitation.[2] Antarctica is a very important region for the global environment because of its unique ecosystem, aquatic resources, natural gas deposits, and metal minerals. It is for this reason that it is known as a laboratory for scientific fields such as atmospheric science, meteorology, geology, and biology.[3]

Antarctica currently has more than 170 research stations operated by over 40 countries. Changes in mood and sleep often occur during long-term residence in the Antarctic station because of the long duration of winter (more than 6–8 months), dispatch in isolation for more than one year, limited private space, monotony of lifestyle, and conflict with other personnel. Changes in sleep, insomnia, and mood disturbances such as depression, hostility, and irritability, also called

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winter-over syndrome, have been reported in Antarctic crews.[4,5] Therefore, previous studies on sleep disturbances and depression among Antarctic crews have been performed.[6]

Long-term Antarctic residence is thought to have a significant effect on human circadian rhythm and sleep-wake physiology; previous studies have reported changes in sleep quality and pattern, as well as decreased sleep duration in Antarctic overwinterers.[7–12] Studies have also been conducted on mood problems and depression caused by long-term residence in Antarctica.[7,13,14] Although many previous studies have reported that sleep problems and mood changes can occur in either the winter or summer period of Antarctica, some studies showed no obvious sleep disturbances or discrepancies in mood according to the period, depending on the research method.[13,15]

Long-term living in Antarctica can lead to mental illnesses. A study found that incidence of subsyndromal seasonal affective disorder (SAD) among Antarctic crews increased significantly from 10.5% in late summer to 28.4% in mid-winter.[16] In addition, a study investigating the incidence of mental illness among Antarctic crewmembers showed that 12.5% satisfied the diagnostic criteria for any psychiatric disorder of the fourth edition of the Diagnostic and Statistical Manual of Mental Disorders (DSM-IV).[17] Since intensive evaluation by a psychiatrist is required for a structured interview, the research on this is still considered inadequate.

Korea is the 16th country in the world to build a permanent research station in Antarctica: King Sejong Station on King George Island (West Antarctica) in 1988 and Jang Bogo Station in Terra Nova Bay (East Antarctica) in 2014. Previous studies have been conducted in different cultural settings, which can affect the pattern of winter-over syndrome.[18] Most studies have been conducted in Antarctic personnel from Western countries including the United States, United Kingdom, and France.[5,7–11,14–17] Following these early studies, altered mood and sleep during Antarctic deployment have been reported in personnel from other countries including those from India,[12] China,[19] Japan,[20] and Latin America.[21] However, no study has been performed from the Korean Antarctic station, which would provide another cultural perspective. In addition, the latitude of the stations can bring differences in the climatic environment such as the duration of the winter period, photoperiod, and temperature. Therefore, it is an interesting research topic to investigate whether changes in mood and sleep differ between stations within and outside the Antarctic circle (66.5 °south of the equator). Because only a small sample size study has been conducted on this,[19] the Korean stations located at different latitudes (King Sejong Station, 62° 13 39.4″ S; Jang Bogo Station, 74° 37 38″ S) are highly suitable sites for research on this subject.

We hypothesized that the individuals dispatched in Antarctica might develop mental illnesses and experience depressive symptoms and insomnia, and that mood and sleep status might differ between latitudes. The aims of this study were to investigate 1) the incidence of mental illness, 2) changes in mood and sleep while in Antarctica compared to before departure, and 3) the difference in changes in mood and sleep between the two Antarctic stations among Korean crew members staying in Antarctica for a one-year period.

Materials and Methods

Participants

Information on the Antarctic stations is described in Table 1. The annual mean temperature of Jang Bogo Station (−15.1 °C) is much lower than that of King Sejong Station (−1.8 °C).

