

ORIGINAL ARTICLE



Association between the accumulation of unhealthy lifestyle factors and musculoskeletal pain in older adults

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Abstract

Background: Although previous studies have examined individual lifestyle behaviors in chronic musculoskeletal pain outcomes, the cumulative impact of unhealthy lifestyle behaviors remains unclear.

Objective: To assess whether the accumulation of unhealthy lifestyle behaviors, as measured by the LIFESTYLE-4 score, is associated with the intensity and distribution of musculoskeletal pain in older adults.

Methods: A cross-sectional study was conducted with 100 older adults with chronic pain (83% women; mean age 69 ± 9.8 years). Lifestyle-related factors were assessed using validated instruments: physical activity (International Physical Activity Questionnaire), diet (Mediterranean diet score), sleep (Pittsburgh Sleep Quality Index), and stress (Perceived Stress Scale-4). The LIFESTYLE-4 score was constructed by assigning one point for each unfavorable factor (Pittsburgh Sleep Quality Index score >5, Perceived Stress Scale-4 score > 8, physical activity <600 metabolic equivalent of task-min/wk, Mediterranean diet score <9). Pain intensity (numerical rating scale, 0–10) and pain distribution (regional vs. widespread) were the main outcomes. The data were analyzed using one-way analysis of variance, χ^2 tests, and multivariate logistic regression adjusted for sociodemographic and clinical covariates.

Results: Analysis of variance showed significant differences in pain intensity between LIFESTYLE-4 score categories ($F = 6.40$, $p = .004$; $\eta p^2 = 0.06$). Participants with the highest score reported greater pain compared to the low (mean difference = 1.80, $p = .010$) and medium (mean difference = 1.49, $p = .011$) groups. Logistic regression showed higher odds of severe pain in the high-score group (odds ratio = 10.5, 95% confidence interval 1.08–102.3). A χ^2 test revealed an association between LIFESTYLE-4 and the number of painful areas ($\chi^2_{(4)} = 12.7$, $p = .013$).

Conclusion: The accumulation of multiple unhealthy lifestyle behaviors was associated with greater intensity and a wider distribution of musculoskeletal pain. These findings underscore the importance of multidomain lifestyle approaches in the prevention and treatment of pain among older adults.

INTRODUCTION

Chronic pain is a multifactorial condition influenced by individual, social, and economic factors, and represents a major public health problem worldwide.¹ It imposes a substantial societal burden through increased health care use, reduced productivity, and diminished quality of life.² The prevalence of chronic pain is higher in women and increases with age,³ with musculoskeletal pain episodes affecting 20% to 50% of individuals over 50 years.⁴ Given the aging population and increased life expectancy, musculoskeletal pain represents a growing challenge for health systems worldwide.⁵

The impact of persistent pain is particularly severe among older adults, worsening both physical and psychological health.⁵ It is associated with morbidity, including reduced mobility, social isolation, and depressive symptoms.⁶ Beyond the physiological changes inherent to aging, modifiable lifestyle factors play a crucial role in determining pain severity in this population.⁷

Research shows that sleep problems, psychological stress, poor diet, and physical inactivity are each independently associated with increased pain intensity.⁸ Sleep disorders exhibit a bidirectional relationship with pain,^{9,10} and chronic stress exacerbates pain through dysfunction of the autonomic nervous system and hypothalamic–pituitary–adrenal axis.¹¹ Healthier dietary patterns have demonstrated beneficial effects on pain reduction.¹² Among these factors, physical activity shows the strongest association,⁷ with consistent evidence of an inverse dose–response relationship with chronic pain severity.¹³ Because these behaviors are modifiable, understanding their relationship with musculoskeletal pain is essential for designing preventive strategies and promoting healthy aging.

However, analyzing each lifestyle behavior in isolation may not fully capture their influence on pain outcomes. The cumulative effect of multiple unhealthy behaviors may better explain the intensity and distribution of musculoskeletal pain in older adults. A composite score integrating sleep quality, stress levels, physical activity, and diet (LIFESTYLE-4) could provide a simple and practical approach to assess the collective influence of unhealthy lifestyles on pain.

The selection of these four lifestyle domains was based on their consistent association with musculoskeletal pain in previous literature, their modifiability, and their relevance in rehabilitation settings.^{7–12} Additionally, these domains can be assessed using validated and feasible instruments in older populations. Other relevant lifestyle factors, such as smoking, alcohol consumption, and social determinants, were not included and should be considered in future research.

