**IATitle:** **The High Sensitivity of Sensory Processing and its relationship with postural 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 using a presential questionnaire and postural balance assessment. 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 eye-closed (EC) postural balance outcome. In particular, the study demonstrated a correlation between the HSPS score and postural balance. While increasing the HSPS score, postural balance was expected in older adults. Conclusions: people with a high HSPS score would be established as a predictor of the result of balance with EC, observing that for every one unit increase in the HSPS score, there is a 6% decrease in the probability of having a balance altered.

KEYWORDS: Sensory processing, Postural balance, Aging, Sensitivity, Neurosciences.

**INTRODUCTION**

People with high sensory processing sensitivity have a more profound 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)(27). 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 (6). 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 (9). Also, on a physical level, these patients have sensory processing sensitivity to external tactile, visual, auditory, and even introspective stimuli such as body balance (38). 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 (23). It has also been observed that it can imply a greater awareness of their bodies and the psychophysiological affectation associated with their well-being (24). In the case of sensory-motor integration, sensitivity to the environment is transcendental for the generation of coordinated movements and postural balance (3). In older people, the deterioration of sensory-motor information processing is an inevitable aging process (37). 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 (4). A profile of high perceptual sensitivity in this group of people could indicate greater efficiency of complex skills, mainly due to increased kinesthetic capacity; however, there is currently no consensus on this adaptive advantage in older people (28). 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.

**METHODS**

*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 in a pilot program, aged between 63 and 77 years. The recruitment for the study primarily relied on inviting individuals through social networks and promotional research posters; every participant signed the informed consent, which was approved by the ethics committee of the Universidad de Magallanes (008/Sh/2021). Finally, the participants were recorded through an anamnesis, including background information such as gender, age, and presence of psychological illnesses.

Inclusion criteria included being 60 or older with permanent residence in the Magallanes and Chilean Antarctic region and without the following diagnosis: diabetic neuropathy, use of pacemakers, clinical depression, cognitive or motor disability, and dementia. Exclusion criteria for the study included the presence of diabetic neuropathy, use of pacemakers, clinical depression, mental or motor disability, and dementia. Furthermore, participants who did not fully complete the required forms or tests were excluded from the study. Additionally, individuals who reported the consumption of stimulants or psychotropic drugs during the investigation, those who had taken drugs or stimulant substances within 12 hours before the evaluation, and those with motor disabilities that prevented movement were also excluded. This study complies with the ethical standards of the International Journal of Exercise Science (31).

*Protocol*

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 comprises 27 items that refer to 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 7, where one means disagree and seven means agree. 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 167 for women and 160 for men (7; 12)**.**

The evaluation of center of pressure (COP) to determine postural balance was performed on a Bertec force plate (model #6090-15, Bertec Corporation, Ohio, USA) in eyes open and eyes closed conditions. This force plate is an electronic device with four pressure force sensors that collect information about the pressure exerted by the user on the ground, and the data collected is used to assess the postural balance and stability of the patient. In addition, a whole-body static platform was used. This platform contains sensors located on the bottom of the feet, which detect changes in the movement of the leg joint. This information is used to assess and determine a patient's degree of body balance. Each evaluation category corresponds to 1 normal, 2 moderate, and 3 altered (13). The instruction to determine postural balance was to stand upright on the platform without shoes for ten seconds with eyes open, keeping the gaze at one point. Then, in the same position, the participant must keep their eyes closed for ten more seconds. Subsequently, an unstable platform is added, and the instruction to stand upright is given again, this time in foam for ten seconds with eyes open and ten more seconds with eyes closed.

*Statistical Analysis*

The study was quantitative, descriptive, and correlational. It was conducted in a single stage using a presential questionnaire and postural balance assessment.

To report the variables, we used the mean and standard deviation (mean ± SD) to describe the numerical variables and the absolute and relative frequencies to describe 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 COP variables in their different modalities and the HSPS score. Analysis of variance (ANOVA) was used to compare the HSPS score between postural balance categories and eta square () as a measure of effect size, using marginal contrast estimation for pairwise comparison of groups as post-hoc analysis (25), 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 odds of a postural change in response to the HSPS score by applying a logistic regression model, reporting the odds 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 (29; 39).