Antarctic crew members who were dispatched to the two stations annually from 2017 to 2020 by the Korea Polar Research Institute and stayed there for one year participated in the study. The crew consists of a researcher, facility maintenance staff, captain, and manager, with one medical doctor included under the category of management. Individuals were first selected based on their qualified professions to fill the roles above. Next, they underwent medical evaluation before deployment to confirm they had no serious medical or surgical problems. For those who met the professional qualification and medical standards, we conducted a psychiatric evaluation and included in this study those who had no psychiatric problems. There were no participants who were excluded through the psychiatric evaluation. Ethical approval for this study was granted by the Institutional Review Board (IRB) of Gil Medical Center (GCIRB2017-319) and all participants provided written informed consent. We conducted this study in compliance with the ethical standards of the Declaration of Helsinki.

Table 1 Characteristics of the Two Korean Antarctic Stations

Characteristics	King Sejong Station	Jang Bogo Station
Location	62° 13′ 39.4″ S, 8° 47′ 19.0″ W	74° 37′ 38″ S, 164° 1′ 16″ E
Altitude	9.85 M	36.6 M
Weather		
Temperature		
Annual mean temperature	−1.8 °C	−15.1 °C
Minimum – maximum and average temperature in each month		
January	−2.2 °C – 7.6 °C, 1.6 °C	−7.7 °C – 2.4 °C, −1.9 °C
February	−3.9 °C – 8.5 °C, 1.5 °C	−11.6 °C – −1.0 °C, −6.6 °C
March	−8.0 °C – 8.1 °C, 0.9 °C	−18.7 °C – −8.2 °C, −13.6 °C
April	−9.7 °C – 6.9 °C, −0.7 °C	−25.0 °C – −12.2 °C, −19.2 °C
May	−12.1 °C – 5.0 °C, −2.6 °C	−27.7 °C – −14.5 °C, −22.2 °C
June	−13.3 °C – 2.8 °C, −4.0 °C	−28.3 °C – −14.5 °C, −21.8 °C
July	−16.4 °C – 3.2 °C, −4.1 °C	−28.0 °C – −12.3 °C, −20.5 °C
August	−16.1 °C – 3.9 °C, −5.5 °C	−28.4 °C – −12.6 °C, −22.5 °C
September	−15.8 °C – 5.0 °C, −4.1 °C	−28.7 °C – −14.1 °C, −22.0 °C
October	−12.7 °C – 5.5 °C, −2.5 °C	−22.7 °C – −6.6 °C, −15.5 °C
November	−5.4 °C – 6.1 °C, −0.2 °C	−10.1 °C – −3.4 °C, −6.7 °C
December	−3.2 °C – 6.8 °C, 0.8 °C	−4.4 °C – 1.1 °C, −1.5 °C
Winter period	April – September	March – October
Summer period	October – March	November – February
Photoperiod	No polar day and no polar night	Polar day: 2nd Nov – 9th Feb Polar night: 5th May – 7th Aug
Animals and plants	Animals: Penguin, seal, gull, and whale Plants: Moss	Animals: Penguin, seal, and gull Penguin and gull disappear in winter No plants
Indoor and living environments of station		
Number of persons (During winter/ Maximum capacity)	18 persons/78 persons	18 persons/80 persons
Accommodations	Single room with bathroom	Single room with bathroom
Food and beverages	Cereal, meat, vegetables, and fruit	Cereal, meat, vegetables, and fruit from May to December
Telecommunication	Telephone and Internet	Telephone and Internet
Social activities	(Before 2020) Antarctic Olympic games, friendly official party (From 2020) No activity because of COVID19 pandemic	(Before 2020) Friendly official party (From 2020) No activity because of COVID19 pandemic
Anniversary	Korean Thanksgiving Day, Lunar New Year's Day, and mid-winter greeting	Korean Thanksgiving Day, Lunar New Year's Day, and mid-winter greeting

Note: The above information is for the period 2018–2020 when the participants were in Antarctica.

