Eur Arch Otorhinolaryngol
DOI 10.1007/s00405-014-2930-9

MISCELLANEOUS

Reliability of postural control measures in children and young adolescents

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Received: 19 September 2013 / Accepted: 3 February 2014

Abstract Although many studies have been carried out regarding postural stability during pediatric age, reliable information and a complete analysis of all age groups are still lacking. The purpose of this study was to verify the test–retest reliability of posturographic parameters in four sensory conditions and provide normative values for children and young adolescents. 289 subjects, aged 6–14 years, were assessed by means of the static posturography system SVeP. 173 elementary school pupils (114 males and 59 females, aged 6–10 years; mean age 8.80 ± 1.53) and 116 middle school students (60 males and 56 females, aged 11–14 years; mean age 12.6 ± 0.9) underwent static posturography in two consecutive trials with four testing conditions: eyes open and eyes closed with and without foam pads. The participants were divided into nine age groups. Thirty healthy young adults were also recruited for comparison. The analysis of test–retest reliability demonstrated an excellent reliability of velocity measurement and a moderate reliability of area measurement. Velocity and area decreased significantly with age in all sensory conditions, indicating an improvement in postural control from childhood to adolescence. Postural stability had not reached the adult level by the age of 13–14 years. Reliable information regarding postural stability can be obtained in children and young adolescents by means of stabilometric parameters. These data can be used as a reference for early detection of atypical postural development and for the assessment of dizziness and balance disorders in children.

Keywords Postural control · Children · Adolescents · Reliability · Normative values

Introduction

Postural control is the complex ability to maintain the body's center of gravity over the base of support while a person is stationary. Appropriate postural control is necessary to maintain an upright position and to maintain balance during most daily life activities; furthermore, it is the fundamental prerequisite for the motor development of children. Postural control requires the organization and integration of somatosensory, visual and vestibular inputs by the central nervous system and the motor control process involved in executing musculoskeletal responses that keep the body within its limits of stability [1]. Children's balance control is less developed as compared to adults and postural stability improves progressively with age from childhood to adulthood [2–11].

Postural stability refers to the inherent ability of a person to maintain, achieve or restore a specific state of balance [12]. Understanding postural stability is relevant in the diagnostic and therapeutic approach to detecting and treating balance disorders in a very important period of development represented by childhood and early adolescence. In clinical practice,

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Published online: 21 February 2014

several methods may be used to assess postural stability. These tests include clinical balance tests and static and dynamic posturography measurements. Static posturography is an objective method of assessing balance: it is the quantitative measurement of the position and displacement of the body's center of pressure (COP), defined as the point of application of the ground reaction forces under the feet, using a force platform. It requires less complex and less expensive equipment than dynamic posturography; it takes little time and can be performed easily by young patients. Nevertheless, its use has been mainly restricted to the adult population.

The Standard Vestibology Platform (SVeP) is a force platform built according to the standard international norms of the Association Française de Posturologie [13], easy to transport and thus extremely useful in the school setting. It is marked with lines that indicate how the feet are to be placed. In addition, the use of foam pads permits the study of the influence of various sensory conditions on postural sway. By closing the eyes or by standing on a foam pad, inaccurate visual and somatosensory input is provided to the central nervous system. Comparing postural sway in different conditions permits the evaluation of sensory strategies for postural control. Moreover, the use of foam pads significantly reduces the variability of static posturography parameters in adults [14].

The COP has an intrinsic variability that affects the reliability and validity of postural control outcomes. Therefore, the reliability of postural control measurements should be established before they are used for clinical practice. Only when test–retest reliability of posturographic measurements is established, can normative data be determined and used to evaluate atypical postural development and to assess dizziness and balance disorders in children and young adolescents.

Static posturography is influenced by the age of the children and the equipment employed [15]. Reliable information could be obtained by posturographic measurements according to Liao et al. [16] in 50 children aged 5–12 years, Gabriel et Mu [17] in 18 children between 5 and 9 years old and Geldhof [12] in 20 children aged 9–10 years. More recently, De Kegel et al. [18] obtained reliable information regarding the postural stability of 49 typically developing children aged 6–12 using an AccuGait system.