The objective of this study was to assess the association between a composite lifestyle score (LIFESTYLE-4) reflecting the cumulative burden of unhealthy lifestyles and the intensity and distribution of musculoskeletal pain

in older adults. We hypothesized that higher LIFESTYLE-4 scores would be associated with higher pain intensity and increased odds of widespread pain. Secondary objectives included exploring whether the lifestyle score is associated with pain distribution (regional vs. widespread), as well as examining correlations between different lifestyle factors and their association with pain intensity.

METHODS

Design and participants

A cross-sectional study was conducted with the participation of men and women aged 60 years or older who had persistent musculoskeletal pain for a period of >3 months and who voluntarily agree to participate in the research. People with uncontrolled chronic cardiovascular or respiratory diseases were excluded, as well as those with active diagnoses of severe psychiatric disorders (eg, schizophrenia, uncontrolled bipolar disorder, or suicidal ideation). These conditions were identified by self-report during eligibility screening and were excluded due to potential clinical instability and interference with participation. Individuals with significant comprehension or communication difficulties that could interfere with the application of the instruments were excluded.

Participants were recruited from three urban districts and one rural district in Chile. Recruitment was carried out in coordination with local authorities and senior citizen offices, which were designated a “community gatekeeper” responsible for facilitating the distribution of invitations to potential participants who meet the inclusion criteria. Subsequently, the research team contacted the interested parties by telephone to confirm their eligibility. Those who met the criteria were administered the questionnaires by telephone. The evaluations were conducted during June and September 2025.

All participants gave their informed consent at their respective health centers, thus ensuring the voluntary nature of their participation. The protocol was approved by an accredited Scientific Ethics Committee of the University of Chile (Protocol No. 2024/40) and the study was conducted in accordance with the guidelines of the Strengthening the Reporting of Observational Studies in Epidemiology statement for observational studies.¹⁴

Independent variables to construct the LIFESTYLE-4 score

The Perceived Stress Scale-4 assesses the degree to which people consider situations in their daily lives to be stressful. It consists of four items that ask how the

individual has felt or interpreted certain experiences during the last month, with response options ranging from “never” to “very often.” The total score ranges from 0 to 16, with higher values indicating a higher level of perceived stress.¹⁵

The Pittsburgh Sleep Quality Index (PSQI) in its abbreviated version allows the quality of sleep to be quantified in different clinical populations. It consists of six self-administered items, whose components are rated on a scale of 0–3. The sum of the components gives an overall score, where 0 reflects no disturbances and higher values indicate greater difficulty sleeping.¹⁶ For this study, the Spanish version of the PSQI was used.¹⁷

The International Physical Activity Questionnaire (IPAQ, short version) measures physical activity in adults using seven questions that address the frequency, duration, and intensity of activity (moderate, vigorous, walking, and sitting time) over the past 7 days. Due to its simplicity, it is particularly useful for population monitoring.¹⁸ The information obtained was used to calculate total weekly energy expenditure expressed in metabolic equivalent of task (MET)-minutes, using standardized formulas. For this study, the Spanish version of the IPAQ was used.¹⁹

The MedDiet Score is a short questionnaire designed to assess dietary patterns in relation to the Mediterranean diet. In this study, the version adapted to the Chilean population was used, which assesses the frequency of consumption of key foods such as fruits, vegetables, legumes, fish, nuts, olive oil, red and processed meats, whole grains, dairy products, and alcohol.²⁰

LIFESTYLE-4 score

To capture the combined influence of multiple lifestyle behaviors, we developed the LIFESTYLE-4 score, a composite index integrating sleep, stress, physical activity, and diet. These domains were selected based on their consistent association with musculoskeletal pain, their modifiability, and their relevance in rehabilitation settings. Each domain was dichotomized using established cutoff points, and participants received one point for each unfavorable behavior: (1) sleep: PSQI score >5 (poor sleep quality); (2) stress: PSS-4 score > 8 (high perceived stress); (3) physical activity: <600 MET-min/wk (insufficient activity according to World Health Organization recommendations); and (4) diet: MedDiet score <9 (lower Mediterranean diet quality). The final score ranged from 0 to 4, with higher values indicating the accumulation of unhealthy lifestyle factors. To facilitate the interpretation, the final score was organized into three categories: 0–1 points (high healthy behavior), 2–3 points (medium healthy behavior),

