ISSN (e): 2382-4603

Anticipated Publication

This article has been approved by the Editorial Commitee of the MedUNAB Journal after peer review. It will be published in PDF version, without proofreading, metadata translation, and layout. The document is available on our website for reading, printing, and wide circulation. Please, keep into consideration that this is a preliminary version, and can be modified for the final version.

Original article

Vol. 29(2):XX-XX, May - August 2026

Exploring Seasonal Sensitivity: Perceived Stress and Physical Performance among Older People in High Southern Latitudes

Explorando la sensibilidad estacional: Estrés percibido y rendimiento físico entre personas mayores en latitudes altas del sur.

Explorando a sensibilidade sazonal: estresse percebido e desempenho físico entre pessoas idosas em altas latitudes austrais

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Article Information

Article received: 22 de abril de 2025

Article accepted: 06 de marzo de 2026

DOI: https://doi.org/10.29375/01237047.5365

How to reference. Herrera RC, Mabe-Castro M, Castillo-Aguilar M, Mabe-Castro D, Villalobos E, Estrada-Goic C, et al. Exploring Seasonal Sensitivity: Perceived Stress and Physical Performance Among Older People in High Southern Latitudes. MedUNAB [Internet]. 2026;29(2):XX-XX. doi: https://doi.org/10.29375/01237047.5365

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RCH. Conceptualization; methodology; formal analysis; investigation; writing - original draft; writing - review & editing; visualization. **DMC**. Conceptualization; methodology; formal analysis; investigation; writing - original draft; writing - review & editing; visualization. **MCA**. Conceptualization; methodology; software; validation; formal analysis; writing - original draft; writing - review & editing; visualization. **MM**. Conceptualization; methodology; formal analysis; investigation; writing - original draft; writing - review & editing; visualization. **EV**. Investigation; writing - original draft; writing - review & editing. **CEG**. Investigation; writing - original draft; writing - review & editing. **SBS**: Investigation; writing - original draft; writing - review & editing. **CNE**. Conceptualization; methodology; validation; formal analysis; investigation; resources; data curation; writing - original draft; writing - review & editing; visualization; supervision; project administration; funding acquisition.

ABSTRACT

Introduction. Aging brings physiological, psychological, and social changes, such as stress-coping strategies and physical fitness. Seasonal sensitivity, which includes mood and behavioral shifts in response to seasonal changes, is particularly influential. This study examines the relationships between seasonal sensitivity, perceived stress, and physical performance in older people who live in High Southern Latitudes. **Methodology**. An analytical cross-sectional study was conducted with 77 older people (60 females and 17 males, aged 60 to 89). Seasonal sensitivity was measured using the Seasonal Pattern Assessment Questionnaire, perceived stress with the Perceived Stress Scale, and physical performance with the Short Physical Performance Battery. **Results**. Increased seasonal sensitivity was associated with higher perceived stress, especially among individuals with "Winter Blues" ($\beta = -0.67$, 95% CI [-1.21, -0.13], $p < .01$) compared to those with typical sensitivity. In contrast, those diagnosed with Seasonal Affective Disorder reported lower stress levels and showed better adaptation to seasonal changes. Physical performance, notably in the sit-to-stand task, was more closely linked to typical sensitivity scores than to extremes of seasonal sensitivity. **Discussion.** These findings highlight the interplay between seasonal sensitivity, stress, and physical performance. Integrated psychosocial and physical interventions may optimize well-being in high-latitude older people. **Conclusions**. Seasonal sensitivity is significantly associated with perceived stress and physical performance in older people in high southern latitudes. Individuals experiencing "Winter Blues" show elevated stress levels compared to those with typical sensitivity, whereas those with SAD display better symptom management.

Keywords: Stress, Psychological; Physical Fitness; Seasonal Affective Disorder; Aged; Motor Activity; Adaptation, Psychological; Resilience, Psychological; Self Concept

RESUMEN

Introducción. El envejecimiento conlleva cambios fisiológicos, psicológicos y sociales, como las estrategias para afrontar el estrés y la condición física. La sensibilidad estacional, que incluye cambios de humor y comportamiento en respuesta a las estaciones, es particularmente influyente. Este estudio examina la relación entre la sensibilidad estacional, el estrés percibido y el rendimiento físico en personas mayores que viven en latitudes australes altas. **Metodología**. Se realizó un estudio transversal analítico con 77 personas mayores (60 mujeres y 17 hombres, de 60 a 89 años). La sensibilidad estacional se midió mediante el Cuestionario de Evaluación del Patrón Estacional, el estrés percibido con la Escala de Estrés Percibido y el rendimiento físico con la Batería Corta de Rendimiento Físico. **Resultados**. Una mayor sensibilidad estacional se asoció con un mayor estrés percibido, especialmente entre las personas con "depresión invernal" ($\beta = -0,67$, IC del 95 % [-1,21, -0,13], $p < 0,01$) en comparación con aquellas con sensibilidad típica. Por el contrario, quienes fueron diagnosticados con Trastorno Afectivo Estacional reportaron menores niveles de estrés y mostraron una mejor adaptación a los cambios estacionales. El rendimiento físico, especialmente en la tarea de sentarse y levantarse, se relacionó más estrechamente con las puntuaciones de sensibilidad típica que con los extremos de la sensibilidad estacional. **Discusión**. Estos hallazgos resaltan la interacción entre la sensibilidad estacional, el estrés y el rendimiento físico. Las intervenciones psicosociales y físicas integradas pueden optimizar el bienestar en las personas mayores de latitudes altas. **Conclusiones**. La sensibilidad estacional está significativamente asociada con el estrés percibido y el rendimiento físico en las personas mayores de latitudes altas del sur. Las personas que experimentan "depresión invernal" muestran niveles de estrés elevados en comparación con aquellas con sensibilidad típica, mientras que aquellas con trastorno afectivo estacional muestran un mejor manejo de los síntomas.

