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# Concurrent validity and reliability of the Pediatric Postural Balance Scale in Chilean preschool and school-aged children with typical development

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## ABSTRACT

***Introduction.*** The pediatric postural balance scale (PBS) is a valuable clinical tool for assessing postural balance in preschool and school-aged children with typical or atypical development.

***Objective.*** To assess the PBS's concurrent validity and inter-rater reliability in Chilean preschoolers and schoolchildren with typical development.

***Population and methods***. Two hundred and three preschool and school children aged 4 to 11 (7.6 ± 2.1 years, 56.2% males) from public and private schools participated in a cross-sectional validation study. Postural balance was evaluated with PBS and postural oscillography, considering maximum lateral velocity (MLV), maximum anteroposterior velocity (MAPV), mean total velocity (MTV), mean radius (MR), and center of pressure area (COP area). Anthropometric parameters and socioeconomic level were measured.

***Results.*** The inter-rater reliability for the PBS with the intraclass correlation coefficient was 0.99 (95%CI: 0.990-0.997). There were weak inverse correlations between PBS total score and oscillography (MLV, MAPV, MTV, MR, and COP area) in the 4- to 6-year age group, standing out the correlations of mean radius (rho: -0.36; *p* 0.002) and COP area (Rho: -0.37; *p* 0.001).

***Conclusion.*** These results suggest that the PBS provides a very strong inter-rater reliability and a weak inverse correlation between the PBS total score and postural oscillography measures in the 4- to 6-year-old age group. Therefore, using PBS is recommended primarily in preschoolers and school children between 4 and 6 years of age.


***Keywords***: *postural balance; child; validation study.*

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## INTRODUCTION

Postural balance is the ability to maintain the center of mass of our body on the base of support to orient and align our body in space; it is a fundamental skill for activities of daily living.[1,2] It depends on the correct interaction between the visual, vestibular, somatosensory, nervous, and neuromuscular systems.[3] Its evaluation in the pediatric population is complex and involves analyzing multiple systems and their interactions.[4,5] Incorporating this evaluation in clinical practice is essential to detect early alterations and prevent or minimize problems in motor function and child development.[6-8]

The pediatric postural balance scale (PBS) has been proposed as a valuable tool for assessing pediatric postural balance in research and clinical practice.[8-11] It is an adaptation for the pediatric population of Berg's balance scale for elderly adults, which reorganizes its items, reduces times for static postures, and details instructions.[4,5] The PBS consists of 14 items, scored from 0 to 4, addressing qualitative and quantitative criteria.[9]

The scale assesses functional balance through three dimensions: static balance, anticipatory balance, and functional transition movements.[10] Functional balance measures the child's ability to maintain and control posture in a bipedal position during daily school and play activities.[5] The PBS is designed to evaluate this construct by measuring the child's ability to maintain and regain balance in tasks that simulate daily life situations, performing a comprehensive assessment of functional balance in children, which allows observing the relationship between postural control and the child's ability to function in their usual environment.[2,5] It was developed to identify balance disorders in school-age children and has proven equally effective in preschoolers.[8,12] In children with atypical motor development with mild to moderate disorders and in children with spastic cerebral palsy,[11] the scale has shown high inter- and intra-rater reliability.[5,11]

There is evidence of associations between the score and variables such as age, height, and body mass index in children aged 2 to 13 with typical motor development.[2] The Spanish version was recently validated in school-aged Spanish children with balance disorders.[9]

It has not been validated in the Chilean population, which prevents its adequate use since the validity of an instrument varies according to cultural and demographic factors. Therefore, it is essential to have a validated version of the PBS in the Chilean pediatric population to ensure an accurate assessment that adequately reflects the children's abilities.[13]

In the present study, the measurement of center of pressure (COP) excursion is used using postural oscillography as a reference to evaluate postural balance, since it is a valid and objective technique to quantify this variable.[14-16] The objective was to assess the PBS's concurrent validity and inter-rater reliability in Chilean preschool/school children with typical motor development.

