Association of Depression With Susceptibility and Adaptation to Seasickness in the Military Seafarers

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ABSTRACT

Background: Although depression and motion sickness are prevalent in military personnel and seafarers, the association between depression and seasickness has been not yet elucidated. We aimed to evaluate the relationship of depression with initial susceptibility and adaptation to seasickness amongst military seafarers.

Methods: This retrospective cohort enrolled Navy seafarers who started seafaring between 2017 and 2019. Three groups were established according to the Beck Depression Inventory (BDI) score: no depression (BDI score of 0), minimal depression (BDI score 1–9), and mild-to-moderate depression (BDI score 10–29). The occurrence of seasickness requiring treatment was observed as the prescription of medication for the first 30 distant seafaring days. Considering adjustment period, the two different outcomes were defined. The susceptibility to seasickness was evaluated via at least one day suffered from seasickness requiring treatment during the early period (the first 5 seafaring days), and adaptation ability to seasickness was defined by more than 10% of the ratio, calculated days suffered from seasickness requiring treatment/days of seafaring during the late period (the 6–30th seafaring days). Binary logistic regression was further evaluated to estimate the odds of BDI groups and BDI score adjusted for age and workplace whether outside visual perception was possible.

Results: Among the 185 recruits, 179 participants (97%) sailed for more than 5 days were included in the study. Of the participants, 36% was susceptible to seasickness in the early period (the first 5 seafaring days), and adaptation ability to seasickness was defined by more than 10% of the ratio, calculated days suffered from seasickness requiring treatment/days of seafaring during the late period (the 6–30th seafaring days). Binary logistic regression was further evaluated to estimate the odds of BDI groups and BDI score adjusted for age and workplace whether outside visual perception was possible.

Conclusion: The present study suggests that depression is associated with poor adaptation to seasickness in Navy seafarers. Depression screening tool might be helpful for providing preventable strategies for population at risk.

Keywords: Motion Sickness; Depression; Mass Screening
INTRODUCTION

As serving the military is mandatory in Korea, establishing adequate environments to help enlisted personnel in adapting to the service is an essential national assignment. However, it is suggested that the hierarchical structure of military command and obligatory enlistment elevate the occurrence of depression and hinder adapting to the service. Furthermore, Navy recruits have several additional risk factors which hamper mental health: harsh climate, noise, deterioration of circadian rhythm, social isolation and less opportunity to get proper medical management. In regards to these circumstances, it is not surprising that depression is prevalent in the seafarers, reported up to 25%. Moreover, the seafarers have been ranked as one of the occupation with the highest suicide rate. Psychologic stress and mental health in the seafarers have become important issues that occupational efficacy and long-term health outcomes are readily affected.

Almost all ship travelers could have seasickness according to the roughness of waves. Motion sickness in the sea could be induced by passive locomotion of the ship inducing intersensory conflict between vestibular and visual pathways. Although seasickness is a physiologic response to the sensory conflict, seasickness substantially affects occupational role and adjustment to seafaring and is thus needed to be managed properly. Considering the importance of depression and seasickness in seafarers; however, the relationship between depression and seasickness has not yet been elucidated. As a depression screening tool is feasible and has been widely applied to assess depression and its relationship with other medical conditions, in this study, we aimed to evaluate the association between depression scale and seasickness in Navy recruits.

METHODS

Study population

The retrospective cohort study included recruits who were firstly designated to a naval ship and never sailed before from July 2017 to March 2019. Among the newcomers, the participants who served less than 5 distant seafaring days were excluded. The ship was 1st class naval ship that sails distant seas. As this study included only those subject to mandatory service, and all participants were male.

Data collection and outcome assessment

On the day of ship boarding, all recruits underwent routine physical examinations for newcomers including diastolic and systolic blood pressure measurement and individual interviews performed by a physician served in the ship's infirmary. The Beck Depression Inventory (BDI) was mandatorily conducted for screening participants with depression before starting the military service. Recruits with BDI score of 10 or more were consulted and referred to a proper psychological management. Information on age and the workplace was obtained. The workplace in the ship was classified into where external visual input is perceptible including deck and bridge of the ship and imperceptible including occupations inside the ship.