**RESULTS**

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

**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.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **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 (kg)** | 73 ± 12 | 73 ± 13 | 76 ± 9 | -3.4 | -9.5, 2.6 | 0.252 |
| **Height (cm)** | 156 ± 8 | 154 ± 6 | 165 ± 9 | -10 | -16, -5.2 | **<0.001** |
| **BMI (kg/m2)** | 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** |  |  |  |  |  |  |
| Normal | 57 (76%) | 45 (75%) | 12 (80%) |  |  |  |
| Mild alteration | 4 (5.3%) | 3 (5.0%) | 1 (6.7%) |  |  |  |
| Altered | 14 (19%) | 12 (20%) | 2 (13%) |  |  |  |
| **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 | | | | | | |

When evaluating the effect of sensory sensitivity on the postural balance, we observed a significant effect on the balance in the EC condition (*F*(2, 39) = 3.34, *p* = 0.046; = 0.15, CI95%[0, 0.34]). When estimating the between-group differences using marginal contrasts analysis, we observed a significant difference between “normal” and “altered” postural balance groups in the EC condition (mean difference = 9.05, CI95%[1.33, 16.76], *t*(39) = 2.37, *p* = 0.023), but not between “normal” and “mild alteration” (mean difference = 13.05, CI95%[-4.89, 30.98], *t*(39) = 1.47, *p* = 0.149), nor between “mild alteration” and “altered” groups in the same condition (mean difference = -4.00, CI95%[-22.10, 14.10], *t*(39) = -0.45, *p* = 0.657). No differences in the HSPS score across postural balance groups in the EO condition were observed (see Table 2).

**Table 2.** Logistic regression models estimating the effect of high sensitivity on balance across different conditions. EO, eyes open; EC, eyes closed.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Model** | **Parameter** | **OR** 1 | **SE** 2 | **95% CI** 3 | **Z** | **P-value** |
| **EC ~ HPHS score** | Intercept | 114.78 | 263.30 | [1.63, 15116.29] | 2.07 | **0.039** |
| HSPS score | 0.94 | 0.03 | [0.88, 0.99] | -2.16 | **0.031** |
| **EO ~ HPHS score** | Intercept | 0.57 | 1.22 | [0.01, 41.33] | -0.26 | 0.792 |
| HSPS score | 1.00 | 0.03 | [0.94, 1.05] | -0.15 | 0.883 |
| 1 OR = Odds ratio | | | | | | |
| 2 SE = Standard error | | | | | | |
| 3 CI = Confidence Interval | | | | | | |

Considering the previous findings, we decided to assess the linear effect of the HSPS score on the probability of having an altered balance on the EC condition. In this context, we observed that for every one-unit increase in the HSPS score, there is a 6% decrease in the odds of having altered the balance (OR = 0.94 CI95% [0.88, 0.99], *p* = 0.031).

**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, generating an allostatic overload and making them more vulnerable to physical pathologies such as fatigue and muscle pain (18; 36). It is here that from the motor field, postural balance is a necessary physical skill for the physical and mental well-being of highly sensitive people (11; 19), mainly because they work as injury prevention factors through an increase in their stability, coordination, and efficiency of movement (14; 30). 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; 35). 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 (10). 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 (17).

After comparing the postural balance results and the Highly Sensitive Person Scale (HSPS), there are three important considerations when correlating HSPS scores and a physiological variable such as body balance. The first points to balance and stability as complex sensorimotor processes that involve the integration of visual, vestibular, and somatosensory stimuli. Therefore, an increase in the HSPS score would point to features in stimulus discrimination but not motor performance derived from such an analysis (2; 15). A second factor was determined to what extent the patients' passive or active lifestyle could have interfered with their physical abilities (16; 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 (8; 40). 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 (22; 32). 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 postural balance (21; 41).

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 EC, 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 (38). 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 (20; 27).

One of the limitations observed is the sample size, which is not significant for a specific group of older people since the participants of this study were part of a pilot program. 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.

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 EC. For each increase of one unit in the HSPS score, there is a decrease of 6 % in the odds of having an altered balance.

**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., E.G.M. 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.

**FUNDING**

This study was supported with funds from C.N.-E. by ANID Proyecto Fondecyt Iniciación N°11220116.

**ACKNOWLEDGMENTS**

We want to thank all the older people who participated in this study and the organizations that collaborated to refer their assistants to this work. The authors declare that the research was conducted without any commercial or financial relationships that could be construed as a potential conflict of interest.

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Readers should be provided with primary references to original research. Avoid using review articles, abstracts, and “personal communication” as references. In text citations should be identified by Arabic numerals in parentheses (and not superscripted). References should be numbered and listed alphabetically. Journal titles should be abbreviated in the style used in Index Medicus. References should be in 10 point font.

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