

CHARACTERISTICS OF VESTIBULAR ABILITY DEVELOPMENT IN 6-10-YEAR-OLD FEMALE GYMNASTS

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Abstract: *This paper focuses on the vestibular ability characteristics of 6-10-year-old gymnasts. **Methods.** Thus, exploratory research was conducted within the CSM Arad, with 25 gymnasts aged 6-10 years, divided into two groups: A (6-7 years, n=10) and B (8-10 years, n=14). The Opto Jump Next system was used for testing the march in place (running in place with eyes open and eyes closed) in 10 sec. 17 parameters were measured (number of steps, contact time, flight time, pace, cycle, jumping point, tendency and used area). The differences in the means of group A show higher values in Jumping Point (L, R) and in group B – number steps, pace (L, R), Tendency and Used Area. All these results highlight the characteristics of vestibular ability development in the 6-10-year-old gymnasts.*

Key words: *parameters, jump test, performance, deviation, correlation analysis.*

1. Introduction

Artistic gymnastics requires the execution of various elements on apparatus [1], [10], while maintaining balance and aesthetic appearance. Coordination and balance is the key to acquiring skills and achieving performance results in young athletes [3], [9].

The vestibular system, a component of the human sensory apparatus, plays a

fundamental role in maintaining balance, spatial orientation and movement coordination [6], [7], [8], [11]. The development of the vestibular system in children, especially in the context of activities requiring precision and agility, such as gymnastics, is of great importance [4], [13], [14].

This study delves into determining the

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characteristics of vestibular ability development in a specific approach among 6-10-year-old female gymnasts.

Before addressing the specific aspects of vestibular ability in young female gymnasts, it is essential to understand the details of the vestibular system itself. As children grow and engage in physical activities, their vestibular system undergoes remarkable development, impacting their motor skills and physical activity in general.

Gymnastics stands out as a sports discipline that involves extraordinary requirements for the vestibular system. The complex movements, jumps and uniaxial rotations performed by gymnasts require fine vestibular functioning, precisely adjusted to maintain balance and spatial orientation [2], [5], [12]. Investigating the development of vestibular abilities in young gymnasts provides insights into their physiological adaptation and also helps to optimize the training protocols and injury prevention strategies.

This study focuses on a specific age group: female gymnasts aged from 6 to 10 years. This age range represents a critical stage of development characterized by rapid physical growth and neural maturation. Understanding how the vestibular system of the gymnasts evolves during this interval is essential for adapting training conditions to fit the specific needs of this age group.

The main objective of this research is to delineate the characteristics of vestibular ability development in female gymnasts aged between 6 and 10 years old. By examining factors such as vestibular

acuity, balance control and adaptation to dynamic movements, the study aims to comprehensively explain the interaction between vestibular function and performance of the gymnasts.

2. Method

For the purpose of this study, an observational research was conducted at CSM Arad in December 2023. It involved a group of 25 gymnasts aged 6-10 years old, divided into two groups: Group A (6-7 years old, $n=10$) and Group B (8-10 years old, $n=14$). Parental consent was obtained and signed in accordance with the Helsinki Declaration prior to the beginning of the research. The study was approved by the Ethics Committee of the Doctoral School of Sports Science and Physical Education (ID: 12/24.01.2024), University Center of Piteşti, Romania.

Tests were performed by means of the Opto Jump Next device. The tests used: marching in place (running in place with eyes open and closed) for 10 seconds.

Statistical analysis was done using the KyPlot program, version 6.0, involving usual descriptive indices such as mean, standard deviation (SD), Confidence Level of Mean (0.95), Confidence Limit of Mean (Lower & Upper), and t-Test Paired Comparison for Means.

3. Results

The results of this research focus on the characteristics of vestibular ability in 6-10-year-old female gymnasts and are listed in Tables 1 and 2.