Palabras clave: Estrés Psicológico; Aptitud Física; Trastorno Afectivo Estacional; Anciano; Actividad Motora; Adaptación Psicológica; Resiliencia Psicológica; Autoimagen.

RESUMO

Introdução. O envelhecimento traz alterações fisiológicas, psicológicas e sociais, como estratégias de combate ao stress e de condicionamento físico. A sensibilidade sazonal, que inclui alterações de humor e de comportamento em resposta às mudanças sazonais, é particularmente influente. Este estudo examina as relações entre a sensibilidade sazonal, o stress percebido e o desempenho físico em idosos que vivem em latitudes elevadas do Sul. **Metodologia**. Foi realizado um estudo transversal analítico com 77 idosos (60 mulheres e 17 homens, com idades compreendidas entre os 60 e os 89 anos). A sensibilidade sazonal foi medida através do Questionário de Avaliação do Padrão Sazonal, o stresse percebido com a Escala de Stress Percecionado e o desempenho físico com a Bateria de Desempenho Físico Curta. **Resultados**. O aumento da sensibilidade sazonal foi associado a um maior stresse percebido, especialmente entre os indivíduos com "Depressão de Inverno" ($\beta = -0{,}67$, IC 95% [-1,21, -0,13], $p < 0{,}01$) em comparação com aqueles com sensibilidade típica. Em contraste, aqueles diagnosticados com Perturbação Afetiva Sazonal relataram níveis de stress mais baixos e mostraram uma melhor adaptação às mudanças sazonais. O desempenho físico, nomeadamente na tarefa de sentar e levantar, esteve mais intimamente ligado a escores típicos de sensibilidade do que a extremos de sensibilidade sazonal. **Discussão**. Estes achados destacam a interação entre a sensibilidade sazonal, o stress e o desempenho físico. As intervenções psicossociais e físicas integradas podem otimizar o bem-estar dos idosos de latitudes elevadas. **Conclusões**. A sensibilidade sazonal está significativamente associada ao stresse percebido e ao desempenho físico nos idosos das altas latitudes do sul. Os indivíduos que experienciam a "depressão de inverno" apresentam níveis elevados de stress em comparação com aqueles com sensibilidade típica, enquanto aqueles com Perturbação Afetiva Sazonal (TAS) demonstram um melhor controlo dos sintomas.

Palavras-chave: Estresse Psicológico; Aptidão Física; Transtorno Afetivo Sazonal; Idoso; Atividade Motora; Adaptação Psicológica; Resiliência Psicológica; Autoimagem.

Introduction

Aging encompasses a multifaceted process involving physiological, psychological, and social transformations that collectively influence the quality of life in older adults. Among these age-related changes, the phenomenon of seasonal sensitivity has gained prominence as a potentially influential factor, particularly in populations exposed to pronounced seasonal variations. Seasonal sensitivity refers to the tendency of individuals to exhibit mood, behavioral, and functional alterations in response to environmental changes, most notably, the reduction in sunlight during the colder months (1-4). During winter, reduced light exposure has been associated with mood disturbances such as sadness and low energy, commonly termed the "Winter Blues" (3,5). While often transient and manageable, these symptoms can, in some cases, intensify and evolve into Seasonal Affective Disorder (SAD), a recurrent form of clinical depression that emerges annually with the onset of winter (6,7). This pattern, originally characterized by Rosenthal et al. (8), highlights the need to investigate seasonal influences on mental health, especially in regions with extended periods of limited daylight (8). The prevalence of seasonal sensitivity is geographically variable, with higher latitudes exhibiting greater vulnerability due to decreased winter sunlight (8). In older populations, this sensitivity may interact with key factors such as physical fitness and stress, both of which are critical to healthy aging (9,10). Physical fitness, understood as the capacity to perform daily tasks with adequate energy and without undue fatigue, is a fundamental determinant of autonomy and overall health status (11). Its decline with age is commonly linked to increased disease risk and loss of independence (12,13). Concurrently, stress plays a mediating role in both physiological and psychological health, with perceived stress levels influencing physical performance and overall well-being (14,15).

Despite growing evidence linking seasonal variations to mood and behavior at higher latitudes, there remains limited empirical work integrating seasonal sensitivity with both perceived stress and objectively assessed physical performance in older adults living in high southern latitudes. This gap is particularly relevant in regions with marked photoperiod changes, where environmental constraints may amplify vulnerability yet also foster compensatory coping and resilience strategies.

Given these interrelated dimensions, it becomes essential to investigate the potential associations between seasonal sensitivity, perceived stress, and physical fitness in aging individuals. This study aims to examine how these variables co-vary, particularly within the unique environmental context of older adults living in the Magallanes region. Insights gained from this research may inform contextually relevant interventions to enhance resilience and life quality in older populations facing extreme seasonal conditions in high southern latitudes.

Methodology

Study design

An analytic cross-sectional study determined the associations between cardiac autonomic modulation, perceived stress, and seasonal patterns in older people. Each person attended the evaluation laboratory on one occasion.

