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EFFECT OF SENSORY CONDITIONS ON POSTURAL CONTROL IN CHILDREN AGED 4 TO 7 YEARS

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ABSTRACT

Introduction: Maintaining stability and body balance are key aspects of motor development during childhood. These are functions of the postural control system, which is linked to the sensory and motor nervous systems. Material and Methods: We studied the effect of sensory conditions of different tasks on postural control in 66 children aged 4 to 7 years. Three tests were passed: visual alteration test, vestibular alteration test and proprioceptive alteration test. Three mixed model MANOVA tests were performed, one for each test, in order to verify the effect of age (x4) and block (x6) on the 3 study variables. Results: The results show that age and block had a main effect on the dependent variables in the 3 tests performed, as well as an effect of age-block interaction on the vestibular test. In addition, the proprioceptive alteration generates a greater postural imbalance and, afterwards, there was a greater sensory reweighting. Conclusions: an effect of the sensorial condition was found in all tests on the postural control in all the ages studied. Moreover, it was observed that the alteration of the vestibular information affects the youngest children to a greater extent.

Key words: balance, stability, sensory reweighting, motor development, centre of pressures

EFECTO DE LAS CONDICIONES SENSORIALES EN EL CONTROL POSTURAL, EN NIÑOS DE 4 A 7 AÑOS

RESUMEN

Introducción: el mantenimiento de la estabilidad y del equilibrio corporal son aspectos clave en el desarrollo motriz durante la niñez. Se trata de funciones del sistema de control postural, el cual está vinculado a los sistemas nerviosos sensoriales y motores. Material y métodos: se estudió el efecto de las condiciones sensoriales de diferentes tareas en el control postural en 66 niños de 4 a 7 años. Se pasaron tres pruebas: de alteración visual, de alteración vestibular y de alteración propioceptiva. Se realizaron tres MANOVA de modelo mixto, una para cada prueba, con el fin de comprobar el efecto de la edad (x4) y del bloque (x6) en las 3 variables de estudio. Resultados: los resultados muestran que existe un efecto principal de la edad y del bloque sobre las variables dependientes en las 3 pruebas realizadas, y un efecto de la interacción edad-bloque en la prueba vestibular. Además, la alteración propioceptiva genera un mayor descontrol postural y, tras ella, se produjo una mayor reintegración sensorial. Conclusiones: se encontró un efecto de la condición sensorial, en todas las pruebas, sobre el control postural, en todas las edades estudiadas. Además, se observó que la alteración de la información vestibular afecta en mayor medida a los niños más pequeños.

Palabras clave: equilibrio, estabilidad, reintegración sensorial, desarrollo motor, centro de presiones

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INTRODUCTION

At present, the importance of a good corporal alignment is demonstrated, as this benefits us from a health standpoint and contributes to a greater functional efficiency (Ludwig, 2017). The posture (of Latin *positura*: plant), is defined as the way of placing the body in space, that is, the configuration of each of the segments and body joints in reference to this one (Woollacott & Shumway-Cook, 2002). To maintain a correct posture, and adapted to a specific movement (walking, running, spinning, jumping, etc.), the information collected by the visual, vestibular and proprioceptive systems is a key aspect (Tropp, Ekstrand & Gillquist, 1984; Palmieri, Ingersoll, Stone & Krause, 2002). This information will be integrated by the nervous system, which will send the relevant orders to the motor system. These three levels give rise to the so-called *postural control system* (Tropp, et al., 1984; Allum, Bloem, Carpenter, Hulliger & Hadders-Algra, 1998). The postural control system matures throughout childhood, passing from primitive reflexes controlled by the spinal cord and the protuberance, to an increasing control by the cerebral cortex (Woollacott & Shumway-Cook, 1990; Assaiante, 1998).

Restricting or altering any sensory system that participates in the maintenance of stability has been a widely used strategy to study its effect on posture: restricting vision by closing the eyes (Butterworth & Hicks, 1977), altering the proprioception by using vibrating surfaces (Olivier, Cuisinier, Vaugoyeau, Nougier & Assaiante, 2010) or altering the vestibular system by means of pink or white sounds (Park, Lee, Lockhart & Kim, 2011; Tanaka, Kojima, Takeda, Ino & Ifukube, 2001) affect postural control. For example, in Olivier et al. (2010), it was verified how the effect of alteration varied from 7 years to adulthood, resulting in much body instability as subjects were younger.