The occurrence of seasickness requiring treatment was retrospectively collected. In this study, we collected the medication prescription records for the first 30 distant seafaring days. All members who needed medical consultation or prescription were referred to the physician.
on board. For patients with seasickness requiring treatment, antihistamine agent (a single
dose of dimenhydrinate 50 mg) was prescribed and intermittent resting was guaranteed in
the infirmary or individual's bedroom. When the patient's symptoms and signs correlated
with seasickness, the medication was prescribed if contraindications of antihistamine drug
were absent. All patients considered on prescription had no contraindication.

According to the previous literature that adjustment period about several days might
be needed for seasickness in seafarers, we separately collected the outcome in the first 5
distant seafaring days (early period) and thereafter (6–30th seafaring days, late period).
We established two different outcomes to distinguish the initial susceptibility (in the early
period) and the adaptation ability to seasickness (in the late period). During the early
period, the susceptibility to seasickness was evaluated as whether the participant had at
least one prescription. For the late period, we calculated the adaptation ability as the ratio of
medication prescription days/seafaring days. We defined poorly adapted individuals as the
above-mentioned ratio of more than 10% and well-adapted individuals ≤ 10%. This ratio may
be a factor that could significantly hinder occupational performance.

Statistical analysis
The temporal trend of seasickness was plotted with time (day) as a X-axis and the proportion
of patients with treatment required seasickness as a Y-axis. The analyzable population was
divided into 3 groups according to BDI scores: BDI score of 0 as no depression, BDI score
of 1–9 as minimal depression, and BDI score of 10–29 as mild-to-moderate depression. Recruit
with severe depression (BDI score ≥ 30) was absent amongst included participants.
Comparisons of baseline routine examination and outcomes were made using the χ² test
for categorical and analysis of variance for continuous variables. Binary logistic regression
models were used for two outcomes. Unadjusted and adjusted odds ratios (ORs) and 95%
confidence intervals (CIs) for the initial susceptibility of the minimal and mild-to-moderate
depression groups with no depression group as a reference (Model 1) and BDI score as
a continuous variable (Model 2) were estimated. Furthermore, ORs and 95% CIs were
estimated for the adaptation ability. Covariates were predetermined: age and the workplace
with external visual perception or not. Data were analyzed using R 4.1.3 and a P value < 0.05
was defined statistically significant.

Ethics statement
The study was approved by the Institutional Review Board of Republic of Korea Armed Force
Medical Command (AFMC-19063-IRB-19-042). Informed consent was waived.

RESULTS
Baseline characteristics and outcomes
Out of a total 185 newcomers, BDI was assessed in all participants. A total of 179 participants
(97%) who served for more than 5 distant seafaring days were analyzed. Median follow-up
days of seafaring were 30 days (interquartile range [IQR] 29–30). Among the analyzable
population, a total of 318 days of seasickness requiring treatment were observed during the
5,044 seafaring days. The ratio of the seasickness days to seafaring days in the early and late
period were on average 13.3% and 6.1%, respectively. The occurrence of treatment requiring
seasickness according to seafaring days was described in Figure 1. Seventy-one participants
(39%) were never treated with seasickness. A total of 64 patients (36%) was susceptible to
seasickness in the early period. Thirty-one patients (17%) were poorly adapted to seasickness in the late period.

**Depression scale and outcomes**

Amongst the population, participants with mild-to-moderate depression were 17 (9.4%) and minimal depression were 112 (61.7%) while no depression were 51 (28.3%). Median of BDI score in the analyzable population was 2 (IQR 0–6). Baseline characteristics according to the BDI score groups were demonstrated in Table 1. Among three groups, the proportions of poor adaptation in the late period were different (41% vs. 15% vs. 14%) that patients with mild-to-moderate depression had the highest rates of poor adaptation. There was no significant difference in the susceptibility in the early period among the groups. Ratio

![Fig. 1. The occurrence of seasickness requiring treatment among the participants according to days of seafaring.](https://jkms.org)

