2024, Retos, 58, 308-314

The High Sensitivity of Sensory Processing and its relationship with postural balance in older people
La Alta Sensibilidad del Procesamiento Sensorial y su relación con el equilibrio postural en personas mayores

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Abstract. High sensory processing sensitivity trait (HSPST) 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 imperceptible to others. Objective: Relate the trait of the HSPST and postural balance in older people. Methods: This was a correlational study. 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. Results: The High Sensitive Person Scale (HSPS) score significantly predicted the eye-closed (EC) postural balance outcome. 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.

Resumen. El rasgo de alta sensibilidad al procesamiento sensorial (HSPST) es una característica neurológica específica que afecta al 20% de la población mundial. Se caracteriza porque la Persona Altamente Sensible (PAS) tiene altos niveles de capacidad empática, relatividad emocional y sensibilidad ante estímulos sutiles imperceptibles para los demás. Objetivo: Relacionar el rasgo del HSPST y el equilibrio postural en personas mayores. Métodos: El estudio fue de tipo correlacional. Se realizó en una única etapa mediante cuestionario presencial y evaluación del equilibrio postural. Los participantes en este estudio fueron seleccionados mediante muestreo accidental y no aleatorio de la ciudad de Punta Arenas, Chile. La muestra estuvo compuesta por 77 adultos mayores con edades entre 63 y 77 años. Resultados: La puntuación de la Escala de personas de alta sensibilidad (HSPS) predijo significativamente el resultado del equilibrio postural con los ojos cerrados (EC). El estudio demostró una correlación entre la puntuación HSPS y el equilibrio postural. Si bien se incrementó la puntuación HSPS, se esperaba un equilibrio postural en los adultos mayores. Conclusiones: las personas con un puntaje HSPS alto se establecería como predictor del resultado del equilibrio con EC, observándose que por cada aumento de una unidad en el puntaje HSPS, hay una disminución del 6% en la probabilidad de tener el equilibrio alterado.
Palabras clave: Procesamiento sensorial, Equilibrio postural, Envejecimiento, Sensibilidad, Neurociencias.

Fecha recepción: 24-04-24. Fecha de aceptación: 15-06-24
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Introduction

People with high sensory processing sensitivity traits have a more profound capacity for detection and response at a physiological and/or emotional level than most of the population (Acevedo et al., 2018). Around 20% of the population is estimated to meet these characteristics, grouping these people into a defined profile called Highly Sensitive Person (HSP)(Listou et al., 2016). This profile has been associated with depth of processing, overstimulation, emotional reactivity, and empathy, implying a high level of responsiveness to the stimuli surrounding these people (E. Aron, 2012). 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 (Baryła-Matejczuk et al., 2022). Also, on a physical level, these patients have sensory processing sensitivity to external tactile, visual, auditory, and even introspective stimuli such as body balance (Ujiie & Takahashi, 2022). 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 (Jauk et al., 2023). It has also been observed that it can imply a greater awareness of their bodies and the psychophysiological affectation associated with their well-being (Jentsch et al., 2022). In the case of sensory-motor integration, sensitivity to the environment is transcendental for the generation of coordinated movements and postural balance (Adolph & Franchak, 2017). In older people, the deterioration of sensory-motor information processing is an inevitable aging process (Toledo & Barela, 2014). 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 (Allison et al., 2006). 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 (Majcen Rosker et al., 2022). 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

This was a correlational study (Sampieri et al., 2018). It was conducted in a single stage by applying a presential questionnaire, The Highly Sensitive Person Scale (HSPS) (Chacón et al., 2021), and postural evaluation (Cordero-Civantos et al., 2019).

Participants

The participants in this study were selected by non-random, accidental sampling from Punta Arenas, Chile, between March and June 2023. The sample consisted of 77 older adults aged between 63 and 77 in a pilot program. The recruitment for the study primarily relied on inviting individuals through social networks and promotional research posters to participate at the Universidad de Magallanes, Centro Asistencial Docente e Investigación (CADI UMAG); 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 included for the 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 (Navalta J et al., 2019).

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.

Instruments

Highly Sensitive Person Scale

The Highly Sensitive Person Scale (HSPS) is a self-assessment scale designed to measure a person's degree of sensory sensitivity (Chacón et al., 2021). 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. (E. N. Aron & Aron, 1997; Chacón et al., 2021).

Postural balance

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 joints. This information was used to assess and determine a patient's degree of body balance. Each evaluation category corresponds to 1 normal, 2 moderate, and 3 altered (Cordero-Civantos et al., 2019).