To observe the effect that the feedback of the sensory information has on recovery of balance and, therefore, the reorganization of postural control, some studies have restricted or altered a sensory system and have therefore eliminated that restriction or alteration. Thus, Vuillerme, Teasdale & Nougier (2001) showed that gymnasts recover their stability, after the alteration of proprioception, more quickly than other athletes. Brown et al. (2006) made a similar approach, but with Parkinson's patients and by visual restriction. The results showed that people suffering from Parkinson's disease recovered the stability worse than people not suffering this disease.

Other studies that also analyze this phase of reorganization may be contextualized in the field of health. As an example of them, we should mention those of Teasdale & Simoneau (2001) and Doumas & Krampe (2010), who investigated the effect of aging in this phase. It is also concluded from this that situations or actions that require a phase of reweighting of sensory inputs could lead to a greater risk of losing balance than situations or actions in which it does not exist.

However, to date, there are few studies focused on early ages. Therefore, the objective of this study was to know the effects of the different sensory conditions of different tasks on the postural control in children aged 4 to 7 years, as well as the evolution of the reorganization or feedback of the sensory information subsequent to the restriction.

METHOD

Participants

In the study, 66 children aged between 4 and 7 years have taken part voluntarily. They were organized in the following groups:

1. 18 children from 4 years to 4 years and 11 months of age.
2. 17 children from 5 years to 5 years and 11 months of age.
3. 18 children from 6 years to 6 years and 11 months of age.
4. 13 children from 7 years to 7 years and 11 months of age.

The exclusion criteria were: i) suffering from cardiovascular or neurological diseases that may affect motor control, ii) having motor impairments or disabilities, iii) having suffered injuries in the lower limbs during the last 6 months, iv) suffering any other alteration or pathology that may affect balance.

The study was approved by the Ethics Committee of the University of Valencia (reference number: H1443609882941). Both the children and their parents or legal guardians were informed of the characteristics of the study, and the latter signed a written consent.

Instruments

A force platform (WBB, Nintendo, Kyoto, Japan) was used. It was made up by four force transducers which registered it at a frequency of 40 Hz. In the case of the third test, two vibration-generating devices were used, made *ad hoc* and placed on the ankles (figure 1).

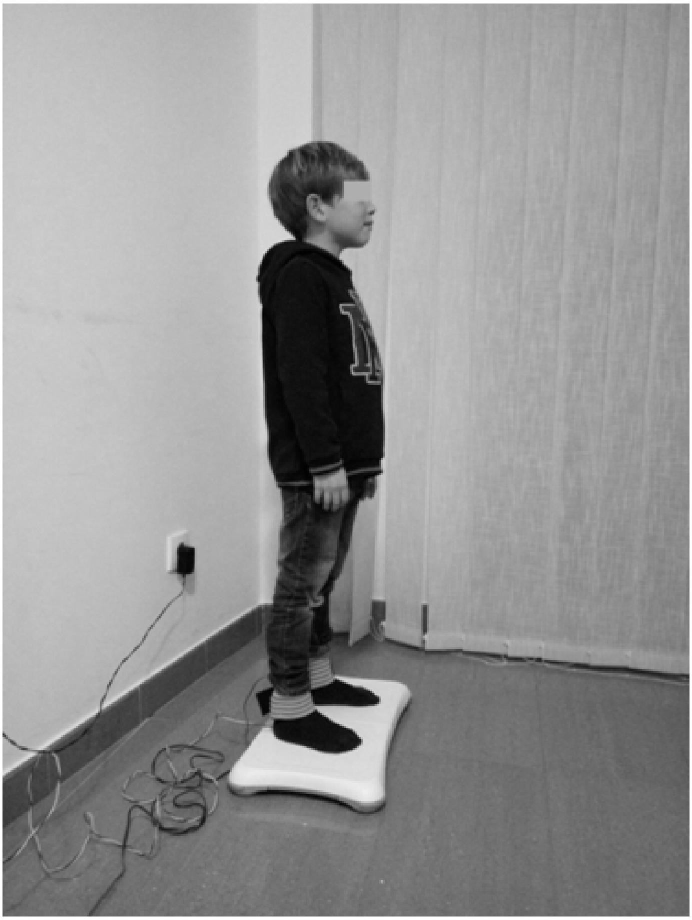

FIGURE 1: Representation of the proprioceptive alteration test.

Measurement of postural control

The force platform was fixed on a stable horizontal surface on the ground so as to avoid distortion and noise in the signal. To standardize the position, barefoot subjects placed the feet parallel and separated to the width of the shoulders.

A reference point (5 cm in diameter) was placed in front of the subject at the level of the eyes, at a distance of 2 m. Since the participants were young children and keeping them concentrated during all the tests was complicated, they were told a story as a game so that they had a stimulus and could be attentive during the whole measurement. A 30-second attempt was recorded in each of the following tests (if they had moved a lot or had been talking during the test, this one was repeated):

1. VIA (visual alteration): the participants placed themselves on the force platform, with their arms at the sides, in a relaxed manner, as static as

possible, and they had their eyes open, looking at the reference located 2 metres away. After 10 seconds, the subjects had to close their eyes. After 10 more seconds, they opened their eyes again and had to still until the end of the 30 seconds which the test took.

