



OPEN Chronic neck pain as an exacerbating factor for depressive symptoms in a 1-Year longitudinal population study

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Chronic neck pain is linked to depression, but its long-term effects on depressive symptoms remain unclear. This study examined the impact of chronic neck pain on depressive symptoms over 1 year in individuals with mild depression or moderate-to-severe depression using data from the Circannual Change in Headache and Sleep (CHASE) study, a nationally representative Korean cohort. Among 1,551 participants, depressive symptoms were assessed using the Patient Health Questionnaire-9 (PHQ-9) across five assessments over 1 year. Chronic neck pain was defined as persistent neck pain at all assessments. Covariates, including anxiety, sleep quality, and lifestyle factors, were adjusted for in the analyses to account for potential confounders. Chronic neck pain was reported by 19% of participants with mild depression ($n=721$) and 36.1% of those with moderate-to-severe depression ($n=108$). At baseline, these participants had poorer sleep quality, greater insomnia severity, and a higher symptom burden. Over 1 year, chronic neck pain was associated with greater increases in PHQ-9 scores, particularly in sleep disturbances, fatigue, and concentration difficulties, despite overall symptom improvement. In conclusion, chronic neck pain exacerbates depressive symptoms over time, especially in sleep-related and physical domains, highlighting the need for integrated treatment approaches addressing both conditions.

Keywords Chronic neck pain, Mild depression, Depression, Longitudinal study, Patient health questionnaire-9

Depression is a major global health concern, with significant implications for the physical, mental, and social well-being of individuals^{1,2}. Epidemiological studies have found depression prevalence rates ranging from 2.2 to 10.4%, with the World Health Organization (WHO) reporting a global prevalence of 5% among adults^{1,3}. Chronic illness has been demonstrated to be a significant factor associated with an increased prevalence of depression^{4,5}. For instance, an analysis demonstrated that the prevalence of depressive symptoms in middle-aged and older adults is 26.0%, with rates increasing in correlation with the number of chronic conditions. Additionally, higher rates of depression have been documented among individuals with chronic pain conditions⁶.

A comprehensive analysis utilizing data from the UK Biobank, including 24,405 patients with chronic pain, revealed a prevalence of 45.7% for a lifetime history of depression among patients with chronic widespread pain, highlighting the close link between depression and chronic pain conditions⁷. Neck pain is a highly prevalent condition, affecting approximately two-thirds of the adult population at some point in their lives⁸. Research has established a significant association between neck pain and depression. A cross-sectional study revealed a significant correlation between depression and neck pain in individuals with neck pain^{9,10}. Notably, an increase in neck pain was also observed in individuals with depression¹¹. Chronic pain conditions, including chronic neck pain, exert a substantial impact on comorbidities compared with non-chronic pain conditions¹². Neck pain usually resolves within days; however, in approximately 10% of cases, the pain recurs or persists¹³. A hospital-based cross-sectional study reported an increased frequency of depression among individuals with chronic neck pain^{14,15}. A longitudinal study examined the relationship between chronic neck pain and depression and found that improvements in depression among patients with chronic neck pain were significantly associated with reductions in pain during rehabilitation¹⁶.

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Mild depression is a highly prevalent condition in the general population and is often considered as the initial stage of the depressive spectrum. Prompt identification and treatment can prevent progression of the condition to a more severe state, which is more challenging to manage¹. Early intervention, particularly non-pharmacological approaches, can mitigate the need for medications, thereby reducing the risk of adverse effects and long-term dependence¹. Despite its “mild” classification, this condition can significantly disrupt daily functioning, productivity, and overall quality of life¹⁷.

Despite previous research, limited information is available on changes in depressive symptoms relative to chronic neck pain in individuals with mild depression. To address this gap in the literature, the present study aimed to investigate the influence of chronic neck pain on changes in depressive symptoms over a 1-year period. Using data from the nationally representative Circannual Change in Headache and Sleep (CHASE) study in Korea, we evaluated participants with mild depression and moderate-to-severe depression, incorporating a range of covariates, including lifestyle factors, sleep quality, and other health conditions.

Results

Survey

A total of 91,153 individuals were invited to participate in the CHASE study via email, of whom 10,699 consented to participate. However, 6,215 participants discontinued their participation during the course of the study; 1,075 withdrew their consent; and 379 were excluded from the study because the sample quota had been exceeded. Ultimately, 3,030 participants completed the baseline assessment, yielding a completion rate of 28.3%. Following the baseline assessment, four follow-up surveys were conducted at 3-month intervals, with a fifth, final survey administered 1 year after the initial assessment. A total of 1,551 participants completed the final survey (Fig. 1).