Procedure

The measurements were done at the CADI-UMAG Nursing and Research Assistance Center in Punta Arenas. The evaluation protocol consisted of applying the high-sensitivity test and evaluating balance on a posturometer. The evaluation was carried out only during the mornings in a controlled laboratory. The average room temperature was 21 degrees, and humidity was 45%. 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 to simulate an unstable surface condition. The instruction to stand upright is given again, in foam, for ten seconds with eyes open and ten more seconds with eyes closed.

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 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 (η^2) as a measure of effect size, using marginal contrast estimation for pairwise comparison of groups as post-hoc analysis (Lakens, 2013). Without correction for multiple comparisons, given the study's exploratory nature, reporting the estimated mean difference and 95% confidence interval (CI95%) in the latter.

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 $CI_{95\%}$ as effect estimators. The significance level was set at 5% ($\alpha = 0.05$) for hypothesis testing. The R programming language was used to compute the statistics and other add-on packages for analysis and visualization (Makowski et al., 2020; Team, 2021; Wickham, 2016).

Results

Table 1 shows the characteristics of the sample evaluated and compares the postural balance and HSPS variables by sex. 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. AP, anteroposterior; ML, mediolateral; EO, eyes open; EC, eyes closed; EOF, eyes open in foam; ECF, eyes closed in foam.

Characteristic	Global N = 77[1]	Sex		Difference[2]	95% CI[2,3]	p-value[2]
		Women N = 62[1]	Men N = 15[1]			
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%)			
Mov. AP EO	0.66 ± 0.44	0.59 ± 0.28	0.94 ± 0.76	-0.35	-0.77, 0.07	0.100
Mov. ML EO	0.34 ± 0.22	0.33 ± 0.22	0.38 ± 0.21	-0.05	-0.18, 0.07	0.382
Score EO	90.8 ± 5.6	91.4 ± 4.2	88.3 ± 9.2	3.2	-2.0, 8.3	0.213
Category EO						
Normal	52 (69%)	44 (73%)	8 (53%)			
Mild alteration	1 (1.3%)	1 (1.7%)	0 (0%)			
Altered	22 (29%)	15 (25%)	7 (47%)			
Mov. AP EC	0.99 ± 1.07	1.01 ± 1.19	0.90 ± 0.27	0.11	-0.23, 0.45	0.518
Mov. ML EC	0.43 ± 0.29	0.44 ± 0.32	0.39 ± 0.16	0.05	-0.07, 0.17	0.403
Score EC	88.0 ± 4.7	87.9 ± 4.9	88.5 ± 3.7	-0.62	-3.0, 1.7	0.593
Category EC						
Normal	37 (49%)	31 (52%)	6 (40%)			
Mild alteration	2 (2.7%)	1 (1.7%)	1 (6.7%)			
Altered	36 (48%)	28 (47%)	8 (53%)			
Mov. AP EOF	0.85 ± 0.35	0.81 ± 0.29	1.02 ± 0.52	-0.20	-0.50, 0.09	0.165
Mov. ML EOF	0.70 ± 0.37	0.68 ± 0.34	0.79 ± 0.45	-0.11	-0.37, 0.16	0.407
Score EOF	87.3 ± 5.2	87.5 ± 4.8	86.3 ± 6.8	1.2	-2.7, 5.1	0.520
Category EOF						
Normal	60 (80%)	49 (82%)	11 (73%)			
Mild alteration	1 (1.3%)	1 (1.7%)	0 (0%)			
Altered	14 (19%)	10 (17%)	4 (27%)			
Mov. AP ECF	19.06 ± 153.54	1.30 ± 0.46	90.09 ± 343.29	-89	-279, 101	0.333
Mov. ML ECF	0.90 ± 0.50	0.85 ± 0.45	1.09 ± 0.64	-0.24	-0.61, 0.12	0.181
Score ECF	81 ± 7	81 ± 6	80 ± 8	1.1	-3.3, 5.5	0.607
Category ECF						

Normal	71 (95%)	57 (95%)	14 (93%)			
Mild alteration	1 (1.3%)	0 (0%)	1 (6.7%)			
Altered	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

When evaluating the effect of sensory sensitivity on postural balance, we observed a significant effect in the EC condition (F(2, 39) = 3.34, p = 0.046; eta al cuadrado= 0.15, CI95%[0, 0.34]). These parameters are shown in Table 2.

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, $CI_{95\%}$[1.33, 16.76], $t(39) = 2.37$, $p = 0.023$), but not between "normal" and "mild alteration" (mean difference = 13.05, $CI_{95\%}$[-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, $CI_{95\%}$[-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.