2. VEA (vestibular alteration): the participants were kept looking at the point during the 30 seconds. After the first 10 seconds, a sound with white noise of 85-100 dB was activated. It could be listened through headphones. After 10 seconds, this sound was over. It was disconnected, returning to the initial situation to finish the last 10 seconds.
3. PRA (proprioceptive alteration): the test was carried out in the same way as the previous one. The difference was that instead of altering the vestibular system by sound, the proprioception was altered by vibrators from the second 10 to the second 20 (frequency = 85 Hz, amplitude = 1 mm), placed on the participants' ankles.

Study variables

The signals were conditioned and calculated using the Matlab 7.0 program. (Mathworks Inc., Natick, USA). The signals were digitally filtered by a fourth order Butterworth low pass filter, with a 12 Hz cut off frequency, and analyzed in the time domain. Each record was divided into 6 blocks of 5 seconds. The following variables were calculated in every block (Prieto, Myklebust, Hoffmann, Lovett & Myklebust, 1996):

EA: swept area by the CoP, also called Ellipse area. (Units: mm^2)

MVAP: mean velocity of the displacement of the CoP in the antero-posterior axis. (Units: mm/s).

MVML: mean velocity of the displacement of the CoP in the medio-lateral axis. (Units: mm/s).

Statistical analysis

The SPSS version 20 program for MAC was used (IBM SPSS, IBM Corporation, Somers, NY). First, the fulfilment of assumptions of normality was verified (Kolmogorov-Smirnov test) and homoscedasticity (Levene test). Then, three mixed model MANOVA tests were performed in order to verify the effect of age (x4) and block of the test (x6) (each test was decomposed in 6 blocks of 5 seconds) on the variables that report postural control. The follow-up of the multivariate contrasts was carried out by means of univariate contrasts. Finally, we requested pairwise comparisons with the Bonferroni adjustment in the case of finding significant univariate effects. The level of significance was set at $p = 0.05$ in all the analyses.

RESULTS

In the VIA test, a main effect of age ($F_{9/183}$ = 3,84; p < 0,001; η^2_p = 0,16) and block ($F_{15/47}$ = 6,38; p < 0,001; η^2_p = 0,67) on the dependent variables was found. However, there was not a significant effect in the interaction of these two factors ($F_{45/147}$ = 1,1; p = 0,32; η^2_p = 0,25). The pairwise comparisons showed higher values in the EA in the 4-year group ($\bar{x}$=488,65; σ=528,11) than in the rest of the ages (p < 0,05). In addition, the MVAP ($\bar{x}$=20,92; σ=8,32) and MVML ($\bar{x}$=19,78; σ=8,07) were also higher in children of 4 years than in the rest of groups (p < 0,05). Regarding the pairwise comparisons related to the blocks, a significantly higher MVAP was found in blocks 3 and 4 than in the rest. Nevertheless, in the EA and MVML variables, no significant differences were found between the blocks as the univariate contrasts had shown (table 1).

TABLE 1
Pairwise comparisons between blocks in the VIA test.

Variable	Block	Mean	Standard deviation
EA (mm²)	Block 1	234.28	289.52
	Block 2	217.43	298.29
	Block 3	279.82	295.21
	Block 4	325.61	408.78
	Block 5	300.65	357.74
	Block 6	276.65	390.21
MVAP (mm/s)	Block 1	14.67*	8.71
	Block 2	14.07*	6.14
	Block 3	18.77	7.37
	Block 4	19.33	9.11
	Block 5	15.65*	6.58
	Block 6	13.85*	5.24
MVML (mm/s)	Block 1	15.02	7.35
	Block 2	14.34	6.66
	Block 3	15.02	6.10
	Block 4	15.51	6.36
	Block 5	15.00	6.92
	Block 6	14.29	6.24

*EA = ellipse area; MVAP = mean velocity in the antero-posterior axis; MVML = mean velocity in the medio-lateral axis. * It indicates significant differences regarding block 3 and 4 (p < 0.05).*

Figure 2 represents the mean of each variable for each block and age group. This graphic representation helps us understand the differences between the blocks and age groups which were previously described.