Table 1. Baseline characteristics according to the depression scale

| Characteristics            | Mild-to-moderate depression (BDI 10–29; n = 17) | Minimal depression (BDI 1–9; n = 111) | No depression (BDI 0; n = 51) | P value |
|----------------------------|-----------------------------------------------|--------------------------------------|--------------------------------|---------|
| Age, yr                    | 21 (21–22)                                    | 21 (21–21)                           | 21 (20–22)                     | 0.959   |
| Male                       | 17 (100)                                      | 111 (100)                            | 51 (100)                       | 1.000   |
| Systolic BP, mmHg          | 122.8 ± 10.1                                  | 122.3 ± 11.0                         | 118.4 ± 19.6                   | 0.220   |
| Diastolic BP, mmHg         | 72.8 ± 9.1                                    | 73.4 ± 9.5                           | 71.1 ± 8.5                     | 0.363   |
| Heart rate                 | 74.3 ± 12.6                                   | 75.1 ± 10.6                          | 71.5 ± 9.4                     | 0.146   |
| Workplace                  |                                               |                                      |                                | 0.832   |
| External visual perception (−)| 10 (58.8)                            | 73 (65.8)                            | 34 (66.7)                      |         |
| External visual perception (+)| 7 (41.2)                             | 38 (34.2)                            | 17 (33.3)                      |         |
| Smoking                    |                                               |                                      |                                | 0.311   |
| Never smoker               | 6 (35.3)                                      | 48 (43.2)                            | 20 (39.2)                      |         |
| Ex-smoker                  | 1 (5.9)                                       | 22 (19.8)                            | 13 (25.5)                      |         |
| Current smoker             | 10 (58.8)                                     | 41 (36.9)                            | 18 (35.3)                      |         |
| Susceptible to seasickness | 8 (47.1)                                      | 38 (34.2)                            | 18 (35.3)                      | 0.588   |
| Poorly adapt to seasickness| 7 (41.2)                                      | 17 (15.3)                            | 7 (13.7)                       | 0.023   |
| Ratio of seasickness/seafaring days | 14.2 ± 24.2                           | 5.3 ± 9.1                            | 6.2 ± 9.2                      | 0.012   |

Values are presented as median (interquartile range), number (%), or mean ± standard deviation. BDI = Beck Depression Inventory, BP = blood pressure.

*aThe presence of at least one seasickness requiring treatment during the first 5 distant seafaring.

*bThe ratio of seasickness days requiring treatment/seafaring days > 10% during the 6–30 distant seafaring.

*cThe ratio of seasickness days requiring treatment/seafaring days during the overall period.
of suffered/seafaring days during the overall period were different that mild-to-moderate depression showed around 14% of days suffered from seasickness.

Comparing participants regarding susceptibility to seasickness in the early period, BDI score as a continuous variable and BDI sub-groups were not significantly different (Table 2).

However, poorly adapted participants in the late period had a trend of higher BDI score although not statistically significant (median 4, IQR [2–7]) compared to those who are well-adapted (2 [0–5]) (Table 3). Proportions of mild-to-moderate depression (22.6%) were higher in the poorly adapted group compared to the well adapted group (6.8%, P = 0.023).

Table 2. Comparing characteristics and BDI depression scores regarding sea-sickness susceptibility in the early period