Participants

This study involved 77 older people (17 males and 60 females) living at high southern latitudes (48°36' to 56°30' south latitude) aged 60 to 89. A convenience non-probabilistic sampling was carried out. The inclusion criteria were: being a resident of the Region of Magallanes and Chilean Antarctica; not using drugs and/or drugs that increase physical performance; not using anxiolytic medicines, high blood pressure medications that can influence Heart Rate Variability (HRV) and/or sleeping pills. The exclusion criteria were congenital heart disease, being under medical treatment, or presenting pain over a visual analog scale of 5. Presenting any musculoskeletal injury at the time of the evaluation or using any technical aid for displacement; not attending at least 80% of the evaluation sessions; having moderate cognitive impairment onwards or having any pathology of neuromotor characteristic.

Sample size justification: The target sample size was determined by feasibility and the size of the accessible older-adult population in the Magallanes region during the recruitment window, and is comparable to prior observational studies in high-latitude settings. Given the modest sample, we adopted a Bayesian framework with weakly informative regularizing priors and explicit uncertainty quantification, which helps stabilize estimation, avoids overfitting, and supports coherent inference under limited data.

The participants gave their permission through informed consent before participation, during which they were informed of their rights as participants. The Ethics Committee approved this study of the University of Magallanes, Chile (code: 008SH2021), following the regulations established by the Declaration of Helsinki on ethical principles in human beings. The volunteers were informed about the research objectives and all the experimental procedures before giving their written informed consent for participation.

Instruments

Upon arrival, the subjects gave their permission to participate voluntarily. All measurements were conducted during winter between 09:00 and 11:00 hours. Anthropometrics, questionnaires, and physical performance were evaluated in the following order:

Morphological measures

Morphological evaluations included the measurement of body mass and body fat percentage. Body mass was obtained using a calibrated digital precision scale and expressed in kilograms (kg). Body fat percentage was estimated through electrical bioimpedance analysis using a Tanita BC-558 Ironman monitor, a device shown to exhibit high agreement with dual-energy X-ray absorptiometry (DEXA), thus supporting its validity for body composition assessment (16). Stature was measured in centimeters using a CHARDER® HM230M manual stadiometer (Charder Electronics Co., Ltd., No.103, Guozhong Rd., Taiwan, R.O.C.).

Seasonal pattern

Seasonal sensitivity was evaluated using a Spanish adaptation of the Seasonal Pattern Assessment Questionnaire (SPAQ), validated for assessing seasonal affective patterns (17). This instrument captures mood and behavioral fluctuations, emphasizing depressive symptoms emerging in autumn and winter, and includes criteria for major depressive disorder and atypical features such as hypersomnia, increased appetite, and carbohydrate cravings—common in Seasonal Affective Disorder (SAD). It also assesses sleep duration, relevant to seasonal mood changes. The Spanish version has shown acceptable reliability and internal consistency, supporting its use in epidemiological and clinical contexts (18).

Perceived stress

Perceived stress was assessed using the Perceived Stress Scale (PSS), adapted to Spanish (version 2.0) by Remor & Carrobles (19). This scale is a self-reported instrument that measures participants' stress levels during the last month (20,21). The PSS consists of 14 items that assess various stress-related situations and feelings on a five-point scale, where participants indicate how frequently they have experienced certain emotions or situations. The PSS is recognized for its psychometric robustness and ability to reflect the subjective perception of stress. It is a valuable tool for research into mental health and well-being in older populations.

Physical performance

Physical performance was evaluated using the Short Physical Performance Battery (SPPB), a widely used tool to assess functional capacity in older adults. The SPPB comprises three components: a balance test, which evaluates the ability to maintain progressively challenging postures; a gait speed test, in which participants are timed while walking 4 meters at their usual pace; and a chair stand test, which assesses lower limb strength by measuring the time required to complete five consecutive sit-to-stand movements. The total SPPB score ranges from 0 to 12, with higher scores reflecting greater physical functioning and mobility (22).

Study data were collected and managed using REDCap electronic data capture tools hosted at the University of Magallanes (23,24). REDCap (Research Electronic Data Capture) is a secure, web-based software platform designed to support data capture for research studies, providing 1) an intuitive interface for validated data capture; 2) audit trails for tracking data manipulation and export procedures; 3) automated export procedures for seamless data downloads to standard statistical packages; and 4) procedures for data integration and interoperability with external sources.

Statistical Analysis

Descriptive statistics

Descriptive statistics were reported as mean and standard deviation (mean ± SD) for continuous variables and absolute (n) and relative (%) frequency for categorical variables.

Analysis framework

A Bayesian analytical framework was applied to examine interrelationships among perceived stress, seasonal sensitivity, and physical fitness in older adults. Bayesian methods provide advantages over frequentist approaches by quantifying uncertainty, incorporating prior knowledge, and enabling probabilistic interpretation of parameters (25, 26). Three Bayesian generalized linear models (GLMs) assessed the influence of seasonal sensitivity on physical fitness and perceived stress, adjusting for HRV, gender, and age. All continuous predictors were standardized to allow direct comparison of effect sizes

<u>Seasonal sensitivity and perceived stress</u>

To assess the effect of seasonal sensitivity on perceived stress, a Bayesian linear Gaussian generalized model parameterized according to Equation 1 was used.

$$y_i \mid X_i \sim N(\mu_i, \sigma_i) \; \mu_i = \beta_0 + \sum_{j=1}^{p} \beta_j \cdot X_{ij} \; \sigma_i = \gamma_0 + \gamma_1 \cdot sexo_i + \gamma_2 \cdot edad_i \qquad (1)$$

In this model, the distributional parameters (μ_i, σ_i), which adjusts the shape of the response variable (y_i), were estimated as the linear combination of the intercept (β_0 for μ_i, y γ_0 for σ_i) and the coefficients used to model the variance (γ_1, γ_2) and mean (β_j) of the independent variables (X_{ij}).