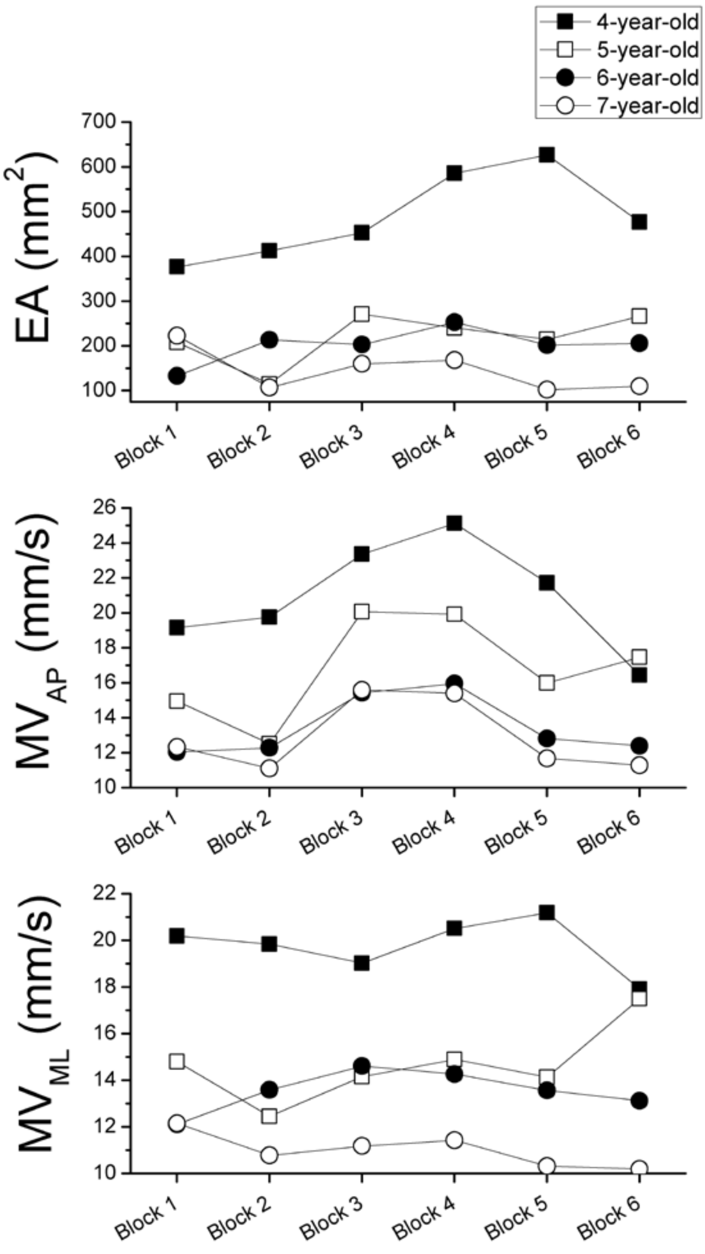

FIGURE 2: Graphs of the variables EA, MVAP and MVML in the VIA test.
EA = ellipse area; MVAP = mean velocity in the antero-posterior axis; MVML = mean velocity in the medio-lateral axis.

In relation to the results obtained in the VEA test, a main effect of age ($F_{9/186}$ = 4,17; p < 0.001; η^2_p = 0,17), block ($F_{15/48}$ = 4,96; p < 0,001; η^2_p = 0,61) and the interaction of these two factors ($F_{45/930}$ = 1,65; p < 0.01; η^2_p = 0,074) on the dependent variables was found. Pairwise comparisons showed higher values in the EA ($\bar{x}$=559,39; σ=822,02) and in the MVAP ($\bar{x}$=19,23; σ=7,48) in the 4-year group than in the 6 and 7-year groups (p < 0,05), and they showed higher values in the MVML in the 4-year group ($\bar{x}$=20,58; σ=9,95) than in the rest of the age groups (p < 0,05). Concerning the pairwise comparisons related to the blocks, on the one hand, a greater EA was found in block 3 ($\bar{x}$=732,53; σ=1377,22) than in blocks 1, 2, 4 and 5. On the other hand, a greater MVAP ($\bar{x}$=26,05; σ=17,62) and MVML ($\bar{x}$=23,49; σ=16,68) in block 3 than in the rest of the blocks.

As far as the pairwise comparison related to the age-block interaction is concerned, an upper EA was found in the 4-year group than in the 6-year group during block 1 and 3, as well as than in the 7-year group in block 6. A higher MVAP was also observed in the 4-year group than in the other groups in block 2, a higher MVAP in the 4-year group than in the 5-year and 6-year groups in block 3, a higher MVAP in the 4 and 5-year groups than in the 6-year group in block 5, and a higher MVAP in the 4-year group than in the 6 and 7-year groups in block 6. Moreover, a superior MVML was demonstrated in the 4-year group than in the rest of groups in blocks 1 and 2. Finally, it was demonstrated a superior MVML in the 4-year group than in the 6 and 7-year groups in blocks 3, 5 and 6. Table 2 shows the associated descriptive statistics.