Psychiatric and Psychological Evaluation Methods

Antarctic crews usually entered Antarctica in November and left Antarctica in December the following year. All participants were evaluated for their mental and sleep status four times in total. For the first evaluation (before departure, September in South Korea), face-to-face interviews with a board-certified psychiatrist, face-to-face psychological tests with a clinical psychologist, and self-administered questionnaires were conducted to screen for any kind of psychiatric disorder. In the second (early winter, mid-April in Antarctica) and third (late winter, late August in Antarctica) evaluation sessions, a video interview with a psychiatrist was conducted to evaluate any psychiatric disorders. Moreover, a self-administered questionnaire was completed to assess mood and sleep. To maintain the consistency of the assessment, the psychiatric interview was conducted by the same board-certified

psychiatrist as before. The fourth and final evaluation (after return, February in South Korea) was performed using a self-questionnaire.

All participants underwent face-to-face psychological tests and completed psychological self-questionnaires. The Rorschach test is a projective method of psychological testing that is widely used to assess emotional function, personality, and underlying thought disorders.[22] The Thematic Apperception Test (TAT) is a projective test to reveal an individual's perception of interpersonal relationships,[23,24] in which thirty-one picture cards are shown as stimuli for descriptions of social situations and interpersonal relationships. The Sentence Completion Test (SCT) is a projective psychological test that examines self-image, conflicts or emotions, interpersonal relationships, and family relationships.[25] The Minnesota Multiphasic Personality Inventory (MMPI) is a standardized psychometric tool for personality and psychopathology with varied reliability across samples.[26–28] These tests were performed only at the baseline evaluation to screen for and exclude any psychiatric disorders. In addition, the Beck Depression Inventory (BDI),[29] Beck Anxiety Inventory (BAI),[30] Mood Disorder Questionnaire (MDQ),[31] Alcohol Use Disorders Identification Test (AUDIT),[32] Insomnia Severity Index (ISI),[33] Pittsburgh Sleep Quality Inventory (PSQI),[34] and Stress Questionnaire for Korea National Health and Nutrition Examination Survey-Short Form (SQ for KNHANES-SF) were performed.[35] The BDI is a 21-item, self-report inventory to evaluate depression. The original version was validated in non-psychiatric populations with a good reliability of 0.81 and in a Korean population with a Cronbach's alpha value > 0.94.[29,36] The BAI is a measure to evaluate anxiety and has high consistency and test-retest reliability in the original ($\alpha = 0.92$, 0.75, respectively) and Korean ($\alpha = 0.92$, 0.84, respectively) versions.[30,37] Scores of both the BDI and BAI range from 0–63 and higher scores indicate more severe depressive and anxiety symptoms. The MDQ, with 15 items, screens for a history of bipolar spectrum disorders and both the original ($\alpha = 0.90$) and Korean ($\alpha = 0.92$) versions are validated.[31,38] The AUDIT is a screening tool to evaluate risky or hazardous alcohol use through 10 self-administered items, with scores ranging from 0–40 where 0 indicates an alcohol abstainer. The original (test-retest reliability ranging from 0.65 to 0.85) and Korean ($\alpha = 0.92$, test-retest reliability = 0.96) versions have been validated.[32,39] The ISI is a brief self-report scale comprising seven items assessing insomnia symptoms with scores ranging from 0–28 where higher scores indicate more severe insomnia. The original version ($\alpha = 0.74$) and the Korean version ($\alpha = 0.92$) have been validated.[33,40] The PSQI is a self-report scale that evaluates sleep quality and can calculate measurements such as total score, sleep efficiency (SE), and total sleep time (TST) with global scores ranging from 0 to 21 where higher scores indicate worse sleep quality. The original version ($\alpha = 0.92$, test-retest reliability = 0.85) and Korean version ($\alpha = 0.84$, test-retest reliability = 0.65) have been validated.[34,41] The SQ for KNHANES-SF is a self-report questionnaire that evaluates an individual's level of stress and quality of life.[35] Nine out of ten items can be scored, resulting in a total score ranging from 9 to 45 where higher scores indicate lower quality of life.