<u>Seasonal sensitivity and fitness</u>

The fitness constituents reported as ordinal variables were modeled using a Bayesian ordinal regression model. This model allows for the assessment of the cumulative probability of each fitness level for each domain, conditional on the variables of interest, and was parameterized according to Equation 2.

$$logit\ P(Y \leq k|X_i) = \alpha_k - \eta_i \; \eta_i = \sum_{j=1}^{p} \beta_j X_{ij} \qquad (2)$$

Where α_k are the specific thresholds for each fitness level of each domain k, and β_j are the coefficients of the independent variables X_{ij}. The thresholds α_k are ordered as parameters of the model: $\alpha_0 = -\infty < \alpha_1 < \cdots < \alpha_k = \infty$.

Priors and hyperparameters

For the linear coefficients (β, γ), normal priors with a regularizing effect were specified (β, γ ~ N(0.10)), constraining extreme estimates and improving model convergence. Models were estimated using the No-U-Turn Sampler (NUTS), a Hamiltonian Monte Carlo variant, implemented in brms (v2.21.0) and rstan (v2.32.6). Five Markov chains were run with 2,000 warm-up and 2,000 sampling iterations per chain (10,000 total).

Following the Sequential Effect eXistence and sIgnificance Testing (SEXIT) framework (26), we reported multiple indices describing effect presence, magnitude, and relevance: the median and 95% credible interval (HDI), directional probability (pd), and practical significance (ps), the proportion of the posterior falling outside the Region of Practical Equivalence (ROPE; ±0.1 SD). Evidence strength was further quantified using Bayes factors (BF_{10}) via the Savage–Dickey ratio, interpreted following Jeffreys and Makowski et al. (26,27).

Model Convergence

The model convergence and sampling stability were assessed using standard diagnostics. The R-hat statistic was required to be below 1.01 (28), and effective sample sizes (ESS) were expected to exceed 1,000 (28). Visual inspection of trace plots and posterior predictive checks were also conducted to ensure sampling adequacy. All statistical analyses were conducted using the R programming language (v4.5.0), with implementation of Bayesian models through relevant R packages (29).

Results

Sample Characteristics

The evaluated sample comprised 77 individuals (17 men and 60 women). **Table 1** shows its characteristics.

Effect of Seasonal Sensitivity on Perceived Stress

When evaluating the effect of the seasonal sensitivity category while controlling for the effects of sex and age, no linear effect was observed (β = 0.04, 95% CI [-0.45, 0.53], pd = 0.57, ps = 0.41, ROPE = 0.33, BF10 = 0.026); **Figure 1**. This indicates that greater seasonal sensitivity is not associated with increased perceived stress; instead, a quadratic association was observed (β = -0.52, 95% CI [-0.96, -0.07], pd = 0.99, ps = 0.97, ROPE = 0.01, BF10 = 0.351), indicating a nonlinear effect derived from polynomial orthogonal contrasts. Pairwise contrast analyses showed that this effect was reflected by the difference between those with typical scores, who reported lower perceived stress levels compared to those with Winter Blues (β = -0.67, 95% CI [-1.21, -0.13], pd = 0.99, ps = 0.98, ROPE = 0.00). Similarly, albeit with less probability, it was observed that those categorized with Winter Blues reported higher levels of perceived stress than those with Seasonal Affective Disorder (Standardized Mean Difference = 0.61, 95% CI [-0.12, 1.34], pd = 0.95, ps = 0.92, ROPE = 0.06).

In the case of perceived severity associated with seasonal sensitivity, a probability close to 95% (pd = 0.95, ps = 0.93, ROPE = 0.03) was found for a linear effect. This suggests that greater self-perceived severity is associated with greater perceived stress (β = 1.16, 95% CI [-0.22, 2.54]). On the other hand, strong evidence was obtained suggesting no quadratic or cubic effect associated with a nonlinear effect between the perceived severity of seasonal sensitivity and perceived stress (quadratic effect, BF10 = 0.069; cubic effect, BF10 = 0.059).

Anecdotal evidence was observed suggesting that female sex is associated with lower perceived stress compared to their male counterparts (β = -0.66, 95% CI [-1.14, -0.18], pd = 0.99, ps = 0.99, ROPE = 0.00, BF10 = 0.965). The same could not be said for age, where very strong evidence was observed suggesting the absence of an age effect on perceived stress (BF10 = 0.015).

Effect of Seasonal Sensitivity on Physical Fitness

Regarding overall physical fitness, represented through the global SPPB score, a 90% probability of a linear effect of the classification of seasonal sensitivity (pd = 0.90, ps = 0.84, ROPE = 0.12) was observed, indicating that for each higher category, there is an increase of 0.35 standard deviations in the SPPB score (β = 0.35, 95% CI [-0.18, 0.84]), showed in **Figure 2**. However, the evidence provided by the data supports the null hypothesis (BF10 = 0.068, 1/BF10 = 14.7). On the other hand, the highest probability was for the quadratic term effect of seasonal sensitivity classification (pd = 0.92, ps = 0.85, ROPE = 0.12). After contrast analysis, it was observed that this effect was generated by the difference between those with Winter Blues and those with a typical score, where the latter had lower physical fitness scores than those with Winter Blues (Standardized Mean Difference = -0.65, 95% CI [-1.19, -0.08], pd = 0.99, ps = 0.97, ROPE = 0.00). Similar differences, albeit with lower probability, were observed when comparing those with Seasonal Affective Disorder and those with a typical score, once again indicating that those without seasonal sensitivity are more likely to have lower physical fitness (Standardized Mean Difference = -0.49, 95% CI [-1.19, 0.25], pd = 0.90, ps = 0.86, ROPE = 0.09).