TABLE 2
Pairwise comparisons between age-block interaction in the VEA test.

Variable	Block	Age	Mean	Standard deviation
EA (mm²)	Block 1	4	312,83	332,85
		5	145,93	104,93
		6	127,16*	91,63
		7	140,83	128,95
	Block 2	4	212,02	142,05
		5	104,16	52,23
		6	181,44	291,72
		7	105,45	63,25
	Block 3	4	1510,47	2371,32
		5	744,66	716,24
		6	295,36*	279,89
		7	244,83	246,01
	Block 4	4	234,33	282,89
		5	150,05	117,88
		6	141,35	112,28
		7	118,02	72,72
	Block 5	4	514,35	945,28
		5	202,82	188,43
		6	110,61	92,95
		7	102,09	75,67
	Block 6	4	572,31	857,74
		5	203,41	142,99
		6	157,36	188,36
		7	96,08*	61,57
MVAP (mm/s)	Block 1	4	14,60	3,81
		5	13,15	5,24
		6	11,07	2,36
		7	12,29	6,06
	Block 2	4	15,10	4,19
		5	11,21*	3,25
		6	10,63*	2,94
		7	10,56*	3,47
	Block 3	4	39,71	22,81
		5	26,95*	14,20
		6	17,87*	8,84
		7	17,27	10,06
	Block 4	4	14,71	4,28
		5	15,17	9,90
		6	11,06	3,08
		7	12,28	5,36
	Block 5	4	15,58	4,75
		5	14,64	7,06
		6	10,27*†	2,52
		7	11,17	2,53
	Block 6	4	15,68	5,03
		5	14,03	4,77
		6	11,43*	3,33
		7	10,45*	3,55

TABLE 2 (Cont.)

MVML (mm/s)	Block 1	4	17,17	6,05
		5	12,97*	3,98
		6	11,57*	3,41
		7	11,73*	3,97
	Block 2	4	16,46	4,06
		5	11,46*	2,81
		6	11,55*	2,35
		7	10,74*	2,95
	Block 3	4	36,90	23,19
		5	23,96	12,63
		6	15,47*	5,73
		7	15,41*	7,01
	Block 4	4	16,02	4,82
		5	13,06	4,77
		6	12,04	3,48
		7	12,36	5,67
	Block 5	4	18,87	13,31
		5	13,38	4,76
		6	10,65*	2,90
		7	10,52*	2,39
	Block 6	4	18,08	8,25
		5	13,69	5,65
		6	11,65*	3,26
		7	10,68*	2,21

EA = ellipse area; MVAP = mean velocity in the antero-posterior axis; MVML = mean velocity in the medio-lateral axis. It indicates significant differences regarding 4-year group ($p < 0.05$). † It indicates significant differences regarding the 5-year group ($p < 0.05$).*

In addition, figure 3 represents the mean of each variable for each block and age group of the VEA test. This graphic representation helps us understand the differences that have been commented on the matter.