and 4 points (low healthy behavior). The selected cutoff points were based on established thresholds reported in the literature.^{15,16,18–21} Dichotomization of each domain was performed to facilitate interpretability and to construct a simple cumulative index reflecting the presence of unfavorable lifestyle factors.^{15,16,18–21} These instruments were selected due to their demonstrated validity and reliability, as well as their feasibility for use in older adults and community-based settings. Their widespread use in epidemiological studies also allows comparability with previous research. The LIFESTYLE-4 score should be considered an exploratory composite index, as it has not been formally validated. It was developed to provide a pragmatic approach to capture the cumulative burden of unhealthy lifestyle behaviors. Other relevant lifestyle factors (eg, smoking, alcohol consumption, and social determinants) were not included and should be considered in future research. Each one-point increase in the score represents the accumulation of one additional unfavorable lifestyle factor.

Dependent variable

The primary outcome was pain intensity, measured using the numerical rating scale. Participants reported their average pain over the previous 7 days using an 11-point scale ranging from 0 (“no pain”) to 10 (“worst pain imaginable”).²² Pain distribution was categorized as regional (1 or 2 body areas) or widespread (≥ 3 body areas) based on the number of self-reported painful areas.

Covariates

The following were considered as sociodemographic and clinical covariates: age, gender (male/female), body mass index (BMI) calculated from self-reported weight and height, comorbidities (presence of at least one chronic disease diagnosed by a physician), educational level (classified according to years of schooling completed), and living arrangement (alone or with others). Comorbidities were assessed by self-report and coded as a binary variable indicating the presence of at least one physician-diagnosed chronic condition.

Sample size

The sample size was estimated following the rule of including at least 10 participants per independent variable in a multivariate logistic regression model. Given a total of 7 independent variables (1 exposure and 6 covariates), the minimum required sample size was calculated to be 70 participants.

Statistical analysis

A multivariate logistic regression model was used to analyze the association between pain intensity (dependent variable) and the LIFESTYLE-4 score. For this analysis, pain intensity (measured on a 0–10 numeric rating scale) was dichotomized into two categories: severe pain (≥ 7 points) versus mild-to-moderate pain (< 7 points). The cutoff was selected according to previous studies defining this threshold as severe, clinically relevant pain.²² The model was adjusted for potential confounders, including age, gender, BMI, multimorbidity, educational level, and living arrangement. The magnitude of the associations was reported as odds ratios (OR) with their 95% confidence intervals (95% CI). Pain intensity was analyzed as a continuous variable in the analysis of variance (ANOVA) to assess differences between LIFESTYLE-4 categories. Subsequently, a one-way ANOVA was first conducted to explore differences in pain intensity across the LIFESTYLE-4 score in three categories (low: 0–1, medium: 2–3, and high: 4 points). Assumptions of normality and homogeneity of variances were tested using the Shapiro–Wilk and Levene's tests, respectively. Given the unequal group sizes and violation of homogeneity, Welch's ANOVA was applied as a robust alternative. When significant, post hoc pairwise comparisons were performed using the Games–Howell test. Additionally, a χ^2 test of independence was applied to examine the association between LIFESTYLE-4 categories, and the number of painful body sites and Spearman's rank correlation coefficients (ρ) were calculated to evaluate the relationships between individual lifestyle factors, and to explore their associations with pain intensity. Correlation strength was interpreted as weak ($\rho < 0.30$), moderate ($\rho = 0.30$ – 0.59), or strong ($\rho \geq 0.60$).²³ The level of statistical significance was set at $p < .05$. All analyzes were performed using Jamovi software version 2.6.44.

RESULTS

A total of 100 participants were included in the study, of whom 83% were women, with a mean age of 69 years (SD = 9.8). The characteristics of the sample are presented in Table 1. Regarding lifestyle-related factors, 76% of participants showed lower Mediterranean diet quality (MedDiet score < 9), and 40% reported insufficient physical activity (< 600 MET-min/wk). In addition, 71% of the sample presented sleep problems (PSQI score > 5), and 36% of participants reported high perceived stress (PSS-4 score > 8). The median LIFESTYLE-4 score was 2.0 (interquartile range: 1–3).

One-way ANOVA revealed significant differences in pain intensity between LIFESTYLE-4 score categories ($F_{(2,44.3)} = 6.40$, $p = .004$), with a moderate effect size ($\eta^2 = .06$). Mean pain scores were 6.34 (SD = 2.47)

TABLE 1 Characteristics of participants.