Regarding the perceived severity associated with seasonal sensitivity, strong evidence that this metric is not associated with the overall fitness of the participants was found (linear effect, BF10 = 0.072; quadratic effect, BF10 = 0.062; cubic effect, BF10 = 0.059).

Neither sex nor age was related to the overall SPPB performance (sex, BF10 = 0.036; age, BF10 = 0.014).

Balance

When assessing the effect of seasonal sensitivity on balance in **Figure 3**, strong evidence was found suggesting that the category of seasonal sensitivity is not associated with this domain of physical fitness (β = -0.42, 95% CI [-1.46, 0.63], pd = 0.79, ps = 0.68, ROPE = 0.21, BF10 = 0.072; quadratic effect, β = -0.26, 95% CI [-1.42, 0.85], pd = 0.68, ps = 0.56, ROPE = 0.24, BF10 = 0.064).

On the other hand, when evaluating the effect of perceived severity associated with seasonal sensitivity, anecdotal evidence supporting the absence of an effect on balance from this variable was observed (linear effect, BF10 = 0.760; quadratic effect, BF10 = 0.592; cubic effect, BF10 = 0.414), despite observing a probability greater than 90% regarding the existence of a positive effect between self-perceived severity and balance (linear effect, β = 4.88, 95% CI [-0.96, 15.26], pd = 0.94, ps = 0.94, ROPE = 0.02, BF10 = 0.760; quadratic effect, β = 3.97, 95% CI [-0.88, 11.98], pd = 0.93, ps = 0.92, ROPE = 0.03, BF10 = 0.592; cubic effect, β = 2.51, 95% CI [-1.03, 7.10], pd = 0.91, ps = 0.89, ROPE = 0.04, BF10 = 0.414).

Neither sex nor age was related to this SPPB performance level (sex, BF10 = 0.144; age, BF10 = 0.033).

Sit-to-Stand

In the case of sit-to-stand, showed in **Figure 4,** strong evidence was found for the absence of a linear effect of seasonal sensitivity on performance in the sit-to-stand test (β = -0.42, 95% CI [-1.46, 0.63], pd = 0.79, ps = 0.68, ROPE = 0.21, BF10 = 0.072) and anecdotal evidence for the absence of a quadratic, nonlinear effect of the same variable (β = -1.19, 95% CI [-

2.36, -0.15], pd = 0.99, ps = 0.97, ROPE = 0.00, BF10 = 0.667). Attempting to discriminate the source of this effect, it was observed that those with a typical score tend to score lower than those with Winter Blues in this domain of the SPPB (Difference = -1.17, 95% CI [-2.55, 0.05], pd = 0.97, ps = 0.95, ROPE = 0.02).

For severity, we observed a linear effect suggesting that greater perceived severity is associated with better performance in this test (β = 6.50, 95% CI [0.74, 17.21], pd = 0.99, ps = 0.99, ROPE = 0.00, BF10 = 2.80), and with less evidence, it was observed a suggestive trend of a quadratic nonlinear effect of the same variable (β = 4.37, 95% CI [-0.44, 12.28], pd = 0.96, ps = 0.94, ROPE = 0.02, BF10 = 0.766), but cubic effects were not related to performance in the test (β = 1.85, 95% CI [-1.38, 5.99], pd = 0.85, ps = 0.90, ps = 0.86, ROPE = 0.09, BF10 = 0.107).

Gait Speed

In assessing the walking speed performance, a 90% probability that seasonal sensitivity classification does not have a linear effect on walking speed was identified (β = 0.18, 95% CI [-0.63, 0.98], pd = 0.90, ps = 0.83, ROPE = 0.09, BF10 = 0.070), showed in **Figure 5**. However, it was noted a strong quadratic effect with a coefficient of β = -0.63 (95% CI [-1.10, -0.15], pd = 0.99, ps = 0.96, ROPE = 0.01, BF10 = 0.412), suggesting that there are differences in walking speed associated with varying seasonal sensitivity categories. Further analysis indicated that those categorized with typical scores had lower walking speeds compared to those with Winter Blues (Standardized Mean Difference = -0.63, 95% CI [-1.25, 0.01], pd = 0.99, ps = 0.98, ROPE = 0.00).

Perceived severity was found to have a negligible impact on walking speed performance, with strong evidence against any effect (linear effect, BF10 = 0.045; quadratic effect, BF10 = 0.059).

In terms of demographic influences, both sex and age did not show significant associations with walking speed (sex, BF10 = 0.125; age, BF10 = 0.021).

Discussion

Our findings reveal a nuanced relationship between seasonal sensitivity, perceived stress, and functional capacity in older adults living at high southern latitudes. Importantly, for several outcomes the Bayesian evidence favored the absence of meaningful associations (i.e., support for the null), and we therefore avoid making strong causal or directional claims in those domains. Instead, we emphasize the uncertainty and the practical relevance criteria used (e.g., ROPE-based decisions) when interpreting small or negligible effects.