For the first evaluation, a face-to-face interview using structured clinical interview for DSM-5 disorders was conducted by a psychiatrist,[42] and psychological tests (Rorschach and TAT) were performed by a clinical psychologist through face-to-face interview.[22–24] The total time required for the face-to-face psychological tests and interview with the psychiatrist was approximately 3 hours. On the same day, participants also completed self-report questionnaires (BDI, BAI, MDQ, MMPI, AUDIT, ISI, PSQI, and SQ for KNHANES-SF). For the second and third evaluations, the board-certified psychiatrists assessed any kind of mental illness through a 30-to 60-minute video interview, and the participants' mood and sleep were assessed using the BDI, ISI, PSQI, and SQ for KNHANES-SF self-administered questionnaires.

Statistical Analysis

For inter-research station comparison, descriptive statistics, chi-square, and independent *t*-test were used. A paired *t*-test was performed to investigate changes in BDI, ISI, and PSQI scores in the early winter, late winter, and after return periods compared to before departure. Linear mixed model analysis was performed to determine the differences in mood and sleep and the interaction between the two stations and each time point. Statistical analyses were performed at a two-sided significance level of $p < 0.05$. Statistical Package for the Social Sciences (SPSS, IBM Inc.) and R 4.1.3 were used for statistical analysis.

Results

Initially, 100 participants were recruited for the study, but six were not dispatched to Antarctica because of personal or health problems, five did not complete the questionnaire, and one withdrew the consent for the study. Finally, the data from 88 participants were included in the analysis. The average age of the subjects was 37.8 years.

Table 2 Demographic and Characteristics of Participants Before Departure and Comparisons Between the Two Stations

Variables	King Sejong Station (n =45)	Jang Bogo Station (n =43)	Statistics
Age, years	38.5 ± 8.3	37.1 ± 8.7	t = -0.76, p = 0.451
Sex, male	43 (93.3%)	43 (100%)	x^2 = 2.97, p = 0.242
Body mass index (BMI)	24.9 ± 2.7	24.2 ± 1.7	t = −1.64, p = 0.106
Marital status, married	23 (51.1%)	24 (57.1%)	x^2 = 0.32, p = 0.573
Type of work			
Captain and manager	10 (22.2%)	9 (20.9%)	
Research	14 (31.1%)	16 (37.2%)	x^2 = 2.17, p = 0.538
Facility maintenance	19 (42.2%)	18 (41.9%)	
Unknown	2 (4.4%)	0 (0%)	
Winter-over			
Winter-over experience (+)	8 (17.8%)	14 (32.6%)	x^2 = 2.56, p = 0.109
Total winter-over experience, months	4.2 ± 10.7	6.0 ± 10.1	t = 0.82, p = 0.414

Note: Data are presented as mean ± standard deviation or number (percentage).

Table 2 describes and compares the demographics and characteristics of the participants in the two Antarctic stations. There was no statistical difference in age, sex ratio, body mass index, marital status, type of work, or previous experience of winter-over in Antarctica between individuals at the two stations. However, as for winter-over experience, Jang Bogo Station showed a higher trend than King Sejong Station (32.6% vs 17.8%).

Table 3 describes the mental illness diagnosed by psychiatrists at each time point. No participant was diagnosed with mental illness before departure; however, in the early winter period, insomnia disorder (n = 3), adjustment disorder (n =

Table 3 Mental Illness and Mood and Sleep States and Their Changes from Baseline Among All Participants