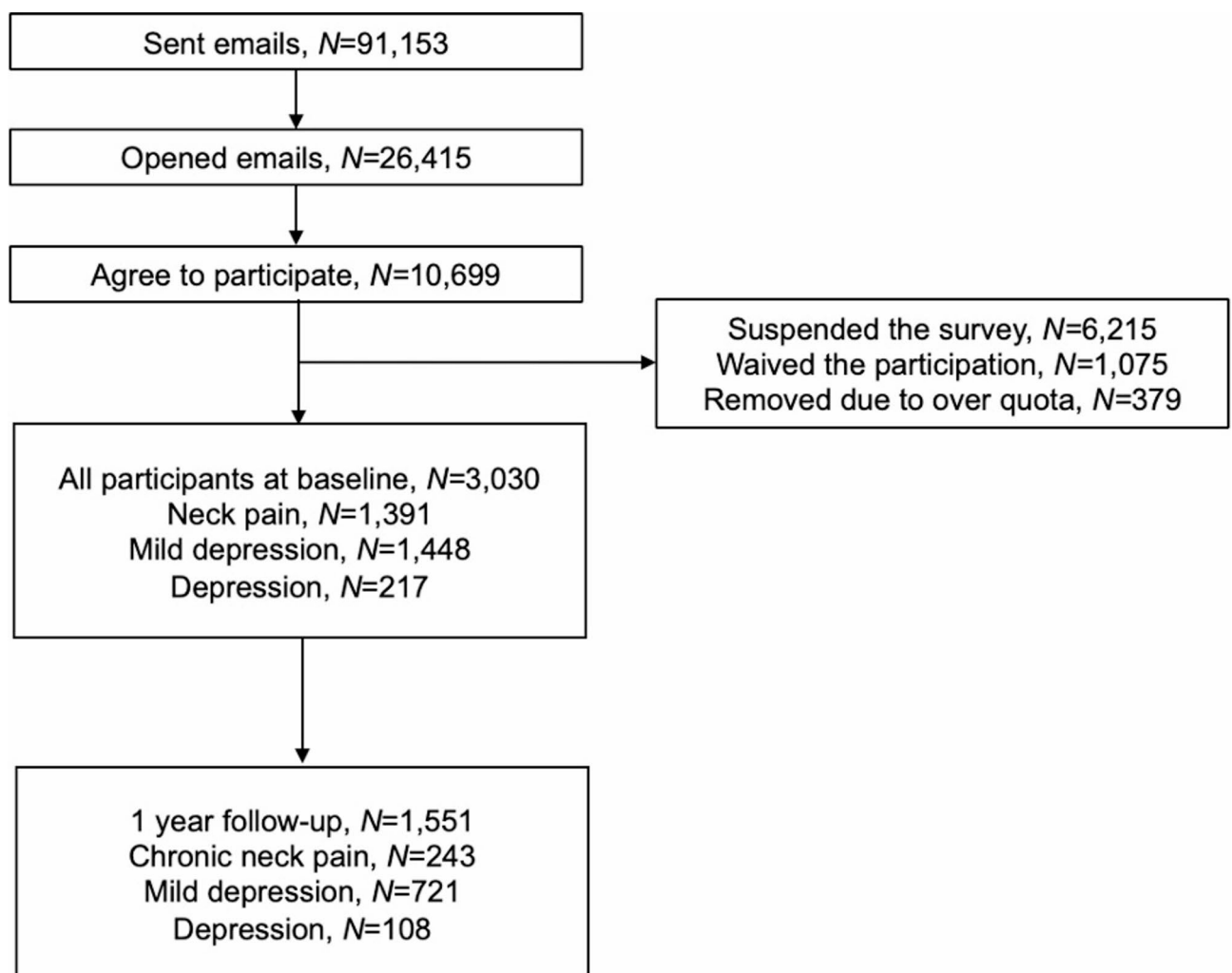


Fig. 1. Flowchart illustrating the progression of participants through the study.

Participant characteristics

The baseline characteristics of the total population, survey participants at baseline, and those who completed the 1-year follow-up, including factors such as age, sex, residential area size, and educational level, were comparable to those of the total Korean population, with consistent distributions observed across groups (Table 1).

Prevalence of neck pain and chronic neck pain in participants with mild depression and moderate-to-severe depression

Among the 1,551 participants who completed all 5 assessments, 243 (15.7%) reported experiencing neck pain across all 5 surveys, indicating the presence of chronic neck pain. The prevalence of chronic neck pain was 19% (137/721) among participants with mild depression and 36% (39/108) among those with moderate-to-severe depression (Supplementary Figure S1 and Supplementary Table S1).