| Characteristics          | Susceptible to seasickness* (n = 64) | Not susceptible to seasicknessa (n = 115) | P value |
|--------------------------|-------------------------------------|-----------------------------------------|---------|
| Age, yr                  | 21 (21–22)                          | 21 (21–22)                              | 0.608   |
| Male                     | 64 (100)                            | 115 (100)                               | 1.000   |
| Systolic BP, mmHg        | 118.8 ± 18.0                        | 122.6 ± 10.8                            | 0.120   |
| Diastolic BP, mmHg       | 71.8 ± 10.0                         | 73.2 ± 8.8                              | 0.332   |
| Heart rate               | 73.6 ± 9.6                          | 74.2 ± 11.1                             | 0.705   |
| Workplace                |                                     |                                         | 0.209   |
| External visual perception (-) | 38 (59.4)                        | 79 (68.7)                               |         |
| External visual perception (+) | 26 (40.6)                         | 36 (31.3)                               |         |
| Smoking                  |                                     |                                         | 0.213   |
| Never smoker             | 21 (32.8)                           | 53 (46.1)                               |         |
| Ex-smoker                | 14 (21.9)                           | 22 (19.1)                               |         |
| Current smoker           | 29 (45.3)                           | 40 (34.8)                               |         |
| BDI score                | 3 (0–6)                             | 2 (0–5)                                 | 0.308   |
| BDI score group          |                                     |                                         | 0.588   |
| No depression            | 18 (28.1)                           | 33 (28.7)                               |         |
| Minimal depression       | 38 (59.4)                           | 73 (63.5)                               |         |
| Mild-to-moderate depression | 8 (12.5)                      | 9 (7.8)                                 |         |

Values are presented as median (interquartile range), number (%), or mean ± standard deviation. BDI = Beck Depression Inventory, BP = blood pressure.
*The presence of at least one seasickness requiring treatment during the first 5 distant seafaring.
^The absence of at least one seasickness requiring treatment during the first 5 distant seafaring.

Table 3. Comparing characteristics and BDI depression scores regarding adaptation ability to sea sickness in the late period

| Characteristics          | Poorly adapted to seasicknessa (n = 31) | Well adapted to seasicknessa (n = 148) | P value |
|--------------------------|----------------------------------------|---------------------------------------|---------|
| Age, yr                  | 21 (21–22)                             | 21 (21–22)                            | 0.108   |
| Male                     | 31 (100)                               | 148 (100)                             | 1.000   |
| Systolic BP, mmHg        | 120.8 ± 10.3                           | 121.4 ± 14.6                          | 0.805   |
| Diastolic BP, mmHg       | 72.7 ± 10.5                            | 72.7 ± 9.0                            | 0.976   |
| Heart rate               | 74.3 ± 12.6                            | 73.9 ± 10.1                           | 0.879   |
| Workplace                |                                        |                                       | 0.760   |
| External visual perception (-) | 21 (67.7)                        | 96 (64.9)                              |         |
| External visual perception (+) | 10 (32.3)                         | 52 (35.1)                              |         |
| Smoking                  |                                        |                                       | 0.633   |
| Never smoker             | 11 (35.5)                              | 63 (42.6)                              |         |
| Ex-smoker                | 8 (25.8)                               | 28 (18.9)                              |         |
| Current smoker           | 12 (38.7)                              | 57 (38.5)                              |         |
| BDI score                | 4 (2–7)                                | 2 (0–5)                               | 0.055   |
| BDI score group          |                                        |                                       | 0.023   |
| No depression            | 7 (22.6)                               | 44 (29.7)                             |         |
| Minimal depression       | 17 (54.8)                              | 94 (63.5)                             |         |
| Mild-to-moderate depression | 7 (22.6)                      | 10 (6.8)                               |         |

Values are presented as median (interquartile range), number (%), or mean ± standard deviation. BDI = Beck Depression Inventory, BP = blood pressure.
*The ratio of seasickness days requiring treatment/seafaring days > 10% during the 6–30 distant seafaring.
^The ratio of seasickness days requiring treatment/seafaring days ≤ 10% during the 6–30 distant seafaring.
In binary logistic regression models, BDI groups and BDI score did not significantly elevate the odds for susceptibility to seasickness in the early period (Table 4). On the other hand, mild-to-moderate depression independently increased the odds for poor adaptation to seasickness in the late period by OR, 4.63 (95% CI, 1.31 – 16.98). Furthermore, every 1 increment in BDI score increased odds for poor adaptation to seasickness by 1.10.

**DISCUSSION**

In the current study, mild-to-moderate depression was associated with poor adaptation ability to seasickness in the naval crew. On the other hand, depression scale was not significantly associated with the initial susceptibility to seasickness. The ratio of days suffered from seasickness requiring treatment was greater in the mild-to-moderate depression group compared to none or minimal.