Variable	Mean $\pm$ SD or median (IQR)	n (%)
Age (y)	69.0 $\pm$ 9.8	
Gender (%female)		83 (83%)
BMI (kg/m ²)	29.0 $\pm$ 5.6	
Living arrangement, n (%)		
Live alone		15 (15%)
Live with others		85 (85%)
Comorbidities, n (%)		
Diabetes		37 (37%)
Hypertension		63 (63%)
Neurological disease		18 (18%)
Heart disease		12 (12%)
Lung disease		8 (8%)
No history		11 (11%)
Multimorbidity		52 (52%)
Painful area, n (%)		
Knee/hip pain		60 (60%)
Shoulder pain		60 (60%)
Lower back pain		47 (47%)
Neck pain		43 (43%)
Other		41 (41%)
Pain distribution, n (%)		
1 area		28 (28%)
2 areas		22 (22%)
≥ 3 areas		50 (50%)
Educational level, n (%)		
Lower		70 (70%)
Higher		30 (30%)
Pain intensity (NRS)	6.8 $\pm$ 2.4	
Physical activity (METs)	711 (330–1520)	
Diet (MedDiet score)	7.75 (7.0–8.50)	
Sleep (PSQI)	9.0 (5–12.0)	
Stress (PSS)	6.5 (3.0–8.0)	

Abbreviations: BMI, body mass index; IQR, interquartile range; MedDiet score, Mediterranean diet score; METs, metabolic equivalent of task–minutes per week; NRS, numeric rating scale; PSQI, Pittsburgh Sleep Quality Index; PSS, Perceived Stress Scale.

in the low score group, 6.65 (SD = 2.45) in the medium score group, and 8.14 (SD = 1.35) in the high score group. Post hoc analyzes showed that participants with a high LIFESTYLE-4 score reported significantly greater pain compared to those with a low (mean difference = 1.80, $p = .010$) or medium (mean difference = 1.49, $p = .011$) score. No significant differences were observed between the low versus medium score groups ($p = .851$). The results are summarized in Table 2 and Figure 1.

In the multivariate logistic regression adjusted model, no significant differences were observed between the

TABLE 2 Pain intensity across LIFESTYLE-4 score categories.

LIFESTYLE-4 score group	N	Mean (SD)	Post-hoc comparisons	Mean difference	p value	Cohen's d
Low (0–1 points)	29	6.34 (2.47)	Low vs. Medium	−0.30	.851	0.13
Medium (2–3 points)	57	6.65 (2.45)	Low vs. High	−1.80	.010*	0.83
High (4 points)	14	8.14 (1.35)	Medium vs. High	−1.49	.011*	0.66

Note: ANOVA $F_{(2,44.3)} = 6.40$, $p = .004$.

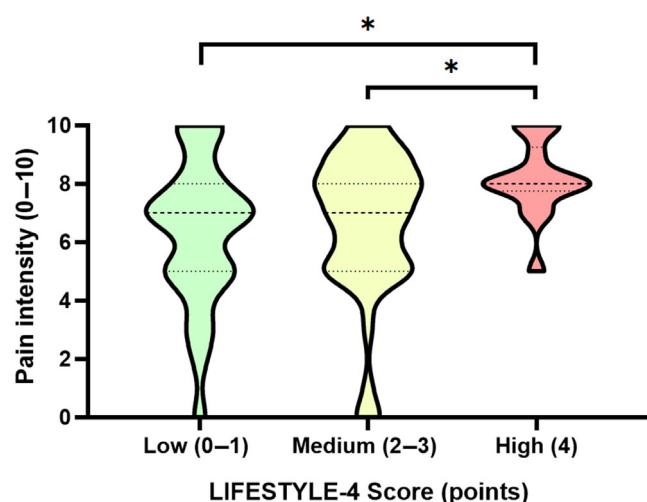


FIGURE 1 Pain intensity across LIFESTYLE-4 score categories. Pain intensity (NRS, 0–10) across LIFESTYLE-4 categories (low: 0–1, medium: 2–3, high: 4 points). Violin plots represent the distribution of pain intensity within each group, with dashed lines indicating the median and interquartile range. Differences between groups were assessed using one-way ANOVA with post hoc comparisons. Asterisks indicate statistically significant differences between groups (* $p < .05$). ANOVA, analysis of variance; NRS, numeric rating scale.

medium and low LIFESTYLE-4 categories (OR = 0.97, 95% CI 0.37–2.57). In contrast, participants in the high LIFESTYLE-4 category had a significantly higher likelihood of severe pain compared with the low category (OR = 10.5, 95% CI 1.08–102.3). The results are summarized in Table 3.