Baseline and 1-year follow-up characteristics of participants with mild depression, stratified by the presence of chronic neck pain

Table 2 summarizes the baseline and 1-year follow-up characteristics of participants with mild depression and moderate-to-severe depression, categorized by the presence of chronic neck pain. Cronbach's alpha values of PHQ-9 for participants with mild and moderate-to-severe depression in the first survey were 0.783 and 0.760, respectively (Supplementary table S2). In the 1-year follow-up, the corresponding values were 0.743 and 0.869, respectively (Supplementary table S3). Among the 721 participants with mild depression, 137 (19%) had chronic neck pain. At baseline, participants with mild depression and chronic neck pain exhibited poorer sleep quality (Pittsburgh Sleep Quality Index [PSQI], $p < 0.001$), higher levels of widespread pain (Widespread Pain Index [WPI], $p < 0.001$), and greater symptom severity (Symptom Severity Scale [SSS], $p < 0.001$) than those without chronic neck pain. At the 1-year follow-up, participants with chronic neck pain continued to show significantly higher anxiety scores (Generalized Anxiety Disorder-7 [GAD-7], $p = 0.007$), poorer sleep quality (PSQI, $p < 0.001$), greater insomnia severity (Insomnia Severity Index [ISI], $p < 0.001$), more widespread pain (WPI, $p < 0.001$), and greater symptom severity (SSS, $p < 0.001$) than participants without chronic neck pain (Table 2).

Baseline and 1-year follow-up characteristics of participants with moderate-to-severe depression, stratified by the presence of chronic neck pain

Among the 108 participants with moderate-to-severe depression, 39 (36.1%) had chronic neck pain. At the baseline measurement, participants with moderate-to-severe depression and chronic neck pain demonstrated poorer sleep quality (PSQI, $p = 0.002$), greater insomnia severity (ISI, $p = 0.004$), more widespread pain (WPI, $p < 0.001$), and greater symptom severity (SSS, $p < 0.001$) than those without chronic neck pain. At the 1-year follow-up, participants with chronic neck pain continued to exhibit significantly poorer sleep quality (PSQI, $p = 0.003$), greater insomnia severity (ISI, $p = 0.007$), more widespread pain (WPI, $p < 0.001$), and greater symptom severity (SSS, $p < 0.001$) than those without chronic neck pain (Table 2).

Differences in patient health questionnaire-9 scores by chronic neck pain status among participants with mild depression and moderate-to-severe depression at baseline and at the 1-year follow-up

In the mild depression group at baseline ($n = 721$), there was no significant difference in PHQ-9 scores between participants with chronic neck pain and those without ($p = 0.224$). However, at the 1-year follow-up, PHQ-

	Total population, N (%)	Survey participants at baseline, N (%)	Survey participants at 1-year follow-up, N (%)	Having neck pain at 1-year follow-up	1-year follow-up of mild depression at baseline	1-year follow-up of mild depression at baseline
Men	15,529,105 (51.2)	1551 (51.2)	826 (53.3)	95, 6.1% (4.9–7.3)	362, 23.3% (21.2–25.4)	40, 2.6% (1.8–3.4)
Women	14,778,651 (48.8)	1479 (48.8)	725 (46.7)	148, 9.5% (8.1–11.0)	359, 23.1% (21.0–25.2)	68, 4.4% (3.4–5.4)
Age						
20–29	6,719,119 (22.1)	673 (22.2)	271 (17.5)	38, 2.5% (1.7–3.2)	144, 9.3% (7.8–10.7)	25, 1.6% (1.0–2.2)
30–39	6,839,377 (22.6)	685 (22.6)	353 (22.8)	65, 4.2% (3.2–5.2)	178, 11.5% (9.9–13.1)	29, 1.9% (1.2–2.5)
40–49	8,208,901 (27.1)	819 (27.0)	443 (28.6)	87, 5.6% (4.5–6.8)	218, 14.1% (12.3–15.8)	29, 1.9% (1.2–2.5)
50–59	8,540,359 (28.2)	853 (28.2)	484 (31.2)	53, 3.4% (2.5–4.3)	181, 11.7% (10.1–13.3)	25, 1.6% (1.0–2.2)
Size of residential area						
Large city	13,667,248 (45.1)	1364 (45.0)	701 (45.2)	124, 8.0% (6.7–9.3)	341, 22.0% (19.9–24.0)	52, 3.4% (2.5–4.3)
Medium-to-small city	12,143,800 (40.1)	1376 (45.4)	696 (44.9)	93, 6.0% (4.8–7.2)	312, 20.1% (18.1–22.1)	43, 2.8% (2.0–3.6)
Rural area	4,496,708 (14.8)	290 (9.6)	154 (9.9)	26, 1.7% (1.0–2.3)	68, 4.4% (3.4–5.4)	13, 0.8% (0.4–1.3)
Education level						
High school or less	12,395,872 (40.9)	1212 (40.0)	621 (40.0)	91, 5.9% (4.7–7.0)	281, 18.1% (16.2–20.0)	51, 3.3% (2.4–4.2)
College or more	17,911,884 (59.1)	1818 (60.0)	930 (60.0)	152, 9.8% (8.3–11.3)	440, 28.4% (26.1–30.6)	57, 3.7% (2.7–4.6)
Total	30,307,756 (100.0)	3030 (100.0)	1551 (100.0)	243, 15.7% (13.9–17.5)	721, 46.5% (44.0–49.0)	108, 7.0 (5.7–8.2)

Table 1. Sociodemographic characteristics of the total population and survey participants at baseline and at the 1-year follow-up.