As this study was conducted for Navy recruits who were naïve to seafaring, we could evaluate the early period for initial susceptibility to seasickness and the late period for adaptation to seasickness. The recent research including college students' first experience sailing suggested gender, age, and birthplace were associated with motion sickness susceptibility but psychological factors were not evaluated in the study. The current study suggested depression could be associated with naïve seafarers' adaptation ability to seasickness. The relationship between psychological status and motion sickness on the laboratory-based research has been explored. Psychological status and motion sickness evaluated by Hospital Anxiety and Depression Scale was associated with inability in updating orientation after a rotation test. Here, we stated the association between depression and seasickness in the real-world setting.

Among various possible explanations for motion sickness, the sensory conflict has been widely accepted in the literatures. According to this theory, if discrepancy in sensory

**Multivariable analysis**

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**Table 4.** Unadjusted and adjusted odds of the depression scale for the susceptibility in the early period and adaptation ability in the late period

| Characteristics         | Susceptible to seasickness<sup>c</sup> | Poorly adapted to seasickness<sup>d</sup> |
|-------------------------|----------------------------------------|-----------------------------------------|
|                         | Unadjusted | Model 1<sup>a</sup> | P value | Model 2<sup>b</sup> | P value | Model 2<sup>c</sup> | P value |
| **Age**                 |            | 1.04 (0.75–1.44) | 0.812   | 1.05 (0.75–1.45) | 0.793   | 1.05 (0.75–1.46) | 0.778   |
| **Workplace**           |            | 1.50 (0.79–2.84) | 0.210   | 1.49 (0.78–2.82) | 0.224   | 1.49 (0.78–2.82) | 0.221   |
| **BDI group**           |            |                    |         |                    |         |                    |         |
| No depression           |            | 0.95 (0.48–1.94) | 0.895   | 0.95 (0.48–1.94) | 0.890   |                    |         |
| Minimal depression      |            | 1.63 (0.53–5.00) | 0.389   | 1.59 (0.51–4.91) | 0.417   |                    |         |
| Mild-to-moderate depression |      | 1.03 (0.97–1.09) | 0.373   |                    |         | 1.02 (0.97–1.09) | 0.393   |
| **BDI score**           |            | 1.04 (0.75–1.44) | 0.812   | 1.05 (0.75–1.45) | 0.793   | 1.05 (0.75–1.46) | 0.778   |

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**BDI = Beck Depression Inventory, OR = odds ratio, CI = confidence interval.**

<sup>a</sup>BDI was assessed as a categorical variable (no depression, BDI 0; minimal depression, BDI 1–9; mild-to-moderate depression, BDI 10–29).

<sup>b</sup>BDI was assessed as a continuous variable.

<sup>c</sup>Model was evaluated for the early period outcome (the presence of at least one seasickness requiring treatment during the first 5 seafaring days).

<sup>d</sup>Model was evaluated for the late period outcome (the ratio of days of seasickness requiring treatment/days of seafaring > 10% during the 6–30 distant seafaring).
signals from proprioception, visual, and vestibular system occur, the motion sickness is provoked.\textsuperscript{22} Seasickness and car-sickness could also be triggered by suppression of vestibule-ocular reflexes. In the current study, we included the workplace as a covariate that outside workers could have more chances to alleviate sensory conflict by looking sea which was associated in the previous literature.\textsuperscript{13} However, the workplace in the ship was not associated with seasickness requiring treatment. Not constricted to the spatial meaning, the workplace implies the different roles, stress, social, and environmental factors that could not be simply defined as a factor reflecting visual perception.

In regards to adaptation, if the conflict of sensory signals is estimated, neural mismatch does not always result in the development of motion sickness.\textsuperscript{23} It is presumed that discrepancy in sensory information is stored in the hippocampus and the vestibular cortex.\textsuperscript{24} Therefore, the motion sickness after exposure to conflict stimuli might be determined with the function of individual’s sensory center as well as a degree and types of sensory conflict. It is suggested that neural plasticity and neuronal adaptation are commonly disrupted in depression via N-methyl-D-aspartate receptor in the amygdala of hippocampus.\textsuperscript{25} Impairment in vestibular system was also associated with increased risk of depression and memory function.\textsuperscript{26} Therefore, this could also apply to the main finding of this study. Hindered adaptation to seasickness in depression patients could be partly explained by possible deterioration of hippocampal and vestibular system in depression.