Normative data available for static posturography in children are less extensive than those existing for adults [7, 12, 19–21]. The largest study is that of Hsu et al. [21] who analyzed the development of balance function with a Gravicoder GS-7 in 251 children, aged 3–12 years. However, test–retest reliability was not performed.

The aim of this study was to establish test–retest reliability of postural control measurements in a large number of typically developing children and young adolescents, aged from 6 to 14 years, and to provide normative values in four different sensory conditions.

Materials and methods

Subjects

This study was performed at the elementary and middle school of Istituto Zaccaria, in Milan. The parents of 315 children were notified by letter and asked for permission for their child to participate in this investigation. 289 parents gave written informed consent. Thus, a total of 289 healthy subjects were enrolled in this study: 173 children attending elementary school (114 males and 59 females, aged 6–10 years; mean age 8.80 ± 1.53) and 116 adolescents attending middle school (60 males and 56 females, aged 11–14 years; mean age 12.6 ± 0.9). Exclusion criteria included: a history of vertigo or dizziness; vestibular or neurologic disorders; uncorrected visual problems; sustained lower extremity injuries; use of medications influencing the balance system; hearing loss, and acute/chronic ear infections.

Prior to testing, a questionnaire was completed by a parent or guardian to determine whether the child had any conditions that would exclude him from participation in the study. Before performing posturography, the children's basic anthropometrical data were registered: body height was measured and recorded in cm to the nearest mm; body mass was measured to the nearest 0.1 kg with an electronic weight scale with the participant wearing shorts and a T-shirt.

The participants were divided into nine age groups: 6 years ($n = 20$); 7 years ($n = 43$), 8 years ($n = 38$), 9 years ($n = 27$), 10 years ($n = 45$); 11 years ($n = 29$); 12 years ($n = 41$); 13 years ($n = 35$); 14 years ($n = 11$). Thirty healthy young adults (mean age 22.2 ± 2.20 years), recruited from the university undergraduate population, volunteered to participate in the study for comparison. The gender, height and weight of the participants divided into age groups are reported in Table 1. This study was approved by the Ethical Committee of Istituto Zaccaria.

Experimental set-up

A routine otoscopic examination was carried out to evaluate the external auditory canal and the tympanic membrane. The audiometric threshold was measured using pure-tone audiometry performed in a quiet room using a portable device (Amplaid A321 Twin Channel, Amplifon, Italy). Air conduction thresholds were measured in each ear separately at octave frequencies between 0.25 and

Table 1 Descriptive characteristics (gender, height, weight) of the participants enrolled in this study, divided into age groups

Age group (years)	6	7	8	9	10	11	12	13	14	Adults
N	20	43	38	27	45	29	41	35	11	30
Boys/girls	11/9	32/11	21/17	17/10	33/12	13/16	19/22	24/11	4/7	6/24
Height (cm)	121 ± 6.6	128 ± 5.6	134 ± 5.3	140 ± 6.5	145 ± 5.9	149 ± 8.5	157 ± 7.9	160 ± 9.4	168 ± 9.1	169 ± 0.05
Weight (kg)	21 ± 4.8	26 ± 4.7	30 ± 4.2	34 ± 5.5	35 ± 6.8	37 ± 6.6	44 ± 8.2	45 ± 9.0	54 ± 8.9	58 ± 6.9

4 kHz transmitted through calibrated earphones (TDH 49). Tympanometry was carried out to detect middle ear abnormalities (Amplaid A321 Twin Channel, Amplifon, Italy). We used Jerger's classification to define tympanograms [22]: the middle ear pressure is higher than -100 daPa in the A-type curve, lower than -100 daPa in the C-type curve and flat in the B-type tympanogram. B- and C-type curves (flat curve and negative pressure) are associated with a middle ear effusion or a Eustachian tube dysfunction.

Static posturography

Static posturography was performed with the subject standing on a SVeP stabilometric platform (Politecnica-Amplifon, Modena, Italy). This is a stable force plate (dimension 50 cm × 50 cm × 7 cm, weight 12 kg), mounted on three strain-gauge force transducers positioned at the vertices of an equilateral triangle measuring 400 mm, which provides a description of body sway in terms of displacement of the patient's COP. Tests were carried out using a fixed visual target placed at a distance of 1.20 m at eye level in a quiet room to limit external influences. The children were instructed to maintain an upright standing position on the platform, barefoot, with their arms hanging by their sides. The platform has various horizontal and divergent lines for different sizes of feet, which are positioned oblique to each other, with the heels together immediately in front of the appropriate horizontal line and the toes pointing along the corresponding divergent line. All of the subjects underwent static posturography in four testing conditions, each lasting 52 s. Unstable condition tests were performed using ''bilayer'' foam pads with a thickness of 8 cm and a density of 100 kg/m^3.