## POPULATION AND METHODS

### Study design and participants

A cross-sectional study was carried out on children from 4 to 11 years of age of both sexes from public and private educational establishments in Temuco, Chile. The sample size calculation of at least 140 children for concurrent validation was based on the feasibility criterion, considering a minimum of 10 individuals per PBS item, increased to compensate for incomplete data.[17]

The selection of schools and participants was non-probabilistic; four schools were invited (two public and two private). Information about the project was sent to parents and guardians, and those who expressed interest received consent documents. Before the start of the study, parents/legal guardians signed an informed consent form, and each child consented to participate. Inclusion criteria were as follows: a) students aged 4 to 11 years, b) born at term (>38 weeks), c) birth weight >2500 g, d) parent/guardian signature of informed consent, and e) informed assent of the child. Exclusion criteria: a) children participating in physiotherapy programs, b) musculoskeletal disorders, and c) neurological disorders affecting postural balance. The research protocol was approved by the Scientific Ethics Committee of the Universidad Autónoma de Chile (CEC N° 16-19).

### Anthropometric evaluations

To evaluate body weight, height, and waist circumference, a digital scale (Seca, model 803, Germany; accuracy 0.1 kg), a measuring rod (Seca, Seca, model 203, Germany; accuracy 0.1 cm), and an inextensible tape measure (Seca 0-205 cm, Germany; accuracy 0.1 cm) were used. Body mass index (BMI) was calculated by dividing weight by height squared (kg/m$^2$) and compared with the World Health Organization reference curves.[18,19]

### Assessment of socioeconomic level

A combination of education, occupation, and *per capita* income levels was used to measure the socioeconomic level and to classify the subjects into the following categories proposed by the Chilean Association of Marketing and Public Opinion Researchers (AIM-Chile): AB, C1a, C1b, C2, C3, D, and E.[20]

### Evaluation of postural balance with the pediatric postural balance scale (PBS)

Functional balance was assessed using the PBS, which is composed of 14 items measuring balance skills, from basic tasks such as sitting and standing to more complex actions such as turning to look over the shoulder. Each item is scored on a scale from 0 to 4, where 0 indicates total inability to perform the task; 1, minimal performance; 2, partial performance with difficulties; 3, acceptable but not ideal performance; and 4, complete performance without assistance. The maximum score is 56 points; the scale is available in *Annex 1*. This instrument is widely used because it does not require expensive materials.[5] To assess inter-rater reliability, two independent raters administered the PBS at different times on the same day (PBS-1: rater 1 and PBS-2: rater 2).

### Assessment of postural balance with postural oscillography

Static equilibrium was measured objectively with postural oscillography equipment (Artoficio®, model Rev0610, Chile), which records and quantitatively analyzes the oscillations of the center of pressure (COP) using load sensors. The following parameters were measured: maximum lateral velocity (MLV), maximum anteroposterior velocity (MAPV), mean total velocity (MTV), mean radius (MR), and the center of pressure area (COP area).

In young, healthy populations, the average COP velocity is 5-10 mm/s, a displacement area of 50-200 mm², and average displacements of 5-10 mm anteroposterior and 3-7 mm mediolateral, reaching speeds of up to 20-40 mm/s under dynamic conditions.[21] The child was instructed to stand on the oscillography platform and not to change the position of his feet until he finished the measurement. The evaluation was carried out in three consecutive stages, each lasting 30 seconds:

- Follow-up reading: assesses the child's ability to control his posture by integrating oculomotor information, i.e., how vision influences voluntary postural control. The child was asked to minimize the movement of the COP, keeping the arms relaxed at the sides.
- Eyes open: represents the child's most natural posture, based on integrating proprioceptive, vestibular, and visual inputs. The child was instructed to look straight ahead with open eyes towards a white wall, without distractions, in a relaxed posture.
- Eyes closed: isolates the influence of the visual system on postural control, prioritizing the evaluation of the vestibular system. The patient was asked to remain with eyes closed.