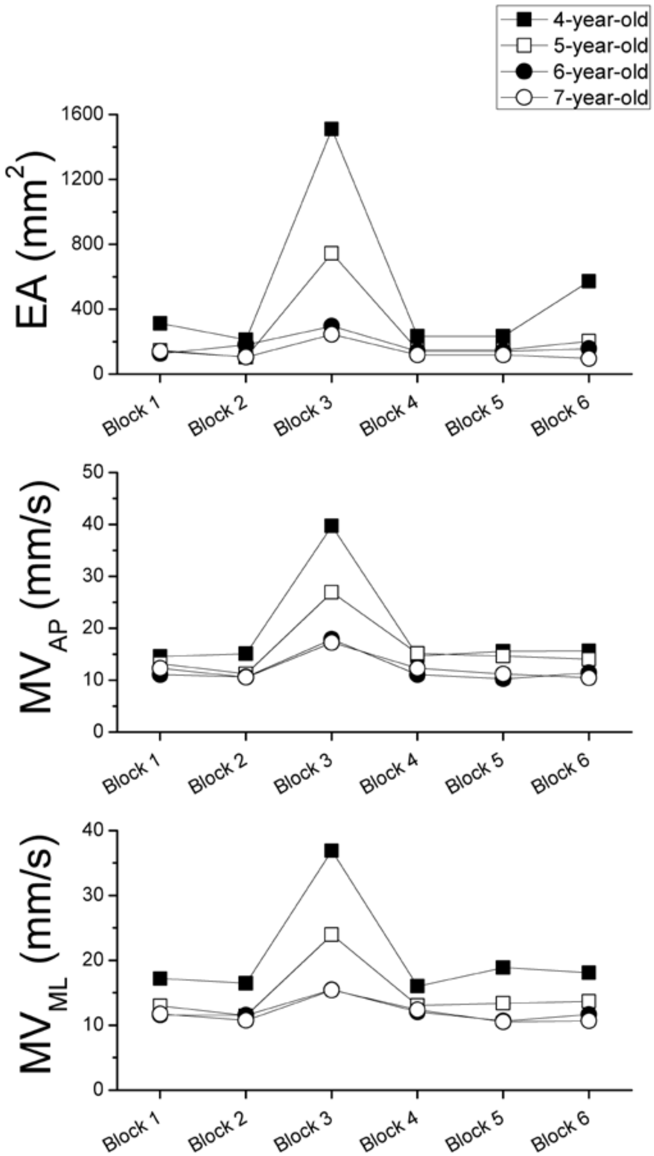

FIGURE 3: Graphs of the variables EA, MVAP and MVML in the VEA test.
EA = ellipse area; MVAP = mean velocity in the antero-posterior axis; MVML = mean velocity in the medio-lateral axis.

Regarding the third test (APR), a main effect of age ($F_{9/186}$ = 3,83; p < 0,001; η^2_p = 0,16) and block ($F_{15/48}$ = 17,73; p < 0,001; η^2_p = 0,85) on the dependent variables was found. Nevertheless, there was no significant effect in the interaction of these two factors ($F_{45/150}$ = 1,03; p = 0,43; η^2_p = 0,24). Pairwise comparisons between age groups showed higher values in the EA of the 4-year group ($\bar{x}$=599,84; σ=544,68) than in the 5 and 7-year groups (p <0.05). Furthermore, the MVAP ($\bar{x}$=30,80; σ=10,45) and MVML ($\bar{x}$=21,32; σ=7,56) were also higher in 4 year-old children than in the rest of groups (p <0.05). Regarding the pairwise comparisons related to the blocks, a greater EA was found in block 3 than in blocks 1, 2, 4 and 6; a greater EA in block 4 than in blocks 1 and 2; a greater EA in block 5 than in blocks 1, 2 and 6; and a greater EA in block 6 than in block 1. Also, a higher MVAP was observed in blocks 3 and 4 than in blocks 1, 2, 5 and 6; a higher MVAP in block 5 than in blocks 1, 2 and 6; and a higher MVAP in block 6 than in block 1. Besides, a higher MVML was detected in blocks 3 and 4 than in blocks 1, 2, 5 and 6; and a higher MVML in block 5 than in blocks 1 and 2 (table 3).

TABLE 3
Pairwise comparisons between blocks in the PRA test.

Variable	Block	Mean	Standard deviation
EA (mm^2)	Block 1	163,82*†‡§	142,66
	Block 2	180,31*†‡	203,87
	Block 3	615,59	607,28
	Block 4	421,27*	393,95
	Block 5	615,08	749,75
	Block 6	317,28*‡	383,45
MVAP (mm/s)	Block 1	16,07*†‡§	5,32
	Block 2	16,15*†‡	5,64
	Block 3	34,87	13,81
	Block 4	31,02	14,22
	Block 5	24,82*†	9,59
	Block 6	18,20*†‡	7,45
MVML (mm/s)	Block 1	13,24*†‡	4,14
	Block 2	12,98*†‡	4,37
	Block 3	22,98	8,47
	Block 4	21,64	7,65
	Block 5	16,09*†	6,67
	Block 6	14,64*†	6,18

*EA = ellipse area; MVAP = mean velocity in the antero-posterior axis; MVML = mean velocity in the medio-lateral axis. * It indicates significant differences regarding block 3 (p < 0.05). † It indicates significant differences regarding block 4 (p < 0.05). ‡ It indicates significant differences regarding block 5 (p < 0.05). § It indicates significant differences regarding block 6 (p < 0.05).*

Then, figure 4 shows the meaning of each variable for each block and age group. This graphic representation can help understand the differences between blocks and age groups described above.