	Mild depression				Moderate-to-severe depression			
	+ Chronic neck pain (n = 137)	- Chronic neck pain (n = 584)	p-value		+ Chronic neck pain (n = 39)	- Chronic neck pain (n = 69)	p-value	
Age (Median [IQR])	40.0 [32.5–48.0]	41.0 [32.0–50.0]	0.711		40.0 [32.0–45.0]	39.0 [30.0–50.0]	0.497	
Sex (Women)	81 (59.1%)	278 (47.6%)	0.015*		31 (79.5%)	37 (53.6%)	0.008*	
Job	123 (89.8%)	540 (92.5%)	0.298		30 (76.9%)	57 (82.6%)	0.473	
Current smoking	27 (19.7%)	155 (26.5%)	0.098		10 (25.6%)	22 (31.9%)	0.495	
Alcohol	105 (76.5%)	483 (82.7%)	0.1		29 (74.4%)	60 (87.0%)	0.099	
	Mild depression at baseline, n = 721				1-year follow-up of mild depression at baseline, n = 721			
	+ Chronic neck pain (n = 137)	- Chronic neck pain (n = 584)	p-value		+ Chronic neck pain (n = 137)	- Chronic neck pain (n = 584)	p-value	
GAD-7 (Median [IQR])	6.0 [3.0–8.0]	6.0 [3.0–8.0]	0.536		6.0 [3.0–9.0]	5.0 [2.0–8.0]	0.007*	
PSQI (Median [IQR])	7.0 [5.0–8.0]	6.0 [5.0–7.0]	<0.001*		6.0 [5.0–7.0]	5.0 [4.0–7.0]	<0.001*	
ISI (Median [IQR])	9.0 [8.0–9.0]	9.0 [7.0–9.0]	0.136		9.0 [7.0–9.0]	8.0 [6.0–9.0]	<0.001*	
WPI (Median [IQR])	6.0 [4.0–8.0]	3.0 [1.0–5.0]	<0.001*		6.0 [4.0–9.0]	2.0 [1.0–4.0]	<0.001*	
SSS (Median [IQR])	7.0 [5.0–8.0]	5.0 [3.3–6.0]	<0.001*		7.0 [5.0–8.0]	5.0 [4.0–7.0]	<0.001*	
EQ-5d (Median [IQR])	0.913 [0.913–0.950]	0.913 [0.913–0.950]	0.008*		0.913 [0.913–0.913]	0.913 [0.913–0.950]	<0.001*	
	Depression at baseline, n = 108				1-year follow-up of moderate-to-severe depression at baseline, n = 108			
	+ Chronic neck pain (n = 39)	- Chronic neck pain (n = 69)	p-value		+ Chronic neck pain (n = 39)	- Chronic neck pain (n = 69)	p-value	
GAD-7 (Median [IQR])	13.0 [10.0–16.0]	13.0 [9.0–16.0]	0.642		10.0 [7.0–15.0]	8.0 [5.5–13.5]	0.151	
PSQI (Median [IQR])	9.0 [8.0–11.0]	8.0 [7.0–10.0]	0.002*		9.0 [8.0–11.0]	7.0 [6.0–9.0]	0.003*	
ISI (Median [IQR])	18.0 [9.0–21.0]	10.0 [9.0–17.0]	0.004*		17.0 [13.0–22.0]	13.0 [9.0–17.0]	0.007*	
WPI (Median [IQR])	7.0 [5.0–10.0]	4.0 [1.0–6.0]	<0.001*		7.0 [5.0–9.0]	2.0 [1.0–4.0]	<0.001*	
SSS (Median [IQR])	8.0 [7.0–9.0]	7.0 [4.5–8.0]	<0.001*		8.0 [7.0–10.0]	7.0 [5.0–8.5]	<0.001*	
EQ-5d (Median [IQR])	0.863 [0.817–0.913]	0.900 [0.817–0.913]	0.499		0.913 [0.863–0.913]	0.913 [0.900–0.913]	0.359	

Table 2. Demographic, lifestyle, psychiatric, and sleep characteristics of participants with mild depression and depression at baseline and at the 1-year follow-up, stratified by the presence of chronic neck pain. GAD-7 = Generalized Anxiety Disorder-7, PSQI = Pittsburgh Sleep Quality Index, ISI = Insomnia Severity Index, WPI = Widespread Pain Index, SSS = Symptom Severity Scale, EQ-5d = EuroQol-5Dimension, IQR = Interquartile Range.