- EO: firm surface with the eyes open; all visual, somatosensory and vestibular inputs interact on balance.
- EC: firm surface with the eyes closed and covered by an eye patch; visual input is removed.
- PAD EO: foam pads with the eyes open; somatosensory input is reduced.
- PAD EC: foam pads with the eyes closed; visual input is removed and somatosensory input is reduced.

To evaluate the reliability of the results, two consecutive trials were performed in each sensory condition. Between trials, an interval of 15 min was allowed to avoid learning or fatigue effects. All the tests were performed in the same room, with the same lighting. Strict instructions for foot placement were given to reduce the possible variation in foot positioning. The examiner checked that the feet were placed along the appropriate lines for the subject's foot size. The sequence of the conditions was the same in the two trials. The test and retest measurements were both performed by the same examiner.

The following *posturographic parameters* were examined: sway velocity (VM—mm/s) i.e., the length pro time unit; sway area (SX—mm^2) i.e., the surface of the confidence ellipse based on 90 % of the sample positions. Correlational analyses were conducted to investigate the influence of age, gender, body height and body weight, sport and tympanometric dysfunctions on the SVeP parameters.

Statistical analysis

The distribution of data was assessed in each age group by means of normal probability plot (QQ plot). On the basis of the results of the QQ plots, test–retest reliability was evaluated by intraclass correlation coefficients (ICCs) determined as intra-subject variance versus total variance [23]. An ICC score in the range 0.00–0.49 was considered poor, 0.50–0.74 moderate and 0.75–1.00 excellent [24]. The 95.0 % confidence interval (CI) for each ICC was also reported to provide a range of possible values. A multivariate approach to repeated measures Analyses of variance (MANOVA) was used [25]. Dependent variables were SX and VM; the categorical variables used as independent factors in the design were age (age class used as the ordinal variable), gender (male, female), practice of sports (yes, no), tympanogram in the left and the right ear (type A, B or C) and sensory condition (EO, EC, PAD EO, PAD EC). The sensory condition was a repeated intra-subject measure, while age, gender, sports practice and tympanograms were inter-subject evaluations. To examine the relative difference among the age groups for SX and VM in each type of test (EO, EC, PAD EO and PAD EC), we performed univariate analyses of variance (ANOVA) with post hoc

Bonferroni correction. Data analysis was performed using SPSS 20.0 (Statistical Package for the Social sciences 20.0, Inc., Chicago, IL).

Results

The physical and clinical characteristics of the participants were as follows: 91 % of the subjects were right-handed; 82 % practiced sport; 37 % wore orthodontic appliances; 17 % wore lenses; 10 % had flat feet; 8 % had attention disorders; 3 % had scoliosis; 18 % of females had menarche. All subjects were developing typically and presented normal motor function in their everyday life.

All of the participants had normal hearing: the PTA (0.5, 1, 2, 4 kHz) of the right ear was: 13.43 ± 2.81 dB SPL; the PTA of the left ear was: 13.49 ± 3.13 dB SPL. Most of the students had A-type tympanograms: these were recorded in 88 % of right ears and in 87 % of left ears of the elementary school children and in 96 % of right ears and in 97 % of left ears of the middle school children.

Test–retest reliability for SVeP measures

The test–retest reliability for SX and VM as assessed in the elementary and middle school children is reported in Table 2. Both test and retest measurements were available for 279 subjects; 10 participants did not perform the second session. The analysis of test–retest reliability demonstrated an excellent reliability of VM and a moderate reliability of SX for all sensory conditions.

Normative values for SVeP measures

Table 3 and Fig. 1 report the mean values and standard deviations of the posturographic parameters—SX, VM—in the four sensory conditions for each age group. Only the data of the first test were considered. The normative data obtained in healthy adults are included in Table 3 for comparison. Data were normally distributed in all age categories.