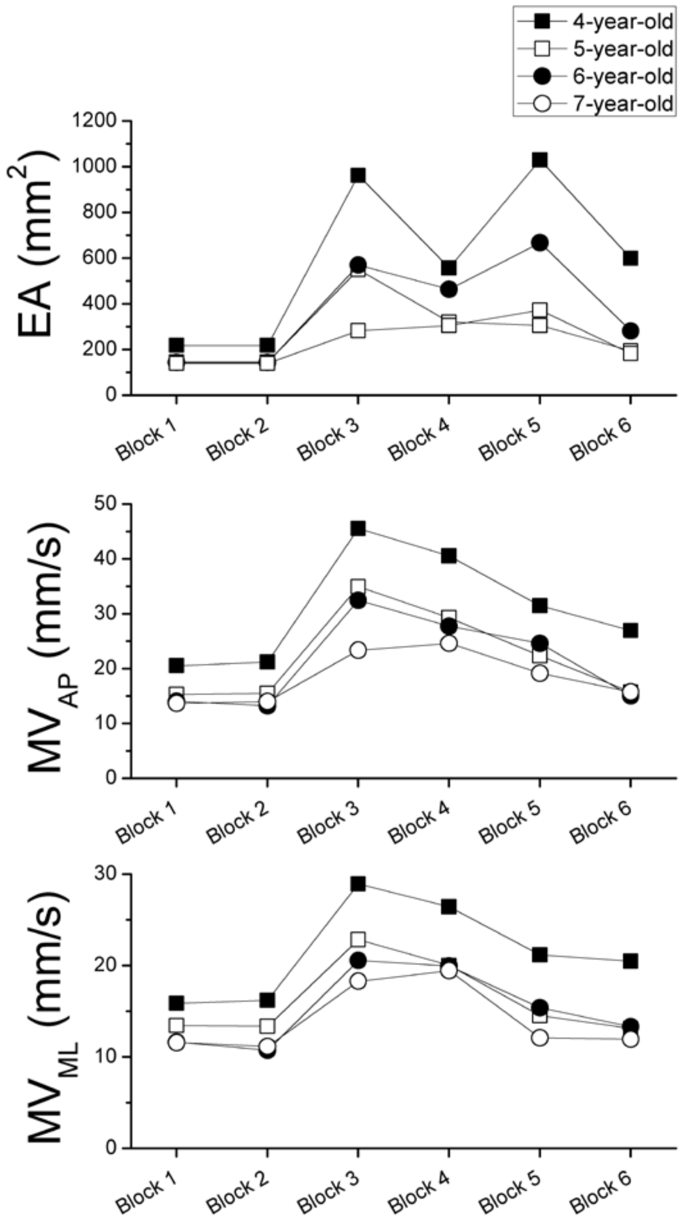

FIGURE 4: Graphs of the variables EA, MVAP and MVML in the PRA test.
EA = ellipse area; MVAP = mean velocity in the antero-posterior axis; MVML = mean velocity in the medio-lateral axis.

DISCUSSION AND CONCLUSIONS

This study is the first one to determine the effect of different sensory conditions on postural control in children from 4 to 7 years old. In addition, postural control tests included in the investigation make it possible to discern how the development of sensory reweighting systems occurs in the maintenance of body stability.

In all three tests, a main effect of age on the dependent variables was found. In the pairwise comparisons, significant differences were observed between 4 year-old children and children of other ages. On the one hand, in the VIA test, the 4-year group showed significantly higher values in the three variables than in the rest of the ages. On the other hand, in the VEA test, the 4-year-old children obtained higher values in the MVML than the rest, and in the EA and MVAP higher than in the 6 and 7-year groups. And in the PRA test, they also obtained higher values in the EA than those of 5 and 7 years, and in MVAP and MVML than in the rest of children.

Comparing these results with the scientific literature (Assaiante, 1998; Olivier et al., 2010; Assaiante, Mallau, Viel, Jover & Schmitz, 2005; Sobera, Siedlecka & Syczewska, 2011), it is agreed that there is an effect of age on postural control. And the fact is that reached the age of 7 years, children give a leap in their motor development and they begin to have a stronger musculature, which allows them to maintain the balance for a longer period of time (Sobera et al., 2011). It must be added that they already have the laterality of the lower limbs determined, which is a factor that facilitates postural control. Another argument redounds to that the difference between 3 and 6 years is located in that the peripheral vision increases and improves as they grow, so that their visual dependence matures. On the other hand, they begin to use the flexion and rotation of the ankle (Cuisinier, Olivier, Vaugoyeau, Nougier & Assaiante, 2011). In this sense, Olivier et al. (2010) verified that the younger children are, the less the postural control.

Regarding the effect of each of the three sensory alterations on postural control, after analyzing the comparisons between the blocks in which the alteration occurred and the previous moments, the following has been proven: In the VIA test, only a significant increase in the MVAP regarding the performance showed with open eyes. In the trend of the graph (figure 2), there is a slight increase in instability (block 3) and produces a kind of plateau (block 4), varying very little activity levels. In contrast, in the VEA test, the values of the three variables rose up when they were listening to the white noise, producing a kind of peak (figure 3). However, there was a sudden descent that suggests that children had an accommodation, recovering the initial levels in the last 5 seconds of the sound alteration. In the same way, in the PRA test, there was also a significant increase in the three variables, as children began to become unbalanced. However, the decrease in block 4 was milder in this case, the instability prevailed, which augurs that the proprioceptive alteration causes a great effect on the postural control, to a greater extent than the vestibular one, and this in turn, more than the visual one.