Variables	Before Departure	Early Winter	Late Winter	After Return
Mental disorders				
Adjustment disorder	0 (88, 0%)	2 (88, 2.3%)	0 (88, 0%)	No face-to-face
Depressive disorder	0 (88, 0%)	1 (88, 1.1%)	0 (88, 0%)	interview
Insomnia disorder	0 (88, 0%)	3 (88, 3.4%)	1 (88, 1.1%)	
Alcohol use disorder	0 (88, 0%)	1 (88, 1.1%)	0 (88, 0%)	
BDI	1.4 ± 2.7 (87)	2.1 ± 2.8 (87)	1.5 ± 2.5 (87)	1.6 ± 2.6 (83)
		t = −2.13, **p = 0.036**	t = −0.53, p = 0.599	t = −0.67, p = 0.507
ISI	1.5 ± 2.1 (88)	3.5 ± 4.2 (88)	3.1 ± 3.6 (88)	2.4 ± 3.8 (85)
		t = −4.74, **p < 0.001**	t = −4.18, **p < 0.001**	t = −2.27, **p = 0.025**
PSQI				
Total score	3.5 ± 2.0 (88)	4.7 ± 2.8 (88)	4.6 ± 2.5 (88)	5.2 ± 10.7 (74)
		t = −3.59, **p = 0.001**	t = −3.96, **p < 0.001**	t = −1.45, p = 0.151
Total sleep time	399.8 ± 67.2 (88)	388.5 ± 65.6 (88)	381.9 ± 64.8 (88)	395.5 ± 74.1 (75)
		t = 1.35, p = 0.182	t = 2.26, **p = 0.026**	t = 0.58, p = 0.565
Sleep efficiency	94.2 ± 6.0 (88)	91.0 ± 10.9 (88)	91.4 ± 10.7 (88)	89.4 ± 16.3 (74)
		t = 2.75, **p = 0.007**	t = 2.44, **p = 0.017**	t = 2.86, **p = 0.005**
SQ for KNHANES-SF	10.4 ± 2.7 (88)	10.9 ± 2.5 (88)	11.3 ± 3.5 (86)	11.2 ± 4.3 (75)
		t = −1.69, p = 0.094	t = −2.07, **p = 0.042**	t = −1.89, p = 0.063

Notes: Mental disorders are presented as number of subjects with mental disorder (number of total participants, percentage of mental illness). Scale data are presented as mean ± standard deviation (number of participants). Before departure was September in South Korea. Early winter and late winter was mid-April and late August in Antarctica, respectively. After return was February in South Korea. Paired t-test was used (before departure vs early winter, before departure vs late winter, before departure vs after return). Bold indicates clinical significance (p < 0.05).
Abbreviations: BDI, Beck Depression Inventory; ISI, Insomnia Severity Index; PSQI, Pittsburgh Sleep Quality Index; SQ for KNHANES-SF, Stress Questionnaire for Korea National Health and Nutrition Examination Survey-Short Form.

2), depressive disorder (n = 1), or alcohol use disorder (n = 1) was diagnosed. As a result, 7 participants (8.0% of the total) were diagnosed with mental illness; however, none of these constituted a condition that caused serious functional impairment in their work. In late winter, one participant was diagnosed with insomnia disorder, and the others recovered to a normal condition.

Table 3 describes the mental illness diagnosed by psychiatrists at each time point. No participant was diagnosed with mental illness before departure; however, in the early winter period, insomnia disorder (n = 3), adjustment disorder (n = 2), depressive disorder (n = 1), or alcohol use disorder (n = 1) was diagnosed. As a result, 7 participants (8.0% of the total) were diagnosed with mental illness; however, none of these constituted a condition that caused serious functional impairment in their work. In late winter, one participant was diagnosed with insomnia disorder, and the others recovered to a normal condition.

Table 3 shows the BDI, ISI, PSQI, and SQ for KNHANES-SF scores at each time point and indicates whether there was a significant change in the later period compared to before departure. The BDI total score increased in early winter, and the ISI total score increased in early winter, late winter, and after return compared to baseline. The PSQI total score increased in early winter and late winter, and the TST of PSQI decreased in late winter compared to baseline. The SE of the PSQI decreased in all phases of early winter, late winter, and after return compared to before departure. The SQ for KNHANES-SF showed an increased total score in late winter compared to baseline.