PHQ-9 Items	Mild depression at baseline, <i>n</i> = 721			1-year follow-up of mild depression at baseline, <i>n</i> = 721			Difference between baseline and 1-year follow-up, <i>n</i> = 721		
	+ Chronic neck pain (<i>n</i> = 137)	– Chronic neck pain (<i>n</i> = 584)	<i>p</i> -value	+ Chronic neck pain (<i>n</i> = 137)	– Chronic neck pain (<i>n</i> = 584)	<i>p</i> -value	+ Chronic neck pain (<i>n</i> = 137)	– Chronic neck pain (<i>n</i> = 584)	<i>p</i> -value
(A)									
Total PHQ-9 score	8.0 (6.5–9.0)	8.0 (6.0–9.0)	0.224	5.0 (4.0–7.0)	5.0 (3.0–6.0)	0.018*	–3	–3	0.011*
PHQ-9 Items	Moderate-to-severe depression at baseline, <i>n</i> = 108			1-year follow-up of moderate-to-severe depression at baseline, <i>n</i> = 108			Difference between baseline and 1-year follow-up, <i>n</i> = 108		
	+ Chronic neck pain (<i>n</i> = 39)	– Chronic neck pain (<i>n</i> = 69)	<i>p</i> -value	+ Chronic neck pain (<i>n</i> = 39)	– Chronic neck pain (<i>n</i> = 69)	<i>p</i> -value	+ Chronic neck pain (<i>n</i> = 39)	– Chronic neck pain (<i>n</i> = 69)	<i>p</i> -value
(B)									
Total PHQ-9 score	18.0 (14.0–22.0)	18.0 (14.5–21.0)	0.928	7.0 (6.0–13.0)	7.0 (5.0–8.5)	0.030*	–11	–11	0.001*

Table 3. Responses to PHQ-9 questionnaire among participants with mild depression (A) and moderate-to-severe depression (B) at baseline and at the 1-year follow-up and differences between the 1-year follow-up and baseline, stratified by the presence of chronic neck pain (Quade’s test). * P-values reflect within-person changes from baseline to 1-year follow-up, not between-subject comparisons.

9 scores were significantly higher among participants with chronic neck pain (*n* = 137) compared to those without (*n* = 584) (*p* = 0.018). Furthermore, the change in PHQ-9 scores from baseline to the 1-year follow-up revealed that the decrease was significantly smaller in participants with chronic neck pain than in those without (*p* = 0.001) (Table 3-A).

Similarly, in the moderate-to-severe depression group at baseline (*n* = 108), no significant difference in PHQ-9 scores was observed between participants with and without chronic neck pain (*p* = 0.928). At the 1-year follow-up, PHQ-9 scores were significantly higher among participants with chronic neck pain (*n* = 39) than those without (*n* = 69) (*p* = 0.030). The reduction in PHQ-9 scores over time was also significantly smaller in the chronic neck pain group compared to those without neck pain (*p* = 0.001) (Table 3-B). In the Quade nonparametric ANCOVA, a statistically significant group difference was observed in total PHQ-9 score between participants with and without chronic neck pain in both the mild depression and moderate-to-severe depression groups. For those with mild depression, the effect size was small ($\eta^2 = 0.011$), indicating a modest difference in depressive symptom burden related to chronic neck pain. In the moderate-to-severe depression group, the group difference was also statistically significant and reflected a moderate effect size ($\eta^2 = 0.059$), suggesting that chronic neck pain exerted a more pronounced influence on overall depression severity in this population.

Discussion

There are three key findings of this study. First, chronic neck pain was present in 19.0% of participants with mild depression and 36.1% of those with moderate-to-severe depression. Second, participants with mild depression and moderate-to-severe depression combined with chronic neck pain exhibited poorer sleep quality, greater insomnia, and more widespread pain compared with those without chronic neck pain, both at baseline and at the 1-year follow-up. Finally, although the total PHQ-9 score at baseline did not differ significantly based on the presence of chronic neck pain in participants with mild depression and moderate-to-severe depression, the change in the total PHQ-9 score was significantly higher among participants with mild depression and moderate-to-severe depression combined with chronic neck pain than among those without chronic neck pain at the 1-year follow-up.