A chi-square independence test revealed a significant association between the LIFESTYLE-4 categories and the number of painful areas of the body ($\chi^2_{(4)} = 12.7$, $p = .013$). Participants in the high LIFESTYLE-4 category (score = 4) were more likely to present widespread pain (≥ 3 body areas) compared to those in the medium and low categories. In contrast, participants in the low and medium categories showed a higher proportion of cases with pain limited to one area (Figure 2).

Spearman's correlations showed that poorer sleep quality was associated with higher stress ($\rho = 0.41$, $p < .001$) and lower physical activity ($\rho = -0.37$, $p < .001$). Stress was weakly correlated with lower physical activity ($\rho = -0.24$, $p = .025$) and poorer diet quality ($\rho = -0.23$, $p = .023$). Pain intensity showed only a weak inverse correlation with physical activity

TABLE 3 Adjusted odds ratios for the association between LIFESTYLE-4 categories and pain severity.

LIFESTYLE-4 categories	Crude OR [95% CI]	Adjusted OR [95% CI]
Low	ref.	ref.
Medium	1.04 [0.42–2.59]	0.97 [0.37–2.57]
High	9.18 [1.05–79.9]	10.5 [1.08–102.3]

Note: Values are adjusted odds ratios (AOR) with 95% confidence intervals (CI). The low LIFESTYLE-4 category was used as the reference group.

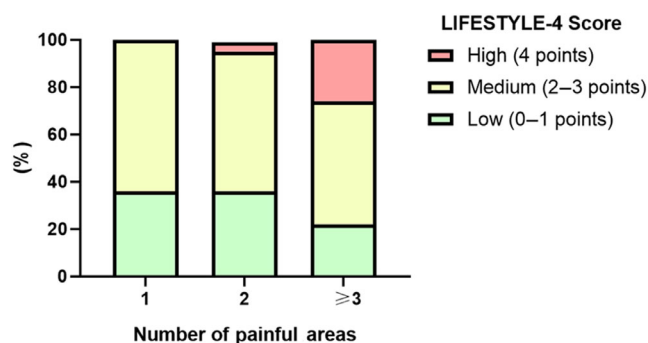


FIGURE 2 LIFESTYLE-4 categories by number of painful areas. Distribution of the number of painful areas (1, 2, and ≥ 3) across LIFESTYLE-4 categories. Pain in ≥ 3 areas was considered widespread pain. Bars represent the percentage of participants within each category.

($\rho = -0.21$, $p = .049$), whereas no significant associations were observed with sleep, stress, or diet (Table 4).

DISCUSSION

This study demonstrates that older adults with chronic musculoskeletal pain who accumulated multiple unhealthy lifestyle behaviors experienced greater pain intensity and more widespread pain distribution. Specifically, participants with all four unhealthy behaviors (poor sleep, high stress, insufficient physical activity, and poor diet) had 10.5 times higher odds of severe pain compared to those with one or fewer unhealthy behaviors. These findings support our hypothesis that lifestyle factors exert cumulative rather than isolated effects on pain outcomes in older adults. The relatively high pain intensity observed in this sample may be

TABLE 4 Spearman's correlations between lifestyle factors and pain intensity.

		PSQI	PSS-4	METs	MedDiet score	NRS
PSQI	Spearman's rho	—				
	<i>p</i> value	—				
PSS-4	Spearman's rho	0.405	—			
	<i>p</i> value	<.001**	—			
METs	Spearman's rho	−0.369	−0.237	—		
	<i>p</i> value	<.001**	.025*	—		
MedDiet score	Spearman's rho	−0.052	−0.227	0.037	—	
	<i>p</i> value	.605	.023*	.730	—	
NRS	Spearman's rho	0.141	0.128	−0.209	−0.132	—
	<i>p</i> value	.163	.206	.049	.190	—

Note: * Significant difference ($p < .05$); ** Significant difference ($p < .001$).