Table 2.
Logistic regression models estimate 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
EC ~ 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 $CI_{95\%}$ [0.88, 0.99], $p = 0.031$). This association is scaled as probability and as OR, as seen in Figure 1.

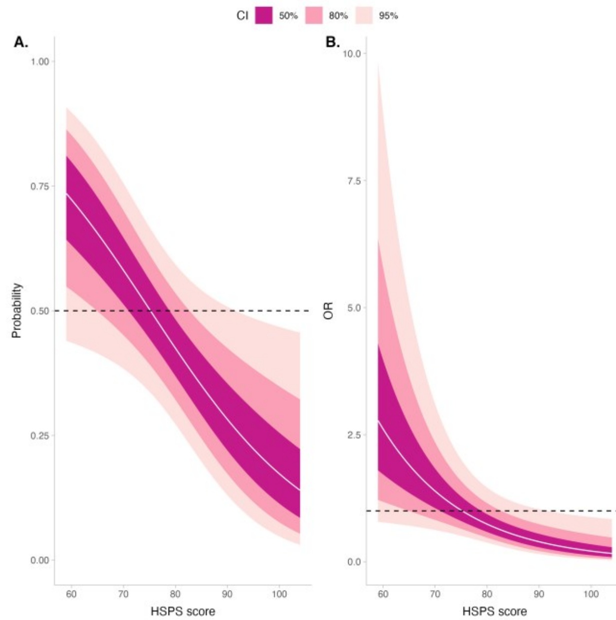

Figure 1. Probability curves of obtaining an altered posturometry with eyes closed EC depending on the HSPS score in probability scale (A) and OR (B).

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 (Herzberg et al., 2022; Smith et al., 2022). 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 (Benham, 2006; Heyne et al., 2014), mainly because they work as injury prevention factors through an increase in their stability, coordination, and efficiency of movement (Doumas & Krampe, 2010; Montero-Odasso et al., 2012). 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 HSP patients learn to control their emotions and manage their anxiety (Levine & Tebbetts, 2019; Santos-Ruiz et al., 2017). 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 (Bas et al., 2021). 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 (Greven et al., 2019).

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 (Adkin & Carpenter, 2018; Gálvez-Barrón et al., 2013). A second factor was determined to what extent the patients' passive or active lifestyle could have interfered with their physical abilities (Gomes et al., 2021; Popkirov et al., 2018). 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 (Bakker & Moulding, 2012; Wu et al., 2020). 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 (Jagiellowicz et al., 2020; Peluso & Guerra de Andrade, 2005). 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 (Ishikami & Tanaka, 2022; Yano et al., 2017).

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 (Ujiie & Takahashi, 2022). Studies suggest that highly sensitive people have more developed than average proprioception. This means the 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 (Iimura et al., 2023; Listou et al., 2016).

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.

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 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.

Funding

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

Acknowledgment

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. We thank the following institutions where the authors are affiliated: Teaching and Research Assistance Center (CADI-UMAG), Punta Arenas, Chile (LHC; JHL; MC-A; KHK; CN-E); to the Department of Psychology, University of Magallanes, Punta Arenas, Chile (LHC; JHL); Department of Kinesiology, University of Magallanes, Punta Arenas, Chile (MC-A); International School of Doctoral Studies, University of Seville, Seville, Spain (AC; MP-Ch); Laboratory of Stress Neurobiology, Center for Neurobiology and Integrative Physiopathology (CENFI), Institute of Physiology, Faculty of Sciences, Valparaíso University, Valparaíso 2360102, Chile (AD-S); Interuniversity Center for Healthy Aging, Code RED211993, Chile (AD-S; CN-E); School of Kinesiology, Faculty of Health, Universidad Santo Tomás, Chile and

School of Kinesiology, Faculty of Health Sciences, Universidad Autónoma de Chile, Talca, Chile (EG-M). School of Medicine of the University of Magallanes, Punta Arenas, Chile (CN-E).

Data availability statement

The original contributions presented in the study are included in the article. Further inquiries can be directed to the corresponding author.

Disclosure of interest

The authors report that there are no competing interests to declare.

Author contributions

All the authors have intellectually contributed to the development of the study, assume responsibility for its content, and agree with the definitive version of the article.

References

Acevedo, B., Aron, E., Pospos, S., & Jessen, D. (2018). The functional highly sensitive brain: a review of the brain circuits underlying sensory processing sensitivity and seemingly related disorders. *Philosophical Transactions of the Royal Society B: Biological Sciences*, *373*(1744), 20170161.

Adkin, A. L., & Carpenter, M. G. (2018). New insights on emotional contributions to human postural control. *Frontiers in neurology*, *9*, 789.