Neural circuits including cholinergic, histaminergic, dopaminergic, and serotonergic system might be involved in the development of motion sickness.\textsuperscript{13,23} In depressive patients, decreased serotonergic function has been suggested as a pathophysiologic mechanism and symptoms were associated with the decreased level of serotonin.\textsuperscript{27} Decreased activity in the dopaminergic pathway in the limbic system and the level of norepinephrine were also related to depression.\textsuperscript{28,29} These neurotransmitters, thus, become major targets for pharmacological treatment in depression. Therefore, decreased activity in these neural circuits in the depressive patients could be associated with the occurrence of motion sickness. Furthermore, patients with migraine were susceptible to motion sickness that the authors suggested tryptophan depletion in these patients could result in decreased synthesis of serotonin and vestibular dysfunction.\textsuperscript{30} Further studies utilizing neuroimaging tools visualizing neural circuits such as functional magnetic resonance imaging could approach pathophysiologic evidence for relationship between depression and seasickness.

There are several recommendations for helping adaptation to seasickness in seafaring. Pharmacological option includes antihistamine agent which reduces the sensory conflict and enhances adaptation to seasickness.\textsuperscript{13,31} Active body motion,\textsuperscript{13,32} exposure to more gradual onset stimulus\textsuperscript{33} and accumulated experience of seafaring\textsuperscript{13,34} could aid in adaptation. As a depression screening tool is feasible even in a large group of population,\textsuperscript{3,35-37} the tool could be used for military seafarers in screening those with depression as well as those at risk of poor adaptation to seasickness in advance. Careful support from superiors and colleagues might help seafarers to well adapt to seasickness and military service.\textsuperscript{38}

This study has strengths in that the environments of the participants enrolled were relatively well controlled in this cohort. The participants were exposed to homogenous environmental stimuli such as similar locomotive force from the ship, food intake, and life cycles. As motion sickness could be largely affected by such environmental factors, the study design and population selection are often difficult. We could overcome this limitation by constructing
a well-controlled homogenous cohort in a particular ship. Furthermore, the dropout rate (3.2%) was low that the result of this study could be less affected by potential selection bias.

This study has a few limitations. First, the result of the current study should be cautiously interpreted as it only included participants with first seafaring. The previous study compared motion sickness in seafarers and non-seafarers that reported veteran seafarers had lower susceptibility to seasickness compared to non-seafarers.\textsuperscript{39} Differential effects of depression on the seasickness for naïve and veteran seafarers are to be further investigated. Second, this study assessed seasickness requiring treatment and much milder seasickness was excluded. Only significant outcomes resulting in diminished standards of work performance due to seasickness in this population were evaluated. Furthermore, prescription-based assessment could be more objective than motion sickness questionnaires. Third, this study was conducted in a large-sized ship sailing distant seas and those of small-sized ships were not included. Fourth, the sample size was limited and further investigation with larger dataset would support the finding of this study.

In the current study, depression was associated with poor adaptation to seasickness in Navy recruits of first seafaring. Depression screening tool might be used to find seafarers with difficulties in adapting to seasickness in advance. Preventing strategies for these population at risk including pre-medication before seafaring could be considered.