### Statistical analysis

The normality of the variables was evaluated using the Shapiro-Wilk (S-W) test to determine the use of parametric or nonparametric tests. A descriptive analysis was performed using relative frequencies for qualitative variables and measures of central tendency and dispersion for quantitative variables (mean and standard deviation when S-W $p$ >0.05 and median and interquartile range when S-W $p$ <0.05).

For inter-rater reliability (PBS-1 and PBS-2), the intraclass correlation coefficient (ICC) was used, which is classified as very strong (ICC: >0.8), moderate (ICC: 0.61 to 0.80), weak (ICC: 0.30-0.60), or poor (ICC: <0.30).[22]

To assess concurrent criterion validity when comparing PBS and postural oscillography, Spearman's correlation coefficient (rho) was used. It was classified as poor (rho: 0.00-0.10), weak (rho: 0.10-0.39), moderate (rho: 0.40-0.69), strong (rho: 0.70-0.89), or robust (rho: 0.90-1.00) correlation.[23]

The Kruskal-Wallis test was used to analyze differences between age groups and socioeconomic levels; differences by sex and school type were evaluated with the Mann-Whitney U test. A significant level of $p$ <0.05 was considered for all analyses performed with STATA 15® software.

## RESULTS

From July to December 2019, two hundred and three preschool and school-aged children, with an average age of 7.6 ± 2.1 years, of whom 56.2% were male, were included. The sociodemographic characteristics of the sample are detailed in *Table 1*.

The PBS results identified that children in private schools obtained statistically significantly

higher scores than those attending public schools (56 [51-56] vs. 55 [48-56]; *p* 0.0017) (*Table 2*). In addition, differences were observed in the PBS scores according to age range, where the 4- to 6-year-old group presented a lower score than the 7- to 9-year-old groups and 10- to 11-year-old (54 [48-56]) vs. 56 [51-56] vs. 56 [55-56] points, respectively; *p* 0.0001). This trend suggests an increase in PBS scores with age, as seen in *Table 2*.

## Reliability

Inter-rater reliability showed a very strong consistency, with an intraclass correlation coefficient (ICC) of 0.99 (95%CI: 0.995-0.998) in the total sample. This strong consistency in reliability was maintained when stratifying by sex (*Table 3*).

## Validity

*Table 4* presents the concurrent validation results, where weak inverse correlations were identified between the PBS total score and the variables measured through postural oscillography (MLV, MAPV, MTV, MR, and COP area). When analyzing the correlation by age ranges, the 4- to 6-year-old group maintained a weak inverse correlation between the PBS total score and the

**Table 1. Sociodemographic characteristics of the study population**

| Variables | Female (n = 89) | Male (n = 114) | Total (n = 203) | *P*-value |
|---|---|---|---|---|
| **Demographics** | | | | |
| Age, years | 7.5 ± 2.14 | 7.7 ± 2.13 | 7.6 ± 2.13 | 0.48 |
| Age groups, n (%) | | | | |
| 4-6 years | 37 (41.5) | 36 (31.6) | 73 (36.0) | 0.23 |
| 7-9 years | 34 (38.2) | 45 (39.5) | 79 (38.9) | |
| 10-11 years | 18 (20.3) | 33 (28.9) | 51 (25.1) | |
| **Type of school, n (%)** | | | | |
| Private | 45 (50,6) | 67 (58,7) | 112 (55.2) | 0,24 |
| Public | 44 (49.4) | 47 (41.2) | 91 (44.8) | |
| **Socioeconomic level, n (%)** | | | | |
| Low | 34 (38.6) | 53 (47,3) | 87 (43.5) | 0,51 |
| Medium | 14 (15.9) | 11 (9.8) | 25 (12.5) | |
| High | 40 (45.5) | 48 (42.9) | 88 (44) | |

*Data are presented as absolute and relative frequencies for qualitative variables, and as means with standard deviation for quantitative variables.*