Table 4 presents the results of analysis of difference in mood and sleep status among the stations and the measurement time point, and the interaction between the station and the measurement time point. Multiple testing corrections through Bonferroni correction were performed for the results that showed statistically significant differences (Supplementary Tables S1 and S2). Table 4 shows that there was no significant interaction effect between the station and the measurement time point, but there were significant changes in two of the scales (ISI total score and PSQI SE) with respect to time (before departure, early winter, late winter, and after return). The average ISI total scores over the four time points were 1.69, 4.02, 3.53, and 2.64 in King Sejong Station, and 1.30, 2.93, 2.61, and 2.15 in Jang Bogo Station. The average PSQI SE scores over the four time points were 93.58, 90.61, 89.53, and 87.60 in King Sejong Station, and 94.91, 91.49, 93.40, and 91.28 in Jang Bogo Station. Additionally, there was a difference in the BDI total scores between the stations at two time points (late winter and after return), with higher scores in King Sejong Station compared to Jang Bogo Station. Even after adjusting for multiple testing, there was a significant difference in the BDI total score between the two stations in late winter and after return (Supplementary Table S1). Further, after the correction of multiple testing comparison, there was a significant difference in the ISI total scores in early winter and late winter at King Sejong station compared to before departure (Supplementary Table S2). After adjusting for multiple testing, there was a significant increase in the ISI total score in early winter and late winter compared to before departure, and there was a significant decrease in PSQI SE between before departure to after return at Jang Bogo Station (Supplementary Table S2).

Discussion

The main result of this study was that mental illnesses such as insomnia disorder, adjustment disorder, depressive disorder, and alcohol use disorder occurred in the early winter among the Korean Antarctic crew. In the self-administered questionnaire, depression worsened in the early winter period, while insomnia and sleep quality worsened in both early and late winter. The differences in mood and sleep changes between the two stations were not significant.

Although the mental illness of the Antarctic crew did not cause serious functional impairment, 8.0% of the crew members developed mental illnesses (including insomnia disorder, adjustment disorder, depressive disorder, and alcohol use disorder), which was most prevalent in early winter, and then mostly recovered in late winter. The incidence of whole mental illnesses in this study was between the prevalence of 12.5% reported in a previous study and the weighted prevalence of 5.2% among the United States Antarctic Program using DSM-IV disorders.[17] Regarding each disorder, the one-year incidence of depressive disorder (1/88, 1.1%), adjustment disorder (2/88, 2.3%), insomnia disorder (4/88, 4.5%), and alcohol use disorder (1/88, 1.1%) in this study were comparable or higher than those in the general Korean population (approximately 0.5% for depressive disorder, 0.02% for adjustment disorder [age 30–39], and 1.23% for insomnia disorder [male; age 30–39]).[43–45] These results are the first findings from Korean Antarctic stations, and are in line with previous studies that showed higher mood and sleep symptoms during Antarctic isolation.[4,5,7–14] Considering

Table 4 Comparison of the Mood and Sleep States Between the Stations and Time Points

