The high sensitivity of sensory processing and its relationship with balance in older people

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Abstract

High sensory processing sensitivity is a specific neurological characteristic affecting 20% of the world's population. It is characterized because the Highly Sensitive Person (HSP) has high levels of empathic capacity, emotional relativity, and sensitivity to subtle stimuli that are imperceptible to other people. Purpose: Relate the trait of the high sensitivity of sensory processing and postural balance in older people. Methods: The study was quantitative, descriptive, and correlational. It was conducted in a single stage by applying a presential questionnaire and balance evaluation. The participants in this study were selected by non-random, accidental sampling from the city of Punta Arenas, Chile. The sample comprised 77 older adults aged between 63 and 77 years. Participants' gender, age, and presence of psychological illnesses were registered using an anamnesis. The participants were invited to participate mainly through social networks and promotional posters of the research. Results: The High Sensitive Person Scale (HSPS) score significantly predicted the eyes-closed (OC) balance outcome. In particular, the study demonstrated a correlation between the HSPS score and balance. While increasing the HSPS score, the balance was expected in older adults. Conclusions: people who have a high HSPS score would be established as a predictor of the result of balance with OC, observing that for every one unit increase in the HSPS score, there is a 6% decrease in the probability of having a balance altered.

# Introduction

People with high sensory processing sensitivity have a deeper capacity for detection and response at a physiological and/or emotional level than most of the population (1). Around 20% of the population is estimated to meet these characteristics, grouping these people into a defined profile called Highly Sensitive Person (HSP) (2). This profile has been associated with depth of processing, overstimulation, emotional reactivity, and empathy, which implies a high level of dependence on the stimuli that surround these people (3). From a practical point of view, this means deep reflection and constant review regarding actions or thoughts, which in turn includes awareness of details, intuitiveness, creativity, and affective sensitivity (4). Also, on a physical level, these patients have sensory processing sensitivity to external tactile, visual, auditory, and even introspective stimuli such as body balance (5). The characteristics associated with HSP could harm a person's ability to adapt to the environment because its amount of sensory information can be perceived as overwhelming (6). It has also been observed that it can imply a greater awareness of their bodies and the psychophysiological affectation associated with their well-being (7). In the case of sensory-motor integration, sensitivity to the environment is transcendental for the generation of coordinated movements and postural balance (8). In older people, the deterioration of sensory-motor information processing is an inevitable aging process (9). Postural balance is key among all the factors that can be sensitively affected by this deterioration. A better postural balance implies a lower risk of falling, greater security of movements, and social security that positively impacts the well-being of people (10). A profile of high perceptual sensitivity in this group of people could indicate greater efficiency of complex skills, mainly due to an increase in their kinesthetic capacity; however, there is currently no consensus on this adaptive advantage in older people (11) Currently, and to the best of our knowledge, it is not known whether or not older people with HSP traits may have a greater sensory advantage in terms of their postural balance compared to those who do not present the trait. For this reason, this study aims to relate the sensory processing sensitivity trait and postural balance in older people. We presume that by assessing these variables, we will better understand how sensitivity traits can affect postural balance in older people.

# Materials and Methods

## Study design

The study was quantitative, descriptive, and correlational. It was conducted in a single stage by applying a presential questionnaire and balance evaluation.

## Participants

The participants in this study were selected by non-random, accidental sampling from the city of Punta Arenas, Chile. The sample consisted of 77 older adults, ages between 63 and 77 years. Participants' gender, age, and presence of psychological illnesses were registered using an anamnesis. The participants were invited to participate mainly through social networks and promotional posters of the research.

Inclusion criteria included being 60 or older; with permanent residence in the Magallanes and Chilean Antarctic region; absence of the following diagnosis: diabetic neuropathy, use of pacemakers, clinical depression, cognitive or motor disability, and dementia. The exclusion criteria were as follows: Exclusion criteria: Presence of diabetic neuropathy, use of pacemakers, clinical depression, cognitive or motor disability, and dementia, not completing some of the forms or tests completely. Consumption of stimulants or psychotropics during the investigation, taking drugs or stimulant substances within the 12 hours before the evaluation, and having some motor disability that prevents movement.