Abbreviations: MedDiet score, Mediterranean diet score; METs, metabolic equivalent of task—minutes per week; NRS, numeric rating scale; PSQI, Pittsburgh Sleep Quality Index; PSS, Perceived Stress Scale.

explained by the inclusion of older adults with persistent musculoskeletal pain, a population often characterized by multimorbidity and complex biopsychosocial factors that can amplify pain perception. These findings should be interpreted within a bidirectional framework. Although unhealthy lifestyle behaviors may be associated with greater pain, pain itself may also contribute to poorer lifestyle habits, such as reduced physical activity or disrupted sleep. Therefore, causality and directionality cannot be established due to the cross-sectional design.

Comparison with previous studies

Notably, participants with the highest LIFESTYLE-4 score (low healthy behavior), reflecting the simultaneous presence of sleep deprivation, high stress levels, insufficient physical activity, and poorer diet quality, reported significantly greater pain intensity compared to those in the low score and medium score categories (high and medium healthy behavior). In addition, this group showed a significantly higher probability of severe pain and a greater number of painful areas on the body. In contrast, participants with low or medium scores showed lower pain intensity and were more likely to report pain limited to fewer areas. In addition, factors such as patient activation and engagement in health-related behaviors may influence both lifestyle habits and pain outcomes, highlighting the complexity of these relationships. In addition, lifestyle factors were interrelated, as poorer sleep quality correlated with higher stress and lower physical activity, whereas only physical activity showed a weak inverse correlation with pain intensity. In contrast, the limited variability observed in the MedDiet score may reflect a relatively homogeneous dietary pattern in this population, with a high proportion of participants showing lower Mediterranean diet quality. This reduced variability may partly explain the weaker associations observed for this

domain. These results are consistent with recent evidence. In a Chinese cohort, Li et al.²⁴ showed that a healthy lifestyle (physical activity, BMI, sleep, smoking, and alcohol consumption) mitigates the longitudinal risk of frailty associated with pain, supporting the clinical relevance of addressing multiple behaviors rather than isolated factors. Ke et al.²⁵ showed that the apparent relationship between chronic pain and accelerated epigenetic aging is nullified after adjusting for lifestyle behaviors, pointing to these habits as key confounders/modifiers of the biological link between pain and aging. This is consistent with our finding of greater pain in those who accumulate unhealthy behaviors. A previous cross-sectional study in a large European sample showed that physical inactivity was the strongest independent predictor of severe pain, followed by lack of sleep and poor diet; however, that study analyzed each lifestyle variable separately and did not assess their cumulative burden or use validated scales.⁷ Overall, our study differs from previous research in that it quantifies the combined influence of lifestyle-related behaviors using validated instruments, highlighting the cumulative association between unhealthy habits and pain intensity and distribution in older adults.

Biological mechanisms underlying cumulative effects

The associations observed in this study can be explained by the complex interaction between biological, psychological, and behavioral mechanisms that link lifestyle factors to pain modulation.²⁶ For instance, sleep disorders are known to disrupt descending pain inhibition pathways and increase levels of proinflammatory cytokines, which may increase pain sensitivity.^{27,28} Similarly, chronic stress disrupts autonomic balance and hypothalamic–pituitary–adrenal axis function, leading to sustained cortisol release and central sensitization.¹¹

Nutritional quality could also influence pain modulation, as deficiencies in antioxidants, omega-3 fatty acids, vitamin D, and magnesium are associated with increased pain,^{29,30} whereas higher consumption of fruits and grains and lower consumption of salt, alcohol, and meat are associated with reduced chronic pain.³¹ Insufficient physical activity contributes to increased pain severity, whereas regular movement has been shown to promote anti-inflammatory and neuroplastic effects.³² Emerging research also points to possible epigenetic pathways through which lifestyle-related behaviors may regulate gene expression and inflammatory processes related to chronic pain.^{33–35} Taken together, these findings support the idea that multiple unhealthy lifestyle factors may exert additive or synergistic effects on pain, consistent with our results showing greater pain intensity and a wider distribution among individuals with higher LIFESTYLE-4 scores. Therefore, addressing lifestyle factors collectively may represent a promising avenue for reducing the burden of chronic pain and promoting healthy aging.