Comparison Variables	King Sejong Station Mean (SE [95% CI], N)	Jang Bogo Station Mean (SE [95% CI], N)	Linear Mixed Models		
			Effect	F	p-value
BDI					
Before departure	1.78 (0.50 [0.81–2.75], 45)	0.95 (0.28 [0.41–1.50], 42)	Time	2.233	0.085
Early winter	2.60 (0.45 [1.72–3.48], 45)	1.67 (0.38 [0.93–2.42], 43)	Station	9.592	**0.003**
Late winter	2.29 (0.46 [1.38–3.20], 45)	0.74 (0.20 [0.35–1.14], 43)	Time:	0.722	0.540
After return	2.28 (0.49 [1.33–3.23], 43)	0.76 (0.24 [0.29–1.22], 41)	Station		
ISI					
Before departure	1.69 (0.33 [1.05–2.33], 45)	1.30 (0.32 [0.68–1.93], 43)	Time	10.650	**< 0.001**
Early winter	4.02 (0.63 [2.79–5.26], 45)	2.93 (0.63 [1.70–4.16], 43)	Station	1.454	0.231
Late winter	3.53 (0.59 [2.38–4.69], 45)	2.61 (0.48 [1.67–3.54], 43)	Time:	0.427	0.734
After return	2.64 (0.60 [1.47–3.80], 44)	2.15 (0.59 [1.00–3.29], 41)	Station		
PSQI total score					
Before departure	3.47 (0.29 [2.90–4.03], 45)	3.63 (0.31 [3.02–4.23], 43)	Time	1.510	0.213
Early winter	4.64 (0.41 [3.84–5.45], 45)	4.70 (0.44 [3.84–5.56], 43)	Station	1.419	0.237
Late winter	4.78 (0.38 [4.04–5.51], 45)	4.51 (0.39 [3.76–5.27], 43)	Time:	1.758	0.156
After return	6.77 (2.44 [1.99–11.55], 37)	3.65 (0.44 [2.79–4.51], 37)	Station		
PSQI total sleep time (min)					
Before departure	403.60 (7.89 [388.10–419.10], 45)	395.80 (12.20 [371.90–419.70], 43)	Time	2.103	0.100
Early winter	390.10 (9.43 [371.60–408.60], 45)	386.70 (10.48 [366.20–407.30], 43)	Station	0.002	0.965
Late winter	379.40 (10.43 [359.00–399.90], 45)	384.40 (9.11 [366.60–402.30], 43)	Time:	0.432	0.730
After return	391.80 (13.50 [365.30–418.20], 37)	399.20 (10.76 [378.10–420.30], 38)	Station		
PSQI sleep efficiency (%)					
Before departure	93.58 (0.84 [91.92–95.23], 45)	94.91 (0.95 [93.04–96.78], 43)	Time	4.435	**0.005**
Early winter	90.61 (1.82 [87.04–94.17], 45)	91.49 (1.44 [88.68–94.30], 43)	Station	2.363	0.128
Late winter	89.53 (1.77 [86.06–93.00], 45)	93.40 (1.38 [90.70–96.10], 43)	Time:	0.776	0.508
After return	87.60 (3.48 [80.79–94.41], 37)	91.28 (1.50 [88.33–94.22], 37)	Station		
SQ for KNHANES-SF					
Before departure	10.69 (0.47 [9.77–11.61], 45)	10.12 (0.30 [9.52–10.71], 43)	Time	2.117	0.099
Early winter	11.09 (0.38 [10.34–11.83], 45)	10.70 (0.39 [9.93–11.46], 43)	Station	2.056	0.155
Late winter	11.54 (0.58 [10.39–12.68], 43)	11.07 (0.49 [10.11–12.03], 43)	Time:	0.916	0.434
After return	11.89 (0.88 [10.16–13.62], 37)	10.45 (0.44 [9.59–11.30], 38)	Station		

Notes: Data are presented as mean (standard error [95% confidence interval], number of participants). The comparisons of the sleep and psychological states between the two stations and time points were performed using the linear mixed models. Bold indicates clinical significance ($p < 0.05$). Before departure was September in South Korea. Early winter and late winter were mid-April and late August in Antarctica, respectively. After return was February in South Korea.

Abbreviations: BDI, Beck Depression Inventory; ISI, Insomnia Severity Index; N, number of participants who completed the questionnaire; PSQI, Pittsburgh Sleep Quality Index; SQ for KNHANES-SF, Stress Questionnaire for Korea National Health and Nutrition Examination Survey-Short Form.

that crew members had no psychiatric problems in the baseline evaluation, the pooled and individual incidence of psychiatric disorders might show the relationship between Antarctic dispatch and mental illness. The reason for the improvement in mental illness in late winter is presumed to be that the crew had adjusted to life in Antarctica, that it would not be long before returning to their hometown, and that the crew members with considerable psychiatric symptoms had access to psychotropic treatments, including antidepressants and light therapy, under the doctor's prescription at the research station, which has been found to be effective in alleviating seasonal and non-seasonal depressive symptoms.[46,47] Regarding the change of symptoms according to the period of winter, the classical concept is that the symptoms of winter-over syndrome peak in mid-winter,[48] however, the change pattern differs between studies,

with some individuals showing a decrease in psychiatric symptoms during early to late winter.[49] In a previous study, sleep disturbance showed a significant correlation with the severity of the climate in early winter, but this significant relationship disappeared in late winter.[49] This is attributed to gradual adaptation to the environment.