The results obtained give a great importance to the proprioceptive system and, in turn, they differ from those reported by Butterworth et al. (1977), since these indicate that in the initial stage of motor development (from 2 to 6 years of age) vision is the most important system of the three to maintain balance. Also, there is discordance with those of Golomer, Dupui, Séréni & Monod (1999). In their study on the spontaneous movement of the classical dancers, they state that the visual system does better than the other sensory systems in the regulation of postural control.

On the other hand, when comparing the blocks 3, 4, 5 and 6, that is, the instants of alteration and the later instants, it has been verified that in the VIA test, when opening the eyes again, the values did not vary too much. This implies that the lack of vision for 10 seconds, in the studied ages, causes later a slow reorganization of the information. Opposite to that, in the VEA test, when the noise stopped, the values of the variables were very similar to those of block 4, in which, although the vestibular system was still being altering, the initial normality about the values had already returned, possibly because of the students adapted perfectly to the alteration even before ending it. Children had a habitual state in this last phase, having produced a total sensory reweighting. On the other hand, in the PRA test, it was found that, after eliminating the vibration, the stability did not barely improve and the levels of neuromuscular activity decreased gradually. Therefore, it can be stated that in the VIA and PRA test there was a lower sensory reweighting, compared to the VEA test.

Regarding this, Cuisinier et al. (2011) argue that there is still no scientific evidence on what type of sensory alteration is most sensitive to their subsequent reintegration of information and claim that it is still a very open study field. They also point out that few studies have examined the development of this sensory reweighting capacity during childhood. All in all, according to Maheu, Sharp, Landry & Champoux (2017), the study of the reweighting of visual information is the predominant one and, instead of it, the study of the sensory reweighting process with auditory signals has been overlooked to date. However, they do study it, but they do not make any comparison with the other sensory systems.

Regarding another aspect that has been analyzed, the effect of age on postural control in the different situations of sensory alteration (blocks 3 and 4) is determined that there was only a significant effect of the age-block interaction on the variables during the VEA test. In block 3, a higher EA was found in the 4-year group than in the 6-year group, a higher MVAP in 4-year group than in the 5 and 6-year groups, and a higher MVML in the 4-year group than in the 6 and 7-year groups. This could be attributed to the fact that the vestibular system suffers a period of evolutionary maturation from 5-6 years of age. In addition, this result leads us to state that it is the sensory system which varies the most according to age.

A possible explanation to this phenomenon is that at 7 years there is a transient disappearance of visual preference, and so the use of the vestibular system is accentuated (Assaiante, 1998). However, it must be highlighted that the present results do not coincide with those of Olivier et al. (2010), who verified, in a significant way, that the proprioceptive alteration was more effective as the subjects were younger, neither do they coincide with those of Golomer et al. (1999), who observed differences in visual dependence based on age, since in the present investigation no significant differences were found between the ages during the alteration of these sensory systems.

In the same way, after analyzing the effect of age on sensory reweighting, as mentioned above, only a significant effect of the age-block interaction occurred during the VEA test. This test also showed significant differences between the 4 year-old children group and other groups, which make us suspect that after 5-6 years of age the ability to reintegrate vestibular information improves. Thus the results do not coincide with those of Cuisinier et al. (2011), which confirm the existence of age-related differences in the processes of reintegration of both visual and proprioceptive information.

Finally, it should be noted that this research may be very useful for Physical Education at school, as it informs on key aspects of motor development in children and it provides new information so that teachers can improve the way they act towards on motor stimulation, and so that they make the most of it according to their evolutionary characteristics.

As a main conclusion, an effect of the sensorial condition was found in all tests on the postural control in all the ages studied. Moreover, it was observed that the alteration of the vestibular information affects the youngest children to a greater extent.

As specific conclusions, in the first place, it should be affirmed that, in the overall of the three tests, postural control was more present in the youngest children and, secondly, that the alteration of the visual and proprioceptive information produced a lower sensory reweighting than the alteration of vestibular information did. This last condition only showed changes in block 3 with respect to the rest, which indicates that it generates instantaneous alterations that are corrected in the short term. Finally, the results of this test could show a worse sensory reweighting of 4 and 5 year-old children compared to 6 and 7 year-old children.

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