## Ethics

Participating subjects gave their permission through informed consent before participation. The Ethics Committee approved this study of the University of Magallanes, Chile (code: 031/CEC-UMAG/2022), 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 in this study.

## Measures

### Highly Sensitive Person Scale

The Highly Sensitive Person Scale (HSPS) is a self-assessment scale designed to measure the degree of sensory sensitivity of a person (12). This scale is made up of 27 items that refer to topics such as emotional sensitivity, perception of details, ease of being stimulated, awareness of the environment, depth of reflection, imagination, resistance to stress, and sensitivity to smells, sounds, and tastes. Participants were invited to respond to these items on a scale of 1 to 5, where one means not true at all and five means entirely true. The total score is obtained by adding the scores obtained in each item. A person is considered highly sensitive if their total score equals or exceeds (12,13)**.**

### Posturography

The evaluation of the measures for postural control was carried out with the use of a posturograph with eyes open and eyes closed. The posturograph is an electronic device with four pressure force sensors on the feet. These sensors collect information about the pressure exerted by the user on the ground, and the data collected is used to assess the balance and stability of the patient. The collected data is analyzed in comparison with the reference values. In addition, a whole-body motion platform was used. This platform contains sensors located on the bottom of the wearer's shoes, which detect changes in the movement of the leg joint. This information is used to assess and determine the degree of body balance a patient achieves (14).

## Procedures

Participants voluntarily signed an informed consent form and then completed the instruments and were tested in a single session in the following order: anamnesis, Highly Sensitive Person Scale, and Posturography evaluation. Each examination was scheduled in a free time of 1 h to answer all questions and assessments.

## Statistical Analysis

To report the variables, we used the mean and standard deviation (mean ± SD) to describe the numerical variables and the absolute and relative frequencies for the description of the categorical variables.

For the hypothesis tests, parametric statistics were used since the empirical distribution of the data followed an approximately Gaussian distribution, which was evaluated using visualization techniques and normality tests.

Pearson's correlation coefficient was used to evaluate the relationship between the balance variables in their different modalities and the HSPS score. Analysis of variance (ANOVA) was used to compare the HSPS score between balance categories and eta square () as a measure of effect size, using marginal contrast estimation for pairwise comparison of groups as post-hoc analysis (15), without correction for multiple comparisons given the exploratory nature of the study, reporting in the latter the estimated mean difference and 95% confidence interval (CI95%).

Subsequently, we describe the probability of postural change in response to the HSPS score by applying a logistic regression model, reporting the likelihood ratio (OR) and its corresponding CI95% as effect estimators. The significance level was set at 5% ( = 0.05) for hypothesis testing. The R programming language was used to compute the statistics and other add-on packages for analysis and visualization (16–18).

# Results

The characteristics of the sample evaluated and the comparison of the variables of balance and HSPS by sex are found in Table 1. No significant correlations were observed between the parameters of body balance, evaluated with balance, and HSPS (*p* > 0.185) (16,19).

When evaluating the relationship between the balance parameter classifications and HSPS, we observed a significant effect of the OC posturography category on the latter (*F*(2, 39) = 3.34, *p* = 0.046; = 0.15, CI95%[0, 0.34]). In estimating the marginal contrasts, we observed significant differences between categories 1 and 3 of posturography with OC. (mean difference = 9.05, CI95%[1.33, 16.76], *t*(39) = 2.37, *p* = 0.023), but not between levels 1 and 2 (mean difference = 13.05, CI95%[-4.89, 30.98], *t*(39) = 1.47, *p* = 0.149), nor 2 and 3 (mean difference = -4.00, CI95%[-22.10, 14.10], *t*(39) = -0.45, *p* = 0.657) (17). From this same domain. No differences were observed in the other balance categories in the HSPS score. When evaluating the effect that the HSPS score had as a predictor of the result of balance with OC, we observed that for every one-unit increase in the HSPS score, there is a 6% decrease in the probability of having altered the balance (OR = 0.94 CI95%[0.88, 0.99], *p* = 0.031). This association scaled as probability and OR can be seen in Figure 1 (18).