MANOVA showed significant differences ($p = 0.016$) among the four test conditions (EO, EC, PAD EO and PAD EC) and a significant reduction of the SVeP parameters (SX, VM) with increasing age ($p < 0.001$) for all tests combined. Furthermore, no significant differences were found between genders (170 males and 107 females; $p = 0.129$) or between subjects who practiced sports or not (265 yes and 12 no; $p = 0.357$). The type of tympanogram had no effect on SX and VM (right ear 253 A-type A, 6 B-type, 18 C-type, $p = 0.487$; left ear 251 A-type, 4 B-type, 22 C-type, $p = 0.670$), nor did weight (mean 35.56 ± 10.76 kg, range 12–70 kg; $p = 0.682$) or height (mean 144.10 ± 14.78 cm, range 112–184 cm; $p = 0.803$). The age groups were significantly different in terms of SX ($p < 0.001$) and VM ($p = 0.001$).

The detailed Bonferroni post hoc test results are reported in Table 4. Children aged 6 and 7 years showed significantly higher values than older children with the exception of VM in the EC condition. From the age of 9, the values continued to decrease, but without significance. From 7 years, VM and SX in the EC condition did not differ among the age groups of children and young adolescents, but did differ from the adults' values.

Bonferroni tests indicate that VM was significantly different between children up to 13 years of age and adults, while the same value showed a decreasing trend in 14-year-old participants with respect to adults. SX was significantly different between 6-, 7- and 8-year-olds and adults, while the older children showed a decreasing trend with respect to adults. Each p value is reported in Table 4.

Discussion

This study presents the results of balance evaluation performed using static posturography on 289 subjects attending elementary and middle school. As far as we know, it comprises one of the largest samples of children and young adolescents assessed using static platforms in literature, providing either test–retest reliability or normative data for stabilometric parameters using SVeP. Static posturography

Table 2 Test–retest reliability for static posturography measures (SX and VM) as assessed in elementary school children (173) and middle school children (116) using SVeP in four different sensory conditions

	Surface (SX)			Velocity (VM)		
	ICC	95 % CI	Evaluation	ICC	95 % CI	Evaluation
EO	0.57	0.48–0.64	Moderate	0.75	0.65–0.78	Excellent
EC	0.61	0.53–0.68	Moderate	0.76	0.70–0.80	Excellent
Pad EO	0.50	0.41–0.58	Moderate	0.75	0.70–0.80	Excellent
Pad EC	0.55	0.47–0.63	Moderate	0.72	0.65–0.77	Excellent

Expressed as intraclass correlation coefficients, and their relative 95 % confidence intervals

Table 3 Static posturography parameters of 289 children and 30 young adults. Mean values and standard deviations of sway area (SX), sway velocity (VM) in the four test conditions for each age group

	6 years	7 years	8 years	9 years	10 years	11 years	12 years	13 years	14 years	Adults
SX (mm^2)										
EO	513.5 ± 286.3	434.5 ± 211.4	364.3 ± 201.2	308.7 ± 176.5	338.9 ± 191.8	227.6 ± 121.6	240.5 ± 117.9	244.1 ± 143.3	219.1 ± 110.7	159.39 ± 97.89
EC	819.8 ± 675.6	589.1 ± 274.5	564.4 ± 337.7	531.2 ± 386.6	548 ± 667.8	407.8 ± 189.3	387.9 ± 162.3	454.2 ± 400.2	312.2 ± 173.8	254.59 ± 178.01
Pad EO	699.3 ± 582.3	501.9 ± 407.3	445.4 ± 314.6	361.9 ± 254.7	352.6 ± 180.2	249.0 ± 122.7	281.7 ± 101.0	382.5 ± 281.3	336.0 ± 331.2	194.09 ± 103.97
Pad EC	1,137.2 ± 657.7	669.3 ± 536.4	602.9 ± 442.0	629.6 ± 383.5	491.5 ± 343.2	335.52 ± 179.6	458.9 ± 344.3	515.9 ± 337.8	392.2 ± 290.2	303.08 ± 144.37
VM (mm/s)										
EO	16.7 ± 4.2	14.5 ± 2.5	12.6 ± 2.32	12.5 ± 2.7	12.1 ± 1.9	13.2 ± 10.9	11.4 ± 2.8	10.3 ± 2.0	9.4 ± 2.1	6.43 ± 1.38
EC	22.8 ± 12.0	19.8 ± 4.95	18.5 ± 5.4	17.4 ± 5.2	19.8 ± 15.1	17.0 ± 6.00	16.2 ± 5.0	15.8 ± 5.5	14.4 ± 2.5	9.34 ± 2.48
Pad EO	20.3 ± 5.4	17.3 ± 5.2	14.7 ± 2.4	13.9 ± 3.5	13.3 ± 2.3	12.3 ± 2.7	12.0 ± 2.8	12.5 ± 2.9	10.6 ± 2.0	7.19 ± 1.67
Pad EC	30.4 ± 8.9	23.7 ± 7.3	21.1 ± 5.00	20.3 ± 4.6	19.2 ± 7.0	16.6 ± 4.2	16.6 ± 4.8	16.5 ± 5.7	14.7 ± 3.4	11.22 ± 2.94