Regarding physical performance, individuals with typical-to-moderate seasonal sensitivity tended to show better functional capacity than those at the extremes, particularly in tasks reflecting lower-limb power (30). Where null effects were supported, the results suggest that seasonal sensitivity may not be a primary determinant of performance in those specific SPPB domains within this sample. The seemingly better adaptation among participants classified with Seasonal Affective Disorder may reflect compensatory coping (e.g., greater symptom awareness, help-seeking, structured routines, or treatment exposure) and resilience processes described in older populations, although alternative explanations (selection effects, measurement limitations, and residual confounding) should be considered.

Equally important is the implementation of structured exercise programs focused on improving mobility and functional fitness. Physical activity has consistently been shown to reduce depressive and anxiety symptoms while promoting cognitive and physical health in older adults (31-34). Beyond physiological benefits, exercise contributes to enhanced self-efficacy and personal agency, both of which are key elements in fostering psychological resilience (35). These dual benefits emphasize the need to integrate physical and psychosocial strategies in intervention designs. A combined approach that incorporates both social support mechanisms and structured physical activity may be particularly effective in addressing the multifactorial nature of seasonal sensitivity (33-35). Group-based exercise programs—such as walking clubs or community fitness sessions—can simultaneously enhance social connectedness and physical capacity, providing synergistic benefits (33,34). Thus, we propose a holistic, multidimensional framework for promoting health and resilience in older adults experiencing seasonal-related stress and functional decline (32-35).

Several limitations must be acknowledged. First, the cross-sectional nature of this study limits causal inference and precludes the analysis of changes over time. Second, the relatively small sample size restricts statistical power and limits generalizability. Third, the gender imbalance within the sample may constrain the validity of comparisons across sexes. Future research should adopt longitudinal designs with larger and more diverse samples to examine the temporal dynamics of seasonal sensitivity, stress, and physical functioning. Such studies would offer a more comprehensive understanding of these interrelated variables and support the design of effective, evidence-based interventions for older populations residing in regions with marked seasonal variation.

Conclusions

Seasonal sensitivity significantly affects perceived stress and physical fitness among older adults in high southern latitudes. Our findings indicate that individuals experiencing "Winter Blues" report higher levels of stress compared to those with typical seasonal sensitivity. At the same time, those diagnosed with Seasonal Affective Disorder (SAD) may exhibit better adaptation to their symptoms. Moreover, individuals with typical seasonal sensitivity scores demonstrated superior functional capacity, particularly in mobility-related tasks. These results underscore the importance of designing integrated interventions that concurrently promote emotional well-being and physical health, aiming to enhance the overall quality of life in this vulnerable population.

Acknowledgments

We thank all the participants and the university authorities who allowed us to carry out this work.

Conflict of interest

The authors declare that they have no conflicts of interest.

Funding

This work was funded by ANID Proyecto Fondecyt Regular Nº1250474 and by the Innovation Fund for Competitiveness of the Regional Government of Magallanes and Chilean Antarctica (BIP Code 40042452-0).

IA declaration

We declare that generative artificial intelligence (ChatGPT, version GPT-4.5, OpenAI, February 2025) was used exclusively as a support tool for stylistic writing in English. This technology was not used for methodological analysis, interpretation of results, or generating scientific, statistical, or conceptual content. The authors ' sole responsibility are all ideas, inferences, interpretations, and analyses presented in the manuscript.

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Table 1. Sample Characteristics

Variable	Global N = 77	Sex: Men N = 17	Women N = 60	Difference	95% CI
Age	70.0 ± 6.4	72.3 ± 5.0	69.3 ± 6.6	0.52	-0.03, 1.1
Seasonal Sensitivity (SS)					
Typical	43 (59%)	12 (75%)	31 (54%)		
Winter Blues	17 (23%)	3 (19%)	14 (25%)		
SAD	13 (18%)	1 (6.3%)	12 (21%)		
SS Severity					
No Problem	61 (79%)	15 (88%)	46 (77%)		
Mild	6 (7.8%)	1 (5.9%)	5 (8.3%)		
Moderate	3 (3.9%)	0 (0%)	3 (5.0%)		
Important	3 (3.9%)	0 (0%)	3 (5.0%)		

Severe	3 (3.9%)	1 (5.9%)	2 (3.3%)		
Extreme	1 (1.3%)	0 (0%)	1 (1.7%)		
SPPB Total Score	11.4 ± 3.8	10.8 ± 4.8	11.6 ± 3.5	-0.19	-0.73, 0.35
PSS Score	18.8 ± 7.5	21.1 ± 6.5	18.1 ± 7.7	0.43	-0.11, 0.97

Note: Sociodemographic characteristics, seasonal sensitivity, and perceived stress of the study participants. In addition to the overall characteristics of the sample, the differences between gender groups are presented. [1,2] n (%); Mean ± SD; [3] Standardized mean difference; [4] 95% CI.