**REFERENCES**

1. Ministry of National Defense (KR). 2012 Defense White Paper. Seoul, Korea: Defense Policy Division, Policy Planning Bureau; 2012.
2. Byeon G, Jo SJ, Lee HW, Yim HW, Park JI. Development of a short form depression screening questionnaire for Korean soldiers. *J Korean Med Sci* 2021;36(27):e185. [PUBMED] [CROSSREF]
3. Shin YC, Kim SM, Kim H, Min KJ, Yoo SK, Kim EI, et al. Resilience as a protective factor for depressive mood and anxiety among Korean employees. *J Korean Med Sci* 2019;34(27):e188. [PUBMED] [CROSSREF]
4. Oldenburg M, Baur X, Schlaich C. Occupational risks and challenges of seafaring. *J Occup Health* 2010;52(5):249-56. [PUBMED] [CROSSREF]
5. Jezewska M, Leszczyńska I, Jaremin B. Work-related stress at sea self estimation by maritime students and officers. *Int Marit Health* 2006;57(1-4):66-75. [PUBMED]
6. Lefkowitz RY, Slade MD. Seafarer mental health study: final report, October 2019. https://seafarerstrust.org/sites/default/files/node/publications/files/ST_MentalHealthReport_Final_Digital-1.pdf. Updated 2019. Accessed May 15, 2022.
7. Iversen RT. The mental health of seafarers. *Int Marit Health* 2012;63(2):78-89. [PUBMED]
8. Lucas D, Mehaneez M, Lodde B, Jegaden D. Seasickness and its impact on researchers’ work on board French oceanographic vessels. *Int Marit Health* 2020;71(3):160-5. [PUBMED] [CROSSREF]
9. Carotenuto A, Molino I, Fasanaro AM, Amenta F. Psychological stress in seafarers: a review. *Int Marit Health* 2012;63(4):188-94. [PUBMED]
10. Allen P, Wadsworth E, Smith A. Seafarers’ fatigue: a review of the recent literature. *Int Marit Health* 2008;59(1-4):81-92. [PUBMED]
11. Williams RA, Hagerty BM, Yousha SM, Hoyle KS, Oe H. Factors associated with depression in navy recruits. *J Clin Psychol* 2002;58(4):323-37. [PUBMED] [CROSSREF]
12. Benson AJ, Barnes GR. Vision during angular oscillation: the dynamic interaction of visual and vestibular mechanisms. *Aviat Space Environ Med* 1978;49(1 Pt. 2):340-5. [PUBMED]

13. Schmäl F. Neuronal mechanisms and the treatment of motion sickness. *Pharmacology* 2013;91(3-4):229-41. [PUBMED | CROSSREF]

14. Hong S, Kim S, Park DH, Ryu SH, Ha JH, Jeon HJ. The mediating effect of insomnia on the relationship between panic symptoms and depression in patients with panic disorder. *J Korean Med Sci* 2021;36(9):e30. [PUBMED | CROSSREF]

15. Altunayoglu Cakmak V, Gazioglu S, Can Usta N, Ozkorumak E, Ayar A, Topbas M, et al. Evaluation of temperament and character features as risk factors for depressive symptoms in patients with restless legs syndrome. *J Clin Neurol* 2014;10(4):320-7. [PUBMED | CROSSREF]

16. Hwang KJ, Kim EH, Kim YI, Hong SB. Frequency of depression and suicidality in patients with neurological disorders: epilepsy, Parkinson's disease, and ischemic stroke. *J Korean Neurol Assoc* 2016;34(3):193-200. [CROSSREF]

17. Beck AT, Ward CH, Mendelson M, Mock J, Erbaugh J. An inventory for measuring depression. *Arch Gen Psychiatry* 1961;4(6):561-71. [PUBMED | CROSSREF]

18. Beck AT, Steer RA, Garbin MG. Psychometric properties of the Beck Depression Inventory: twenty-five years of evaluation. *Clin Psychol Rev* 1988;8(1):77-100. [CROSSREF]

19. Zhang X, Sun Y. Motion sickness predictors in college students and their first experience sailing at sea. *Aerosp Med Hum Perform* 2020;91(2):71-8. [PUBMED | CROSSREF]

20. Alcantara-Thome M, Miguel-Puga JA, Jauregui-Renaud K. Anxiety and motion sickness susceptibility may influence the ability to update orientation in the horizontal plane of healthy subjects. *Front Integr Neurosci* 2021;15:742100. [PUBMED | CROSSREF]