could be performed easily on a pediatric population; the test required only few minutes to be carried out; the only difficulty we found was in maintaining the children's concentration during the whole time of data acquisition.

One of the most common objections related to the clinical application of static posturography is the poor repeatability of tests due to high intra-subject and inter-subject variance of the sway measurements [26]. The current study revealed a moderate to excellent reliability of sway parameters obtained using a SVeP system. In 6- to 14-year-old children, the mean velocity demonstrated an excellent test–retest reliability for all the sensory conditions. VM is one of the most commonly used COP parameters, indicating how well the subject accomplishes the task of standing as still as possible. It represents an expression of the energy spent by the postural system to maintain balance [27]. Our result is in line with previous studies reporting mean sway velocity as the most reliable traditional parameter in adults and children [12, 18, 28, 29]. In children aged 6–14 years, the SX value showed a moderate reliability in all conditions. It is the quantitative index of postural sway, reflecting the area beneath the feet on which the COP oscillates and might be more affected than other measures by the degree of attention of the subjects examined. Standard deviations were large for all measurements and larger in the younger subjects compared with the older subjects and adults, thus indicating a high inter-subject variability of stabilometric parameters, as is already known [30].

Reference values are provided for two parameters (SX and VM) in four sensory conditions (open/closed eyes, with and without foam pads) for nine age groups of children, aged 6–14 years. Sway measurements—SX and VM—decreased significantly with age in all sensory conditions, indicating an improvement in postural control from childhood to adolescence consistent with that reported by previous posturographic studies [2, 4, 7, 8, 10, 11, 21, 31]. When visual information was not available, all of the groups behaved in the same way and differed only from adults in terms of VM, even though there was a decreasing trend; as for SX, the group of 6-year-olds differed from the groups of 11 years and above. Data obtained in EC condition may be explained by the visual predominance in children already reported by many authors [3, 8, 9].

In our sample, the children and young adolescents swayed more than the adults and their postural stability had not reached the adult level by the age of 13–14 years. These results lead us to hypothesize that balance control and the processing of sensory integration are still developing during early adolescence. In the literature, there are different opinions regarding when postural control becomes comparable to that of adults. Some authors [3, 11] indicate the age of 7–10 years, while others [7, 32, 33] suggest that some aspects of postural control still appear to be developing