Neck pain is a common and important symptom in patients with depression, closely linked to the frequency and severity of depressive symptoms. Previous studies have suggested that psychological factors are key risk factors for neck pain. For example, Hogg-Johnson et al. highlighted that psychological burden contributes to the prevalence and persistence of neck pain³³. Furthermore, Elbinoune et al. observed high rates of anxiety (68.4%) and depression (55.7%) among patients with chronic neck pain³⁴ emphasizing the importance of addressing mental health when managing chronic neck pain. In this study, participants were categorized into mild and moderate-to-severe depression groups based on their PHQ-9 scores. The PHQ-9 is a widely used instrument for assessing depressive symptom severity over the past two weeks and has been validated across various populations and settings²⁰. However, depressive symptoms are best conceptualized as existing on a continuum rather than as discrete categories²³. While a PHQ-9 cutoff score of ≥ 10 is commonly used to define probable depression and was applied in our study, both mild and moderate-to-severe symptoms represent gradations along the same symptom spectrum. Empirical evidence shows that incremental increases in PHQ-9 scores are associated with functional declines in life satisfaction, well-being, and cognitive performance. Furthermore, longitudinal studies have documented bidirectional transitions between symptom levels over time. In this context, our use of PHQ-9–based groups reflects symptom severity rather than distinct diagnostic entities. The observed association between chronic neck pain and exacerbation of depressive symptoms in both groups supports the conceptualization of depression as a dimensional construct. The present population-based follow-up study also observed a close relationship between depression and neck pain. Chronic neck pain was present in 19.0% of participants with mild depression and 36.1% of participants with moderate-to-severe depression. Participants with moderate-to-severe depression were nearly twice as likely to report chronic neck pain compared with

those with mild depression, indicating that the severity of depressive symptoms is associated with an increased risk of chronic neck pain. In our study, a higher proportion of women was observed across several groups, consistent with established epidemiological evidence that women experience higher rates of chronic pain and mood disorders compared to men⁷. This demographic pattern aligns with previous research and supports the appropriateness and representativeness of our study population. Considering the health burden of depression and neck pain, these results also suggest that comorbid chronic neck pain in patients with mild depression and moderate-to-severe depression may impose a greater health burden than for those without comorbid neck pain^{35,36}.

Consistent with these observations, the present study found no significant difference in depression severity at baseline between participants with mild depression and those with moderate-to-severe depression. However, significant worsening of depressive symptoms was observed at the 1-year follow-up in participants with chronic neck pain compared with those without. These findings suggest that chronic physical pain can significantly influence the progression and severity of depression. These results underscore the necessity of comprehensive management strategies that address both physical pain and mental health. Early intervention and adequate treatment of chronic conditions, such as chronic neck pain, can improve patients' overall quality of life and play a pivotal role in preventing the worsening of depressive symptoms. By addressing both aspects, healthcare providers can mitigate the long-term impact of these coexisting conditions and improve patient outcomes.

Participants with chronic neck pain demonstrated poorer outcomes across several parameters, including sleep quality, insomnia severity, and widespread pain levels, compared to those without chronic neck pain at baseline. These effects persisted or even worsened for 1 year. Among both the mild depression and moderate-to-severe depression groups, participants with chronic neck pain exhibited significantly worse outcomes in terms of sleep quality and pain levels compared with those without chronic neck pain. Interestingly, while overall PHQ-9 scores improved in both the mild depression and moderate-to-severe depression groups, participants with chronic neck pain experienced more pronounced difficulties in specific symptom domains, such as sleep quality (PSQI), insomnia severity (ISI), and greater symptom severity (SSS). This discrepancy suggests that, although general depressive symptoms may improve over time, chronic neck pain imposes a persistent burden on certain aspects of mental and physical functioning. Notably, the PHQ-9 score in the moderate-to-severe depression group decreased significantly from 18 to 7 over the 1-year follow-up. This improvement may reflect the natural fluctuation of depressive symptoms and external contextual factors. The baseline assessment took place in October 2020, during the peak of the COVID-19 pandemic in South Korea, a period of heightened psychological distress. As pandemic-related restrictions eased and daily life normalized, overall mental well-being may have improved, contributing to the reduction in depressive symptoms. These findings reinforce the idea that while depressive symptoms may be transient or situational in some individuals, chronic pain conditions such as neck pain can exert a sustained negative influence on health, regardless of broader contextual improvements. From a clinical standpoint, this highlights the importance of targeting chronic pain management—using both pharmacologic and non-pharmacologic interventions—to better address residual symptom burdens in patients with depression. Pharmacological treatments include paracetamol, non-steroidal anti-inflammatory drugs, and topical medications³⁷. Non-pharmacological treatments encompass manual therapy, exercise programs/therapy, and psychotherapy³⁷. Effective management of chronic neck pain through these interventions may help prevent the progression of mild depression to more severe depression, thereby facilitating more effective treatment of these conditions. Furthermore, the presence of chronic neck pain in individuals with mild or severe depression should be closely monitored due to the potential risk of further worsening over time.