Depressive symptom scores increased significantly in early winter compared to before departure, although it was not at a level that could be considered a clinical problem and decreased in late winter to a level similar to before departure. In a previous study conducted on US station personnel, the depression score measured using the Profile of Mood States of winter-over staff in the South Pole decreased in later winter compared to that in early winter.[50]

In this study, insomnia and sleep quality deteriorated in both early and late winter. In the previous studies, long-term residents in Antarctica showed shallow nighttime sleep, frequent awakening, increased sleep latency, and increased insomnia and daytime sleepiness.[51,52] It is reported that sleep disturbances are usually severe in winter and have been attributed to harsh weather, polar nights, and emotional and psychological reactions to isolation.[53] Results from a study conducted at the Antarctic Station of India found that the TST and SE significantly decreased and the waking period after sleep onset of polysomnography increased in winter compared to before departure from India.[12] In this study, the SE of PSQI decreased not only during winter in Antarctica, but also during the after-return period. This was probably due to the long journey home, jet lag, and irregular sleeping habits after returning. Additionally, the co-morbidity of depression and insomnia in this study might be attributed to the complicated and shared mechanisms among mood, sleep, suicidal behavior, and anxiety in a stressful environment.[54–56]

Despite the symptom changes over the time course, there were no differences in the changes in depression or sleep between stations in this study. A study previously conducted with the Chinese Antarctica crew showed a greater increase in anger at Zhongshan Station located at 66° S compared to Great Wall Station located at 62° S.[19] Table 1 shows significant difference in annual mean temperature between King Sejong Station and Jang Bogo Station (−1.8 °C vs −15.1 °C, respectively) due to the latitude difference and also a large difference in the photoperiod (no polar day and polar night in King Sejong Station vs polar day and polar night in Jang Bogo Station). Despite the large climatic difference between the two Korean stations, the reason for the lack of differences in changes in depression and sleep between the stations might be the characteristics of the two groups, as shown in Table 2. The proportion of those with winter-over experience tended to be higher at Jang Bogo Station, although there was no significant difference in the demographic characteristics between the two stations. This is thought to be because Jang Bogo Station is usually considered a more difficult station to adapt to; therefore, more crews with past Antarctic experience were deployed to Jang Bogo Station. Past experience of working in Antarctica may have helped the crew cope with worsening mood and sleep. Since the number of participants at the two stations in this study was relatively small, for a more accurate comparison between the stations, a larger study should be conducted with the same crew demographics and characteristics in the future. However, the results in this study add cultural variation to the literature regarding the relationship between Antarctic deployment and mood and sleep disturbances.[5,7–12,14–17,19–21]

This study has several limitations. Although no participants were infected with COVID-19, it is possible that the global pandemic declaration may have affected the mental health of the participants. However, since the crews were completely isolated, they might not have been very anxious or fearful about COVID-19. An additional limitation is that no face-to-face psychiatric evaluation was planned for after their return due to crewmembers resuming their original jobs, which could have yielded a more complete view of the mental state of the crewmembers upon return. The relatively small number of participants and lack of objective measures are other limitations. However, thorough evaluation of the participants through follow-up online, face-to-face interviews by the clinical psychiatrists and psychologists could complement the mood and sleep assessments of the participants.

Conclusion

In summary, the crew who stayed in Antarctica for a long-term period experienced mental illnesses and increases in depressive and insomnia symptoms during the winter. Factors such as harsh weather, extreme photoperiod, and isolation during their stay in Antarctica may have affected mood and sleep deterioration. For future research, it is suggested that changes in mood and sleep be tracked during the entire year of stay, with more participants involved, and the incorporation of an objective sleep measurement device, laboratory tests for biomarkers of mood and sleep, and

consideration of group dynamics. Additionally, including a detailed investigation of the environment, comprising temperature, glaciers, length of daytime, and online connectivity outside of the Antarctic stations.

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Disclosure

The authors report no conflicts of interest associated with this work.

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