**Table 2. Median scores obtained in the pediatric postural balance scale (PBS) according to sociodemographic variables**

| Variables | PBS score | *P*-value |
|---|---|---|
| **Demographics** | | |
| **Sex** | | |
| Female | 56 (48-56) | 0.4808 |
| Male | 56 (50-56) | |
| **Age groups*** | | |
| 4-6 years | 54 (48-56) | |
| 7-9 years | 56 (51-56) | **0.0001** |
| 10-11 years | 56 (55-56) | |
| **Type of school*** | | |
| Private | 56 (51-56) | **0.0017** |
| Public | 55 (48-56) | |
| **Socioeconomic level** | | |
| Low | 55 (48-56) | 0.2008 |
| Medium | 56 (50-56) | |
| High | 55 (49-56) | |

*PBS scores are expressed as median and interquartile range. **P** values in black and (*) indicate significant differences between groups, with Mann-Whitney U and Kruskal-Wallis tests. PBS: pediatric postural balance scale.*

postural oscillography variables with eyes opened and closed (MLV, MTV, MR, and COP area). In this group, correlations with MR (rho: -0.36; *p* 0.002) and COP area (rho: -0.37; *p* 0.001) stood out. No significant correlations were found in the older age groups (*Table 4*).

## DISCUSSION

The main findings of this research support the inter-rater reliability of the PBS in typically developing children aged 4 to 11 years with a very strong intraclass correlation coefficient (ICC: 0.99). A weak inverse correlation was observed between the PBS scale and the oscillography variables in the 4- to 6-year-old subgroup; the higher the score on the PBS, the lower the value on the oscillography variables, suggesting better postural control.

Significant differences were observed in the total PBS score across age ranges, with lower scores in the 4- to 6-year-old group, attributable to the motor and postural development of this stage, essential to perform the activities evaluated by the PBS.[2,24] The 7-9 and 10-11-year-old groups reached the maximum score, which coincides with previous studies that reported a ceiling effect in older children.[2,4]

This event is associated with the maturation of postural balance, which has shown progressive improvement with age.[25] Postural stability has been reported to improve between 4 and 5 years of age in fixed sensory environments; however, in dynamic sensory environments, improvements vary according to sensory conditions.[26]

Regarding sex differences, previous studies[2,27] have shown no differences in PBS total scores between boys and girls, suggesting that the development of postural balance follows a similar

**Table 3. Inter-rater reliability of PBS**

| PBS | Total | | Female | | Male | |
|---|---|---|---|---|---|---|
| | ICC | 95%CI | ICC | 95%CI | ICC | 95%CI |
| Average | 0.997 | 0.995-0.998 | 0.996 | 0.990-0.998 | 1.000 | |

*ICC: intraclass reliability coefficient. PBS: pediatric postural balance scale.*

**Table 4. Spearman's correlation coefficient (rho) between the pediatric postural balance scale (PBS) and postural oscillography by age group and total sample**