1. **Discussion**

The perception of the environment is essential to adapt to it. In this regard, highly sensitive people perceive the environment with excess sensory information, which can generate an allostatic overload and make them more vulnerable to physical pathologies such as fatigue and muscle pain (McEwen and Akil, 2020) (20,21). It is here that from the motor field, balance, and postural control are necessary physical skills for the physical and mental well-being of highly sensitive people (22,23), mainly because they work as injury prevention factors through an increase in their stability, coordination, and efficiency of movement (24,25). This is why the clinical treatments with the best effectiveness rate to date for people with this profile include relaxation exercises and cognitive-behavioral therapy, interventions that help PAS patients learn to control their emotions and manage their anxiety (26,27). In this regard, in a study by Elaine Aron, the neural correlates of 18 highly sensitive people were measured by functional Magnetic Resonance Imaging (fMRI) to check their response to stressful situations. The results showed that the group HSPS was associated with activating brain regions involved in motor performance, such as the integration of sensory information and action planning (28). Likewise, this study concludes that HSPS would be better able to perceive sensory information related to their environment. However, given this significant advantage in physical performance, no studies have been carried out considering clinical practice, which should be deepened (29).

After comparing the posturography results and the Highly Sensitive Person Scale (HSPS), no significant relationship was found between the variable of body balance and the HSPS score. This could respond to three factors: the first points to balance and stability as complex neurological processes that involve the integration of visual, auditory, somatosensory, and postural stimuli. Therefore, an increase in the HSPS score would point to features in stimulus discrimination but not motor performance derived from such an analysis (30,31). A second factor was determined to what extent a sedentary or active lifestyle on the part of the patients could have interfered with their physical abilities (32,33). This situation is repeated in the scale for HSPS since sedentary lifestyles have been associated with lower sensitivity levels compared to active lifestyles. This is because sedentary lifestyles lead to less exposure to external stimuli that can affect highly sensitive people. By contrast, active lifestyles tend to expose highly sensitive people to various external stimuli, which can increase their sensitivity (34,35). In addition, active lifestyles include activities such as exercise, which can help highly sensitive people develop coping mechanisms that can help them both manage their sensitivity levels and increase the performance of their physical abilities (36,37). Finally, a third explanatory factor could be associated with the fact that the increase in the HSPS score may be the result of a specific improvement in the level of attention and concentration of the patient concerning the environment that surrounds him, which will not necessarily translate into an improvement in balance or postural control (38,39).

However, regarding this last point, a link can be established with the significant results found in the study since the score of the patients in HSPS resulted in a significant predictor regarding an altered outcome in balance with eyes closed, the concept of kinesic proprioception can explain the above, this refers to a person's innate ability to detect movement, pressure, and position of muscles, tendons, and joints. This ability is part of the somatic nervous system and is related to the perception of posture and coordination (5). Studies suggest that highly sensitive people have more developed than average proprioception. This means your somatic nervous system can more easily detect body stimuli such as pressure, posture, and muscle movements. This ability contributes to a higher level of body awareness and allows HSP to see internal changes in their body more deeply and accurately (2,40).

One of the limitations of this study is the sample size, which is not significant for a specific group of older people. Another important factor to consider in future studies is objectifying the moment of the evaluation and integrating other psychological scales that complement the information obtained from the HSPS. In addition, we believe that future research should include other physiological measurements to more accurately determine the values that reflect physiological changes in the sensitivity of older people.

# Conclusions

In this study, it was possible to determine that people with a high HSPS score would be established as a predictor of the balance with OC. For each increase of one unit in the HSPS score, there is a decrease of 6 % in the probability of having an altered balance.