Clinical implications

The results of this study have important implications for clinical practice. First, they highlight the potential value of assessing lifestyle habits collectively, rather than in isolation, to better identify older adults with multiple coexisting risk factors who experience chronic musculoskeletal pain. Identifying patients with multiple unhealthy habits using a simple composite index, such as the LIFESTYLE-4 score, may help clinicians identify higher-risk profiles and inform clinical decision-making. Second, the results suggest the potential value of integrating multidomain approaches into rehabilitation programs, emphasizing the combined promotion of physical activity, healthy eating, stress management, and sleep hygiene. These strategies may help improve pain-related outcomes, although causal effects cannot be inferred from this study. Finally, incorporating routine lifestyle assessment into routine clinical evaluations could reinforce preventive and therapeutic strategies. In primary care settings, where older adults with musculoskeletal pain are frequently encountered, brief screening using validated tools (PSS-4, PSQI, IPAQ, MedDiet) could inform personalized treatment plans and facilitate early intervention in individuals at higher risk of more severe or widespread pain.

Strengths and limitations

This study has several strengths. First, we applied validated instruments for each lifestyle domain, including the PSS-4, PSQI, MedDiet score, and IPAQ, which increases the reliability of the measures. Second, the construction of a composite index (LIFESTYLE-4)

allowed us to capture the combined effect of multiple behaviors, going beyond the traditional approach of analyzing each factor in isolation. Moreover, the consistency of the results across different analytical approaches reinforces the robustness of the observed associations. However, some limitations must be considered and the results interpreted with caution. The cross-sectional design prevents establishing causal relationships between lifestyle factors and pain outcomes, making it impossible to determine directionality, as these associations are likely bidirectional. The relatively small sample size, especially in the high LIFESTYLE-4 category, resulted in wide confidence intervals in the regression models, limiting the precision of the estimates. Also, the higher proportion of women in the sample may reflect recruitment from community-based settings, where women are more likely to participate in health-related activities. The predominance of women in the sample may limit the generalizability of the findings to older men. The use of self-reported measures for lifestyle-related behaviors may have introduced recall or social desirability bias. In addition, the lack of specific diagnostic information regarding the underlying causes of musculoskeletal pain may have influenced the observed associations, as different conditions may present distinct relationships with lifestyle factors. Finally, although several important confounding factors were adjusted for, the possibility of residual confounding cannot be completely ruled out.

Future directions

Although the LIFESTYLE-4 score captured four key modifiable behaviors—physical activity, diet, sleep, and stress—it did not include other lifestyle and psychosocial domains such as social connectedness or substance use (eg, alcohol, tobacco, and drug consumption). These factors are particularly relevant in older adults, where loneliness and social isolation have been shown to influence pain perception and overall health. Future studies should expand the multidomain approach by integrating validated measures of social engagement and substance use, which may further refine the understanding of lifestyle patterns and their relationship with chronic pain.

Several new questions emerge from our findings. Longitudinal studies are needed to establish temporal relationships and determine whether improvements in LIFESTYLE-4 scores lead to reductions in pain intensity and distribution over time. Randomized controlled trials testing multidomain lifestyle interventions versus single-domain approaches would clarify whether combined interventions yield superior outcomes, as our results suggest. Additionally, research should explore potential dose–response associations and whether improvements in some domains can compensate for

persistent challenges in others, or whether all four domains must be optimized for maximum benefit. On the other hand, comorbidities were self-reported and coded as a binary variable, which may not fully capture differences in overall disease burden. Also, the LIFESTYLE-4 score has not been formally validated as a composite measure, and therefore its use should be interpreted with caution. Finally, investigating biological mediators (e.g., inflammatory markers, cortisol patterns, sleep patterns) could potentially elucidate the mechanistic pathways through which cumulative lifestyle factors influence pain outcomes.

CONCLUSION

Our results indicate that the cumulative burden of unhealthy lifestyle habits, as measured by the LIFESTYLE-4 score, was significantly associated with greater pain intensity and a greater number of painful areas of the body. These findings highlight the importance of considering the combined effect of lifestyle factors, rather than evaluating each behavior in isolation. Although causality cannot be established due to the cross-sectional design, our results suggest that interventions addressing multiple lifestyle domains may be more effective in reducing the burden of musculoskeletal pain in older adults.

FUNDING INFORMATION

None.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

ETHICS STATEMENT

The protocol was approved by an accredited Scientific Ethics Committee of the University of Chile (Protocol No. 2024/40).

DISCLOSURE

Each author certifies that there are no funding or commercial associations (consultancies, stock ownership, equity interest, patent/licensing arrangements, etc.) that might pose a conflict of interest in connection with the submitted article related to the author or any immediate family members.

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