Adolph, K. E., & Franchak, J. M. (2017). The development of motor behavior. *Wiley Interdisciplinary Reviews: Cognitive Science*, *8*(1-2), e1430.

Allison, L. K., Kiemel, T., & Jeka, J. J. (2006). Multisensory reweighting of vision and touch is intact in healthy and fall-prone older adults. *Experimental brain research*, *175*, 342-352.

Arel-Bundock V. Marginaleffects (2023) *Package "marginal effects"* [Internet]. R-project.org,.

Aron, E. N. (2013). *The highly sensitive person: How to thrive when the world overwhelms you*. Kensington Publishing Corp.

Aron, E. N., & Aron, A. (1997). Sensory-processing sensitivity and its relation to introversion and emotionality. *Journal of personality and social psychology*, *73*(2), 345.

Bakker, K., & Moulding, R. (2012). Sensory-processing sensitivity, dispositional mindfulness and negative psychological symptoms. *Personality and individual differences*, *53*(3), 341-346.

Baryła-Matejczuk, M., Porzak, R., & Poleszak, W. (2022). HSPS-10—Short Version of the Highly Sensitive Person Scale for Students Aged 12–25 Years. *International Journal of Environmental Research and Public Health*, *19*(23), 15775.

Bas, S., Kaandorp, M., de Kleijn, Z. P., Braaksma, W. J., Bakx, A. W., & Greven, C. U. (2021). Experiences of adults high in the personality trait sensory processing sensitivity: A qualitative study. *Journal of Clinical Medicine*, *10*(21), 4912.

Benham, G. (2006). The highly sensitive person: Stress and physical symptom reports. *Personality and individual differences*, *40*(7), 1433-1440.

Chacón, A., Pérez-Chacón, M., Borda-Mas, M., Avargues-Navarro, M. L., & López-Jiménez, A. M. (2021). Cross-cultural adaptation and validation of the highly sensitive person scale to the adult Spanish population (HSPS-S). *Psychology Research and Behavior Management*, 1041-1052.

Cordero-Civantos, C., Calle-Cabanillas, M. I., & Álvarez-Gómez, L. (2020). Rehabilitación vestibular con posturografía dinámica. *Revista ORL*, *11*(1), 89-95.

Doumas, M., & Krampe, R. T. (2010). Adaptation and reintegration of proprioceptive information in young and older adults' postural control. *Journal of neurophysiology*, *104*(4), 1969-1977.

Gálvez-Barrón, C., Sanguino, M. J., Narvaiza, L., Cavestany, F., Collado, I., Macho, O., ... & Rodríguez-Molinero, A. (2013). Association with and predictive capacity of self-perceived risk of falling in recurrent falls in older people: a prospective study. *Aging clinical and experimental research*, *25*, 591-596.

Amaral Gomes, E. S., Ramsey, K. A., Rojer, A. G., Reijnierse, E. M., & Maier, A. B. (2021). The association of objectively measured physical activity and sedentary behavior with (instrumental) activities of daily living in community-dwelling older adults: a systematic review. *Clinical interventions in aging*, 1877-1915.

Greven, C. U., Lionetti, F., Booth, C., Aron, E. N., Fox, E., Schendan, H. E., ... & Homberg, J. (2019). Sensory processing sensitivity in the context of environmental sensitivity: A critical review and development of research agenda. *Neuroscience & Biobehavioral Reviews*, *98*, 287-305.

Herzberg, P. Y., Fricke, K. R., & Konrad, S. (2022). Normierung der deutschen Fassung der Highly Sensitive Person Scale (HSPS-G)–Selbstbeurteilungsskala an einer deutschsprachigen Stichprobe. *PPmP-Psychotherapie· Psychosomatik· Medizinische Psychologie*, *72*(03/04), 108-116.

Heyne, D., Sauter, F. M., Ollendick, T. H., Van Widenfelt, B. M., & Westenberg, P. M. (2014). Developmentally sensitive cognitive behavioral therapy for adolescent school refusal: Rationale and case illustration. *Clinical Child and Family Psychology Review*, *17*, 191-215.

Iimura, S., Yano, K., & Ishii, Y. (2023). Environmental sensitivity in adults: Psychometric properties of the Japanese version of the highly sensitive person scale 10-item version. *Journal of Personality Assessment*, *105*(1), 87-99.

ISHIKAMI, Y., & TANAKA, H. (2022). Emotional contagion and mirror system activity in the highly sensitive person. In *International Symposium on Affective Science and Engineering ISASE2022* (pp. 1-4). Japan Society of Kansei Engineering.