# Conflict of Interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

# Author Contributions

Conceptualization, L.H., and C.N.-E.; methodology L.H. and C.N.-E.; formal analysis, M.C.-A.; investigation, L.H., M.C.-A., and C.N.-E.; resources, C.N.-E.; writing—original draft preparation, L.H., J.H.L., K.H.K., and C.N.-E.; writing—review and editing, L.H., J.H.L., K.H.K., A.C., M.P.C. A.D.S. and C.N.-E.; visualization, M.C.-A., and C.N.-E.; supervision, C.N.-E.; project administration, C.N.-E.; funding acquisition, C.N.-E. All authors have read and agreed to the published version of the manuscript.

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**Table 1**. Sociodemographic and balance characteristics of the study sample, the observed mean difference, confidence interval, and statistical significance of the student’s t-test for comparisons between men and women by parameter are presented. AP, anteroposterior; Lat, side; OA, open eyes; OC, eyes closed; OAE, open eyes in foam; OCE, closed eyes in foam.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Characteristic** | **Global**  **N = 771** | **Sex** | | **Difference2** | **95% CI2,3** | **p-value2** |
| **Women**  **N = 621** | **Men**  **N = 151** |
| **Age** | 70 ± 7 | 69 ± 7 | 72 ± 5 | -3.2 | -6.4, -0.06 | **0.046** |
| **Weight** | 73 ± 12 | 73 ± 13 | 76 ± 9 | -3.4 | -9.5, 2.6 | 0.252 |
| **Height** | 156 ± 8 | 154 ± 6 | 165 ± 9 | -10 | -16, -5.2 | **<0.001** |
| **BMI** | 30.0 ± 5.0 | 30.4 ± 5.2 | 28.2 ± 3.4 | 2.2 | -0.08, 4.5 | 0.058 |
| **BMI category** |  |  |  |  |  |  |
| Underweight | 1 (1.4%) | 1 (1.8%) | 0 (0%) |  |  |  |
| Normal | 7 (9.9%) | 5 (8.8%) | 2 (14%) |  |  |  |
| Overweight | 32 (45%) | 24 (42%) | 8 (57%) |  |  |  |
| Obesity | 31 (44%) | 27 (47%) | 4 (29%) |  |  |  |
| **Balance score** | 75 ± 18 | 75 ± 18 | 76 ± 19 | -1.2 | -12, 10 | 0.823 |
| **Balance Category** |  |  |  |  |  |  |
| 1 | 57 (76%) | 45 (75%) | 12 (80%) |  |  |  |
| 2 | 4 (5.3%) | 3 (5.0%) | 1 (6.7%) |  |  |  |
| 3 | 14 (19%) | 12 (20%) | 2 (13%) |  |  |  |
| **Mov. AP OA** | 0.66 ± 0.44 | 0.59 ± 0.28 | 0.94 ± 0.76 | -0.35 | -0.77, 0.07 | 0.100 |
| **Mov. Lat. OA** | 0.34 ± 0.22 | 0.33 ± 0.22 | 0.38 ± 0.21 | -0.05 | -0.18, 0.07 | 0.382 |
| **Score OA** | 90.8 ± 5.6 | 91.4 ± 4.2 | 88.3 ± 9.2 | 3.2 | -2.0, 8.3 | 0.213 |
| **Category OA** |  |  |  |  |  |  |