| Oscillography | Total, PBS (n = 203) | | 4-6 yrs, PBS (n = 73) | | 7-9 yrs, PBS (n = 79) | | 10-11 yrs, PBS (n = 51) | |
|---|---|---|---|---|---|---|---|---|
| | Rho | *P*-value | Rho | P-value | Rho | *P*-value | Rho | *P*-value |
| **MLV (mm/s)** | | | | | | | | |
| Eyes open | -0.27 | **0.000*** | -0.13 | 0.262 | -0.23 | **0.042*** | 0.05 | 0.707 |
| Eyes closed | -0.41 | **0.000*** | -0.33 | **0.004*** | -0.23 | **0.037*** | -0.20 | 0.156 |
| **MAPV (mm/s)** | | | | | | | | |
| Eyes open | -0.31 | **0.000*** | -0.28 | **0.016*** | -0.12 | 0.300 | -0.29 | **0.041*** |
| Eyes closed | -0.40 | **0.000*** | -0.29 | **0.013*** | -0.15 | 0.188 | -0.18 | 0.197 |
| **MTV (mm/s)** | | | | | | | | |
| Eyes open | -0.37 | **0.000*** | -0.33 | **0.004*** | -0.09 | 0.419 | 0.01 | 0.950 |
| Eyes closed | -0.35 | **0.000*** | -0.38 | **0.000*** | -0.15 | 0.198 | -0.11 | 0.433 |
| **MR (mm)** | | | | | | | | |
| Eyes open | -0.30 | **0.000*** | -0.36 | **0.002*** | -0.19 | 0.088 | -0.05 | 0.719 |
| Eyes closed | -0.31 | **0.000*** | -0.36 | **0.001*** | -0.13 | 0.258 | -0.10 | 0.471 |
| **COP area ($mm^2$)** | | | | | | | | |
| Eyes open | -0.26 | **0.000*** | -0.36 | **0.002*** | -0.15 | 0.177 | -0.04 | 0.791 |
| Eyes closed | -0.36 | **0.000*** | 0.37 | **0.001*** | -0.15 | 0.197 | -0.12 | 0.414 |

*MLV: maximum lateral velocity. MAPV: maximum anterior-posterior velocity. MTV: mean total velocity. MR: mean radius, COP area: area of the center of pressure. P values in black and (*) indicate significant differences between groups. Rho: Spearman correlation coefficient. PBS: pediatric postural balance scale.*

pattern in both sexes.

The weak correlation between PBS and the postural oscillography variables in our study could be explained by the ceiling effect associated with the maturation of postural control, which is reached around 6 years of age. In the subanalyses by age groups, the weak correlation is maintained in the 4-6 years group, disappearing in the 7-9 years and 10-11 years groups. These differences reflect the influence of sample size on the magnitude of the total correlation, which underlines the importance of focusing on the results of younger children. These findings are consistent with previous studies in populations with typical motor development.[2] However, PBS has been shown to have greater validity in children with special needs.[5,11]

Statistically significant differences in PBS scores were found between types of educational establishments; they were lower in public educational establishments. This disparity could be due to possible inequalities in opportunities to participate in extracurricular sporting activities,[28] economic resources,[29] and greater interest of parents in encouraging physical activity.[30] Private schools also tend to allocate more hours to physical education.[31]

This phenomenon highlights the importance of extrinsic factors in developing postural balance.

The results showed that the PBS has very strong inter-rater reliability, similar to that reported by Franjoine et al. (ICC = 0.85) in typically developing 5- and 7-year-old children[13] and in children with mild to moderate motor impairment, also showing high inter- and intra-evaluator reliability.[5,32,33]

The strengths of this study include an appropriate methodological design for the proposed objective, trained evaluators, and the use of validated instruments for the measurement of each variable. Among the limitations that should be considered for the interpretation of the results, the non-probabilistic selection may limit the extrapolation of the results; likewise, although the sample size exceeds the minimum necessary for the statistical tests used, this could influence the magnitude of the correlation found in the complete sample. However, stratifying the analyses by age range improved the adequacy of the sample size for each subgroup. Although postural oscillography provides an objective and accurate measurement of static balance by the center of pressure (COP) analysis,[15] lacks dynamic balance assessment. This represents a limitation shared with most of the studies that use this method since no instrument is accepted as a gold standard that jointly assesses static and dynamic components of postural balance. However, oscillography and COP are widely used in the international literature.

In conclusion, the PBS showed a very strong inter-rater reliability and a weak inverse correlation between the total score and the postural oscillography measurements in the 4- to 6-year-old age group, recommending its use mainly in this age group.

Future studies should consider different cultural contexts to evaluate the psychometric properties of PBS in preschoolers under 4 years of age, typically developing children, and children with educational needs. ■

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The supplementary material provided with this article is presented as submitted by the authors. It is available at: https://www.sap.org.ar/docs/publicaciones/archivosarg/2025/10276_AO_Andrade-Mayorga_Anexo.pdf

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