Jagiellowicz, J., Zarinafsar, S., & Acevedo, B. P. (2020). Health and social outcomes in highly sensitive persons. *The highly sensitive brain*, 75-107.

Jauk, E., Knödler, M., Frenzel, J., & Kanske, P. (2023). Do highly sensitive persons display hypersensitive narcissism? Similarities and differences in the nomological networks of sensory processing sensitivity and vulnerable narcissism. *Journal of Clinical Psychology*, *79*(1), 228-254.

Jentsch, A., Hoferichter, F., Raufelder, D., Hageman, G., & Maas, L. (2022). The relation between sensory processing sensitivity and telomere length in adolescents. *Brain and Behavior*, *12*(9), e2751.

Lakens, D. (2013). Calculating and reporting effect sizes to facilitate cumulative science: a practical primer for t-tests and ANOVAs. *Frontiers in psychology*, *4*, 863.

Levine, A., & Tebbetts, K. (2019). The Relationship Between Highly Sensitive People and Eating Attitudes. *Journal of the Academy of Nutrition and Dietetics*, *119*(9), A67.

Listou Grimen, H., & Diseth, Å. (2016). Sensory processing sensitivity: Factors of the highly sensitive person scale and their relationships to personality and subjective health complaints. *Perceptual and motor skills*, *123*(3), 637-653.

Majcen Rosker, Z., Vodicar, M., & Kristjansson, E. (2022). Relationship between cervicocephalic kinesthetic sensibility measured during dynamic unpredictable head movements and eye movement control or postural balance in neck pain patients. *International journal of environmental research and public health*, *19*(14), 8405.

Makowski, D., Ben-Shachar, M. S., Patil, I., & Lüdecke, D. (2020). Methods and algorithms for correlation analysis in R. *Journal of Open Source Software*, *5*(51), 2306.

Montero-Odasso, M., Verghese, J., Beauchet, O., & Hausdorff, J. M. (2012). Gait and cognition: a complementary approach to understanding brain function and the risk of falling. *Journal of the American Geriatrics Society*, *60*(11), 2127-2136.

Navalta, J. W., Stone, W. J., & Lyons, T. S. (2019). Ethical issues relating to scientific discovery in exercise science. *International journal of exercise science*, *12*(1), 1.

Peluso, M. A., & Guerra de Andrade, L. H. (2005). Physical activity and mental health: the association between exercise and mood. *Clinics (Sao Paulo, Brazil)*, *60*(1), 61–70. https://doi.org/10.1590/s1807-59322005000100012.

Popkirov, S., Stone, J., & Holle-Lee, D. (2018). Treatment of persistent postural-perceptual dizziness (PPPD) and related disorders. *Current treatment options in neurology*, *20*, 1-11.

Team, F. F. P. (2013). TEAM 3.

Sampieri, R. H. (2018). *Metodología de la investigación: las rutas cuantitativa, cualitativa y mixta*. McGraw Hill México.

Santos-Ruiz, A., Robles-Ortega, H., Pérez-García, M., & Peralta-Ramírez, M. I. (2017). Effects of the cognitive-behavioral therapy for stress management on executive function components. *The Spanish journal of psychology*, *20*, E11

Smith, H. L., Sriken, J., Sherman, M., Erford, B. T., & Beck, S. K. (2022). Furthering the Clinical and Research Utility of the Highly Sensitive Person Scale: Cluster Analysis of Gender Differences and Risks for Depression and Anxiety. *Journal of Mental Health Counseling*, *44*(3), 245-265.

Toledo, D. R., & Barela, J. A. (2014). Age-related differences in postural control: effects of the complexity of visual manipulation and sensorimotor contribution to postural performance. *Experimental Brain Research*, *232*, 493-502.

Ujiie, Y., & Takahashi, K. (2022). Subjective Sensitivity to Exteroceptive and Interoceptive processing in Highly Sensitive Person. *Psychological Reports*, 00332941221119403.

Wickham, H., & Wickham, H. (2016). Programming with ggplot2. *ggplot2: Elegant graphics for data analysis*, 241-253.

Wu, Z. J., Wang, Z. Y., Hu, B. Q., Zhang, X. H., Zhang, F., Wang, H. L., & Li, F. H. (2020). Relationships of accelerometer-based measured objective physical activity and sedentary behaviour with cognitive function: a comparative cross-sectional study of China's elderly population. *BMC geriatrics*, *20*(1), 1-8.

Yano K, Kimura S, Oishi K. (2017). The relationship between daily exercise and sensory-processing sensitivity among university students. Taiikugaku kenkyu (*Japan Journal Physical Education Health and Sport Sciences*) 62(2).

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