21. Reason IT. Relations between motion sickness susceptibility, the spiral after-effect and loudness estimation. *Br J Psychol* 1968;59(4):385-93. [PUBMED | CROSSREF]

22. Lackner JR. Motion sickness: more than nausea and vomiting. *Exp Brain Res* 2014;232(8):2493-510. [PUBMED | CROSSREF]

23. Leung AK, Hon KL. Motion sickness: an overview. *Drugs Context* 2019;8:2019-9-4. [PUBMED | CROSSREF]

24. Zhang LL, Wang JQ, Qi RR, Pan LL, Li M, Cai YL. Motion sickness: current knowledge and recent advance. *CNS Neuosci Ther* 2016;22(1):15-24. [PUBMED | CROSSREF]

25. Liu W, Ge T, Leng Y, Pan Z, Fan J, Yang W, et al. The role of neural plasticity in depression: from hippocampus to prefrontal cortex. *Neural Plast* 2017;2017:6871089. [PUBMED | CROSSREF]

26. Bigelow RT, Semenov YR, du Lac S, Hoffman HI, Agrawal Y. Vestibular vertigo and comorbid cognitive and psychiatric impairment: the 2008 National Health Interview Survey. *J Neurol Neurosurg Psychiatry* 2016;87(4):367-72. [PUBMED | CROSSREF]

27. Meltzer H. Serotonergic dysfunction in depression. *Br J Psychiatry Suppl* 1989;155(8):25-31. [PUBMED | CROSSREF]

28. Kapur S, Mann JJ. Role of the dopaminergic system in depression. *Biol Psychiatry* 1992;32(1):1-17. [PUBMED | CROSSREF]

29. Nutt DJ. Relationship of neurotransmitters to the symptoms of major depressive disorder. *J Clin Psychiatry* 2008;69 Suppl E1:4-7. [PUBMED]

30. Drummond PD. Effect of tryptophan depletion on symptoms of motion sickness in migraineurs. *Neurology* 2005;65(4):620-2. [PUBMED | CROSSREF]

31. Spinks AB, Wasiak J, Villanueva EV, Bernath V. Scopolamine for preventing and treating motion sickness. *Cochrane Database Syst Rev* 2004;(3):CD002851. [PUBMED | CROSSREF]
32. Held R. Exposure-history as a factor in maintaining stability of perception and coordination. *J Nerv Ment Dis* 1961;132(1):26-32. [PUBMED] [CROSSREF]

33. Ruckenstein MJ, Harrison RV. Motion sickness. Helping patients tolerate the ups and downs. *Postgrad Med* 1991;89(6):139-44. [PUBMED] [CROSSREF]

34. Helling K, Westhofen M. Experimental studies of motion sickness on board of a research ship. *HNO* 1994;42(4):214-9. [PUBMED]

35. Cha JM, Kim JE, Kim MA, Shim B, Cha MJ, Lee JJ, et al. Five months follow-up study of school-based crisis intervention for Korean high school students who experienced a peer suicide. *J Korean Med Sci* 2018;33(28):e192. [PUBMED] [CROSSREF]

36. LimAY, Lee SH, Jeon Y, Yoo R, Jung HY. Job-seeking stress, mental health problems, and the role of perceived social support in university graduates in Korea. *J Korean Med Sci* 2018;33(19):e149. [PUBMED] [CROSSREF]

37. Sohn BK, Park SM, Park II, Hwang JY, Choi JS, Lee JY, et al. The relationship between emotional labor and job stress among hospital workers. *J Korean Med Sci* 2018;33(39):e246. [PUBMED] [CROSSREF]

38. Woo SY, Kim HJ, Kim BR, Ahn HC, Jang BN, Park EC. Support from superiors reduces depression in Republic of Korea military officers. *BMJ Mil Health* 2021;167(6):378-82. [PUBMED] [CROSSREF]

39. Chan G, Moochhala SM, Zhao B, WI Y, Wong J. A comparison of motion sickness prevalence between seafarers and non-seafarers onboard naval platforms. *Int Marit Health* 2006;57(1-4):56-65. [PUBMED]