Source: prepared by authors

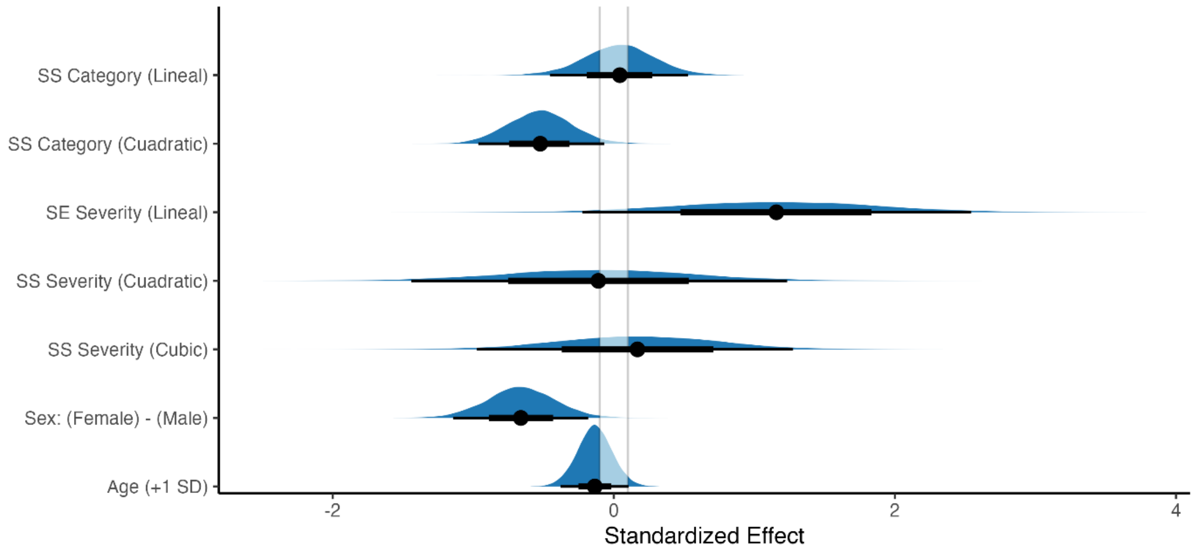

Figure 1. Seasonal Sensitivity (SS), sex, age, and their effect on perceived stress.

The light-blue area represents the practical equivalence area (ROPE).

Source: prepared by authors

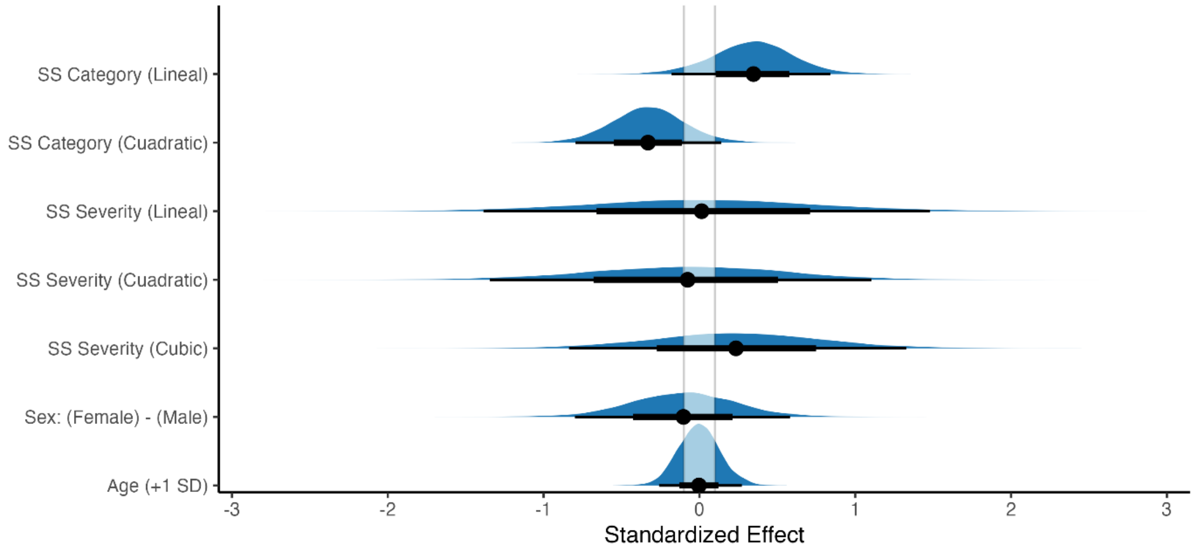

Figure 2. SS, sex, age, and their effect on the overall SPPB score.

The light-blue area represents the practical equivalence area (ROPE).

Source: prepared by authors

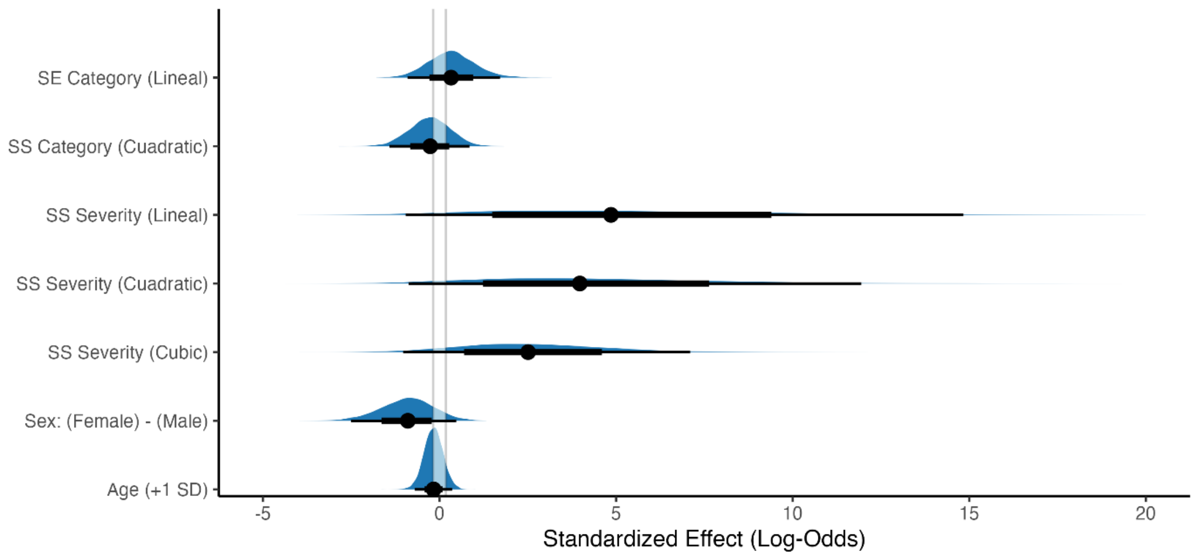

Figure 3. SS, sex, age, and their effect on the balance domain score of the SPPB.