This study has several limitations. First, depression was assessed using the PHQ-9, which, while widely used and based on Diagnostic and Statistical Manual of Mental Disorders (DSM)-IV criteria²⁰ does not replace a clinical diagnosis by a health care provider. This could limit the accuracy of findings related to clinically diagnosed depression. Second, participants were categorized into depression severity groups based on their baseline PHQ-9 scores. However, depressive symptoms are inherently dynamic and can fluctuate over time. As such, our time-invariant classification may not fully reflect these temporal changes across the 1-year follow-up period. This Limitation stems from our analytic Choice to anchor depression categorization at baseline, which may oversimplify symptom progression. Future studies may benefit from time-varying modeling approaches that can more accurately capture longitudinal changes in depressive severity. Third, although the 1-year follow-up period was informative, it may not fully capture the long-term or delayed effects of chronic neck pain, which highlights the need for longer observational periods in future research. Fourth, neck pain was assessed based on self-reported experiences over the past week, without detailed musculoskeletal evaluations. This may limit insights into specific etiologies and their differential impacts on depression. Fifth, owing to a relatively small sample size of participants with moderate depression, we merged moderate and severe depression into a single category. While this approach was necessary to ensure sufficient statistical power, it may limit the interpretability of differences across distinct levels of depression severity. Finally, some Cronbach's alpha values were below 0.8. Although values above 0.8 are often recommended, this threshold is a rule-of-thumb rather than a strict standard, and the internal consistency of certain measures should therefore be interpreted with caution³⁸.

This study also has notable strengths. First, chronic neck pain was rigorously defined by tracking participants consistently reporting neck pain across five assessments over a 1-year period, offering a reliable measure of chronicity. Second, the population-based design and proportionally sampled cohort, representative of the Korean population, bolster the generalizability of the findings. Finally, the inclusion of comprehensive covariates, such as demographic, lifestyle, sleep, and mental health factors, reduces potential confounding, strengthening the reliability of the observed associations between chronic neck pain and depression.

In conclusion, this study evaluated the impact of chronic neck pain on changes in depressive symptoms among participants with mild depression and moderate-to-severe depression over a 1-year period, using a population-based sample in Korea. The findings revealed that chronic neck pain was a significant exacerbating

factor for depressive symptoms in these participants, even after adjusting for covariates. These results not only provide valuable insight into the relationship between neck pain and depression but also contribute to the effective management of mild depression and moderate-to-severe depression.

Methods

Study design and participants

This study utilized data from the CHASE study, a nation-wide, web-based longitudinal survey designed to examine various health conditions, including pain, headache, mood, sleep, and quality of life. The methodology of the CHASE study has been previously detailed¹⁸. Briefly, participants were monitored over a 1-year period, beginning with an initial baseline survey, followed by four additional assessments at 3-month intervals. Data were collected at five timepoints to facilitate a comprehensive understanding of changes across multiple health conditions. The baseline survey collected demographic and socioeconomic information, as well as data on headache, body pain, disability, sleep status and duration, anxiety, depression, insomnia, and quality of life.

The CHASE study employed a two-stage stratified cluster sampling approach to ensure a representative sample of the population. Personalized survey links were distributed through email invitations to encourage participation. Data collection began with the baseline survey in October 2020 and concluded with the final follow-up assessment in October 2021. The demographic characteristics of our study population, including the distribution of sex, age, and other factors, were generally consistent with the national population of South Korea within the targeted age range. All participants were of South Korean ethnicity, as this study was conducted using a nationally representative Korean panel. The CHASE study received technical support from HanKook Research (Seoul, Republic of Korea).

Chronic neck pain, widespread pain index, and symptom severity scores

Body pain, including neck pain, was assessed using the modified 2016 American College of Rheumatology fibromyalgia diagnostic criteria¹⁹. The WPI quantified the number of painful regions among 19 specified body areas, including the neck. The participants were surveyed on the presence of pain in the 19 areas over the past week at each timepoint in the study. The SSS score was employed to evaluate the severity of symptoms, including fatigue, waking unrefreshed, and cognitive and physical symptoms. Participants who reported neck pain at all five assessment points were classified as having chronic neck pain.

Mild depression and moderate-to-severe depression

Depressive symptoms were evaluated using the PHQ-9, which assesses symptoms across nine DSM-aligned items: (1) anhedonia or loss of interest; (2) depressed mood, including feelings of sadness or hopelessness; (3) sleep disturbances, such as insomnia or hypersomnia; (4) fatigue and low energy; (5) appetite changes (either increased or decreased); (6) feelings of guilt or worthlessness; (7) concentration difficulties; (8) psychomotor changes, including agitation or retardation; and (9) suicidal ideation, including thoughts of self-harm^{20,21}. Participants rated the symptoms they had experienced over the previous two weeks. PHQ-9 scores of 5–9 were classified as mild depression, whereas scores ≥ 10 were categorized as moderate-to-severe depression^{20,22}. The PHQ-9 was previously validated in the Korean language²³. The PHQ-9 is a validated and widely used instrument with established psychometric properties, and was used in this study to assess total depressive symptom severity.