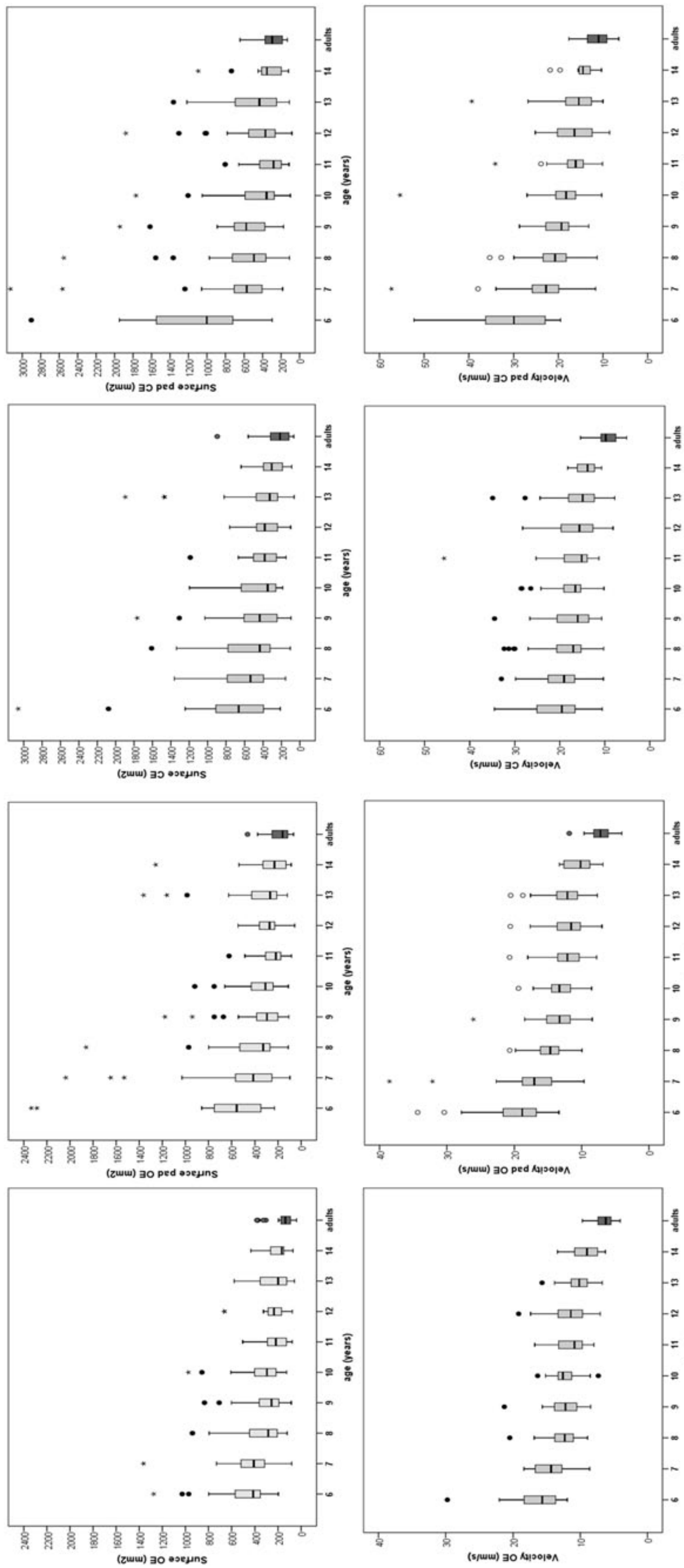

Fig. 1 Box plots of VM and SX in the nine age groups in four sensory conditions. Any data not included between the whiskers has been plotted as an outlier with a dot

Table 4 *P* values of Bonferroni post hoc tests comparing SVeP parameters of each test condition in two age groups