The light-blue area represents the practical equivalence area (ROPE).

Source: prepared by authors

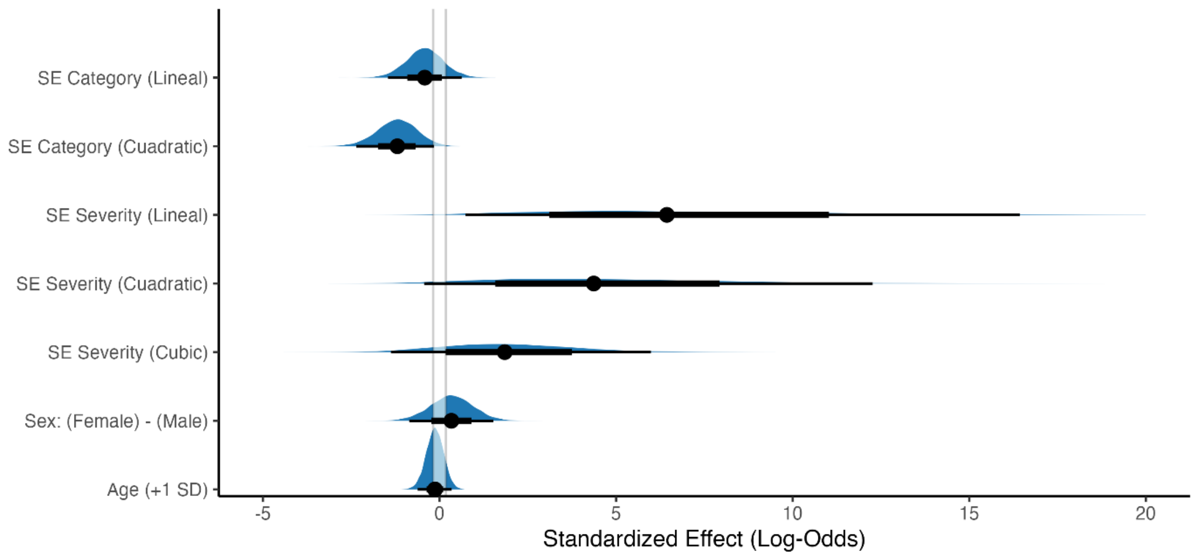

Figure 4. SS, sex, age, and their effect on the sit-to-stand domain score of the SPPB.

The light-blue area represents the practical equivalence area (ROPE).

Source: prepared by authors

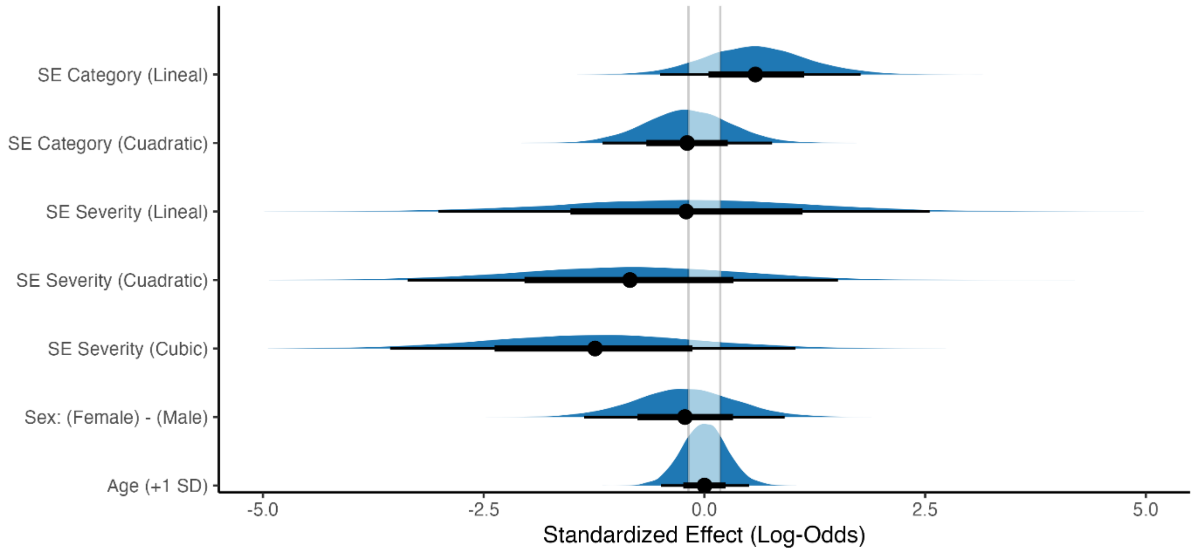

Figure 5. SS, sex, age, and their effect on the walking speed domain score of the SPPB.

The light-blue area represents the practical equivalence area (ROPE).

Source: prepared by authors