Anxiety

Anxiety was assessed using the GAD-7 scale, which measures key anxiety symptoms across seven items. Each item reflects common anxiety symptoms, including nervousness, inability to control worrying, excessive worry, restlessness, difficulty relaxing, irritability, and fear of something terrible happening. Each of the seven items was ranked on a four-point scale (0–3), yielding a total score between 0 and 21^{24,25}. The GAD-7 has been validated in Korean populations, with a high sensitivity and specificity²⁶.

Insomnia and sleep quality

Insomnia was evaluated using the ISI, which includes seven items assessing the severity of various insomnia symptoms, including difficulty falling and/or staying asleep, and its impact on daily functioning. Participants rated each item on a five-point scale from 0 (none) to 4 (very severe), with total ISI scores ranging from 0 to 28. A higher score indicates more severe insomnia symptoms²⁷.

Sleep quality was assessed using the PSQI, which covers seven areas: sleep quality, latency, duration, efficiency, disturbances, use of sleep medication, and daytime dysfunction^{28,29}. The Korean versions of the ISI and PSQI have been previously validated²⁹.

Quality of life

Health-related quality of life was assessed using the EQ-5D-3 L instrument, structured around five core dimensions: mobility, self-care, usual activities, pain/discomfort, and anxiety. The Korean version of the EQ-5D-3 L has been validated for use in the Korean general population³⁰. A higher score on the EQ-5D-3 L indicates a better quality of life.

Lifestyle factors

Lifestyle factors, including alcohol consumption, smoking, and employment status, are known to influence depression. In this study, these factors were examined and adjusted for in the analyses: alcohol consumption was categorized as less than twice per week or more than twice per week; smoking status was classified as current smoker, never smoker, or past smoker; and employment status was recorded as either employed or unemployed.

Statistical analysis

Binary and ordinal variables are summarized as counts and percentages, whereas continuous variables are presented as means and standard deviations or medians and interquartile ranges (IQRs), depending on their distribution characteristics. The distribution of the total number of participants was considered non-normal if the absolute skewness was ≥ 2.0 and the absolute kurtosis was ≥ 7.0 when the total number of participants was greater than 300^{31,32}. If the number of participants in a categorized group was less than 300 or greater than 30, the normality was assessed using the Kolmogorov–Smirnov normality test. Group comparisons for normally distributed variables were conducted using independent two-tailed t-tests or one-way analysis of variance (ANOVA). For non-normally distributed variables, the Mann–Whitney U test or Kruskal–Wallis test was employed. Categorical variables were compared using the chi-square test.

When the model's residuals satisfied parametric assumptions, ANOVA or analysis of covariance (ANCOVA) was performed. If these assumptions were not met, Quade's non-parametric ANCOVA was utilized. Specifically, differences in changes in anxiety (GAD-7), sleep quality (PSQI), insomnia (ISI), widespread pain (WPI), symptom severity (SSS), and quality of life (EQ-5D-3 L) over the 1-year follow-up period, based on the presence of chronic neck pain at baseline, were analyzed using Quade's non-parametric ANCOVA, adjusted for sex, age, occupation, alcohol and smoking status, and baseline values of each variable. In the 1-year follow-up analysis of changes in depression by chronic neck pain status, the additional covariates anxiety and sleep quality were included.

The sample size was based on available data, without pre-study power calculations. A two-tailed p -value < 0.05 was considered statistically significant. All analyses were conducted using IBM SPSS software, version 28.0 (IBM Corp., Armonk, NY, USA). This analysis constituted the primary evaluation, with all methods determined prior to data collection and no requirement for post-hoc testing. No missing data were recorded, as the web surveys were marked as complete only after all responses were provided.

Data availability

The datasets generated and analyzed during the current study are available in the Figshare repository: <https://doi.org/10.6084/m9.figshare.23599749>.

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Declarations

Ethical approval

The CHASE study was approved by the Institutional Review Board at Severance Hospital, Yonsei University (approval no. 2020–0034–001). All participants provided written informed consent before participating. The study procedures adhered to the ethical standards outlined in the Declaration of Helsinki and its subsequent amendments, ensuring compliance with ethical guidelines for research involving human participants.

Competing interests

The authors declare the following potential conflicts of interest with respect to the research, authorship, and/or publication of this article: MKC was a site investigator for a multicenter trial sponsored by Biohaven Pharmaceuticals, Allergan Korea, and Ildong Pharmaceutical Company. He has received lecture honoraria from Eli Lilly and Company, Handok-Teva, and Ildong Pharmaceutical Company over the past 24 months. He received grants from the Yonsei University College of Medicine (6-2021-0229), the Korea Health Industry Development Institute (HV22C0106), and a National Research Foundation of Korea grant from the Korean Government (MSIT; 2022R1A2C1091767). The other authors declare no conflicts of interest.

Additional information

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