| 1 | 52 (69%) | 44 (73%) | 8 (53%) |  |  |  |
| 2 | 1 (1.3%) | 1 (1.7%) | 0 (0%) |  |  |  |
| 3 | 22 (29%) | 15 (25%) | 7 (47%) |  |  |  |
| **Mov. AP OC** | 0.99 ± 1.07 | 1.01 ± 1.19 | 0.90 ± 0.27 | 0.11 | -0.23, 0.45 | 0.518 |
| **Mov. Lat. OC** | 0.43 ± 0.29 | 0.44 ± 0.32 | 0.39 ± 0.16 | 0.05 | -0.07, 0.17 | 0.403 |
| **Score OC** | 88.0 ± 4.7 | 87.9 ± 4.9 | 88.5 ± 3.7 | -0.62 | -3.0, 1.7 | 0.593 |
| **Category OC** |  |  |  |  |  |  |
| 1 | 37 (49%) | 31 (52%) | 6 (40%) |  |  |  |
| 2 | 2 (2.7%) | 1 (1.7%) | 1 (6.7%) |  |  |  |
| 3 | 36 (48%) | 28 (47%) | 8 (53%) |  |  |  |
| Mov. AP OAE | 0.85 ± 0.35 | 0.81 ± 0.29 | 1.02 ± 0.52 | -0.20 | -0.50, 0.09 | 0.165 |
| **Mov. Lat. OAE** | 0.70 ± 0.37 | 0.68 ± 0.34 | 0.79 ± 0.45 | -0.11 | -0.37, 0.16 | 0.407 |
| **Score OAE** | 87.3 ± 5.2 | 87.5 ± 4.8 | 86.3 ± 6.8 | 1.2 | -2.7, 5.1 | 0.520 |
| **Category OAE** |  |  |  |  |  |  |
| 1 | 60 (80%) | 49 (82%) | 11 (73%) |  |  |  |
| 2 | 1 (1.3%) | 1 (1.7%) | 0 (0%) |  |  |  |
| 3 | 14 (19%) | 10 (17%) | 4 (27%) |  |  |  |
| **Mov. AP OCE** | 19.06 ± 153.54 | 1.30 ± 0.46 | 90.09 ± 343.29 | -89 | -279, 101 | 0.333 |
| **Mov. Lat. OCE** | 0.90 ± 0.50 | 0.85 ± 0.45 | 1.09 ± 0.64 | -0.24 | -0.61, 0.12 | 0.181 |
| **Score OCE** | 81 ± 7 | 81 ± 6 | 80 ± 8 | 1.1 | -3.3, 5.5 | 0.607 |
| **Category OCE** |  |  |  |  |  |  |
| 1 | 71 (95%) | 57 (95%) | 14 (93%) |  |  |  |
| 2 | 1 (1.3%) | 0 (0%) | 1 (6.7%) |  |  |  |
| 3 | 3 (4.0%) | 3 (5.0%) | 0 (0%) |  |  |  |
| **Mov. anterior %** | 69 ± 24 | 70 ± 25 | 64 ± 20 | 5.8 | -6.8, 18 | 0.353 |
| **Mov. posterior %** | 44 ± 18 | 43 ± 17 | 48 ± 19 | -5.1 | -16, 5.9 | 0.345 |
| **Mov. left %** | 76 ± 26 | 76 ± 27 | 76 ± 20 | -0.63 | -14, 12 | 0.921 |
| **Mov. right %** | 79 ± 25 | 80 ± 27 | 78 ± 16 | 1.9 | -9.0, 13 | 0.723 |
| **Mov. anterior cm** | 6.59 ± 2.49 | 6.66 ± 2.62 | 6.32 ± 1.90 | 0.35 | -0.87, 1.6 | 0.565 |
| **Mov. posterior cm** | 4.16 ± 1.68 | 4.00 ± 1.60 | 4.81 ± 1.89 | -0.81 | -1.9, 0.30 | 0.144 |
| **Mov. left cm** | 7.23 ± 2.61 | 7.15 ± 2.73 | 7.57 ± 2.13 | -0.43 | -1.8, 0.92 | 0.521 |
| **Mov. right cm** | 7.71 ± 2.81 | 7.68 ± 2.99 | 7.84 ± 1.99 | -0.16 | -1.5, 1.2 | 0.802 |
| **Score HSPS** | 79 ± 13 | 80 ± 13 | 74 ± 10 | 6.0 | -3.3, 15 | 0.181 |
| 1 mean ± DE; n (%) | | | | | | |
| 2 Student t | | | | | | |
| 3 CI = Confidence Interval | | | | | | |