Age groups (years)		SX				VM			
		EO	EC	PAD EO	PAD EC	EO	EC	PAD EO	PAD EC
6	7	ns	ns	ns	<0.001	ns	ns	0.05	<0.001
	8	ns	ns	0.08	<0.001	ns	ns	<0.001	<0.001
	9	<0.001	ns	0.01	<0.001	ns	ns	<0.001	<0.001
	10	0.02	ns	<0.001	<0.001	0.01	ns	<0.001	<0.001
	11	<0.001	0.01	<0.001	<0.001	ns	ns	<0.001	<0.001
	12	<0.001	<0.001	<0.001	<0.001	<0.001	ns	<0.001	<0.001
	13	<0.001	0.04	0.01	<0.001	<0.001	ns	<0.001	<0.001
	14	<0.001	0.03	0.05	<0.001	<0.001	ns	<0.001	<0.001
	Adults	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
7	8	ns	ns	ns	ns	ns	ns	0.02	ns
	9	ns	ns	ns	ns	ns	ns	<0.001	ns
	10	ns	ns	ns	ns	ns	ns	<0.001	0.03
	11	<0.001	ns	0.01	0.01	ns	ns	<0.001	<0.001
	12	<0.001	ns	0.03	ns	0.07	ns	<0.001	<0.001
	13	<0.001	ns	ns	ns	<0.001	ns	<0.001	<0.001
	14	0.02	ns	ns	ns	0.04	ns	<0.001	<0.001
	Adults	<0.001	0.013	<0.001	0.004	<0.001	<0.001	<0.001	<0.001
8	9	ns	ns	ns	ns	ns	ns	ns	ns
	10	ns	ns	ns	ns	ns	ns	ns	ns
	11	0.04	ns	ns	ns	ns	ns	ns	0.04
	12	0.09	ns	ns	ns	ns	ns	0.02	0.03
	13	ns	ns	ns	ns	ns	ns	ns	0.03
	14	ns	ns	ns	ns	ns	ns	0.02	0.06
	Adults	<0.001	0.046	0.016	ns	<0.001	<0.001	<0.001	<0.001
9	10	ns	ns	ns	ns	ns	ns	ns	ns
	11	ns	ns	ns	ns	ns	ns	ns	ns
	12	ns	ns	ns	ns	ns	ns	ns	ns
	13	ns	ns	ns	ns	ns	ns	ns	ns
	14	ns	ns	ns	ns	ns	ns	ns	ns
	Adults	ns	ns	ns	ns	<0.001	0.003	<0.001	<0.001
10	11	ns	ns	ns	ns	ns	ns	ns	ns
	12	ns	ns	ns	ns	ns	ns	ns	ns
	13	ns	ns	ns	ns	ns	ns	ns	ns
	14	ns	ns	ns	ns	ns	ns	ns	ns
	Adults	0.001	ns	ns	ns	<0.001	<0.001	<0.001	<0.001
11	12	ns	ns	ns	ns	ns	ns	ns	ns
	13	ns	ns	ns	ns	ns	ns	ns	ns
	14	ns	ns	ns	ns	ns	ns	ns	ns
	Adults	ns	ns	ns	ns	<0.001	0.002	<0.001	0.008
12	13	ns	ns	ns	ns	ns	ns	ns	ns
	14	ns	ns	ns	ns	ns	ns	ns	ns
	Adults	ns	ns	ns	ns	<0.001	0.007	<0.001	0.005
13	14	ns	ns	ns	ns	ns	ns	ns	ns
	Adults	ns	ns	ns	ns	0.016	0.03	<0.001	0.010
14	Adults	ns	ns	ns	ns	ns	ns	ns	ns

after 9–10 years of age. Our findings are in accordance with those of Hirabayashi and Iwasaki [6], Ferber-Viart et al. [8], Peterka and Black [34], Cumberworth et al. [35] and Steindl et al. [36] who observed that the maturation progress continues throughout childhood and does not reach the adult level even at the age of 14–15 years. Our study concerns individuals attending elementary and middle school that ends at the age of 13–14 years; the group of 14-year-olds is therefore limited ($n = 11$). It would be interesting to extend the evaluation by including a greater number of individuals in the group of 14-year-olds and also by adding older adolescents.

In our study, all of the participants practiced physical activity at school (3 h a week) and most of them were engaged in various sports after school and at the weekend. The practice of sporting activities did not seem, however, to influence postural stability as demonstrated by the absence of correlation with sway parameters. This investigation showed no relation between anthropometric measurements (height and weight) and balance parameters in children aged 6–14 years. Our data regarding body height and weight are in accordance with those of Nolan et al. [7], Lebiedowska and Syczewska [19] and Peterson et al. [32] and differ from those of Schmid et al. [20], and Hsu et al. [21]. According to Nolan [7], this observation might be explained by the fact that, although stature and weight change as children grow, the development of the visual, vestibular and somatosensory systems may account for changes in balance control to a greater extent. Therefore, it would seem that the age and the development of the individual's sensory organization affect results more than anthropometric characteristics. Tympanometry was performed to detect middle ear abnormalities, since Eustachian tube dysfunction is considered a common cause of balance disorder in children [37] and subjects with otitis media with effusion have demonstrated increased postural sway during dynamic stabilometry [38]. Middle ear dysfunction was reported in a minority of young participants of our sample and was not correlated to sway parameters.

In conclusion, the present study showed that reliable information regarding postural stability may be obtained from children and young adolescents in terms of stabilometric parameters—velocity and area—using the SVeP system. In particular, velocity showed an excellent test–retest reliability confirming other researchers' results that it is the most reliable index to use for early detection of atypical postural development and for the assessment of dizziness and balance disorders in young patients.

Acknowledgments The authors would like to thank the parents and the children who participated in this study and Amplifon Politecnica (Modena, Italy) for granting use of the stabilometric platform.

Conflict of interest None.

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