Descriptive and comparative statistical analysis

Table 1

Variables	Open /closed eyes	Mean $\pm$ SD	CV (%)	Confidence Level of Mean (0.95)	Confidence Limit of Mean		t- Test	
					Lower	Upper	t	P
Age (years)	-	6.4; $\pm$ 0.52	8.07	0.37	6.03	6.77	-	-
No. of steps (rep)	Open	17.3; $\pm$ 1.70	9.84	1.22	16.08	18.52	0.00	1.00
	Closed	17.3; $\pm$ 1.34	7.73	0.96	16.34	18.26		
TCont. L[s]	Open	0.23; $\pm$ 0.04	16.73	0.03	0.20	0.26	0.57	0.58
	Closed	0.23; $\pm$ 0.02	9.63	0.02	0.21	0.24		
TCont. R[s]	Open	0.23; $\pm$ 0.03	14.22	0.02	0.20	0.25	0.57	0.58
	Closed	0.23; $\pm$ 0.03	11.91	0.02	0.21	0.24		
TFlight L[s]	Open	0.44; $\pm$ 0.09	20.09	0.07	0.38	0.51	-2.01	0.07
	Closed	0.49; $\pm$ 0.08	16.10	0.06	0.44	0.55		
TFlight R[s]	Open	0.39; $\pm$ 0.04	10.33	0.03	0.36	0.42	0.87	0.41
	Closed	0.39; $\pm$ 0.04	11.58	0.03	0.35	0.42		
Pace L[step/m]	Open	198.91; $\pm$ 20.43	10.27	14.62	184.3	213.5	0.32	0.76
	Closed	198.04; $\pm$ 16.92	8.54	12.10	185.9	210.1		
Pace R[step/m]	Open	196.29; $\pm$ 15.58	8.45	11.86	184.4	208.1	-0.43	0.67
	Closed	197.75; $\pm$ 15.19	7.68	10.87	186.9	208.6		
Pace L[cycles/s]	Open	1.66; $\pm$ 0.17	10.31	0.12	1.53	1.78	0.26	0.79
	Closed	1.65; $\pm$ 0.14	8.49	0.10	1.55	1.75		
Pace R[cycles/s]	Open	1.64; $\pm$ 0.14	8.52	0.09	1.54	1.74	-0.36	0.72
	Closed	1.65; $\pm$ 0.13	7.64	0.09	1.55	1.74		
Cycle L[s]	Open	0.62; $\pm$ 0.05	8.25	0.04	0.58	0.66	0.92	0.38
	Closed	0.61; $\pm$ 0.04	7.42	0.03	0.58	0.65		
Cycle R[s]	Open	0.62; $\pm$ 0.05	8.54	0.04	0.58	0.66	1.06	0.32
	Closed	0.61; $\pm$ 0.05	7.58	0.03	0.58	0.65		
Jumping Point L[cm]	Open	-0.18; $\pm$ 6.90	-83.6	4.94	-5.12	4.76	0.97	0.36
	Closed	-2.34; $\pm$ 5.36	89.8	3.83	-6.17	1.49		
Jumping Point R[cm]	Open	-0.32; $\pm$ 6.67	-86.5	4.77	-5.09	4.46	0.96	0.36
	Closed	-2.33; $\pm$ 0.19	89.8	3.82	-6.15	1.49		
Tendency L[cm]	Open	0.14; $\pm$ 0.39	76.02	0.27	-0.14	0.42	2.03	0.07
	Closed	-0.19; $\pm$ 0.37	94.4	0.26	-0.45	0.07		

Variables	Open /closed eyes	Mean $\pm$ SD	CV (%)	Confidence Level of Mean (0.95)	Confidence Limit of Mean		t- Test	
					Lower	Upper	t	P
Tendency R[cm]	Open	0.02; $\pm$ 0.36	91.9	0.26	-0.24	0.28	1.65	0.13
	Closed	-0.19; $\pm$ 0.39	82.5	0.28	-0.47	0.09		
Used Area L[cm]	Open	10.05; $\pm$ 2.57	25.62	1.84	8.20	11.89	0.63	0.54
	Closed	9.62; $\pm$ 2.11	21.9	1.51	8.11	11.13		
Used Area R[cm]	Open	10.19; $\pm$ 2.69	26.37	1.92	8.27	12.11	0.81	0.44
	Closed	9.63; $\pm$ 1.91	19.8	1.37	8.26	10.99		

Descriptive and comparative statistical analysis

Table 2

Variables	Open /closed eyes	Mean $\pm$ SD	CV (%)	Confidence Level of Mean (0.95)	Confidence Limit of Mean		t- Test	
					Lower	Upper	t	P
Age (years)	-	8.71; $\pm$ 0.73	8.33	0.42	8.29	9.13		
No. of steps (rep)	Open	16.28; $\pm$ 0.99	6.11	0.57	15.71	16.86	1.05	0.31
	Closed	15.78; $\pm$ 2.04	12.95	1.18	14.60	16.97		
TCont. L[s]	Open	0.22; $\pm$ 0.02	8.02	0.01	0.21	0.23	-1.94	0.07
	Closed	0.23; $\pm$ 0.02	8.78	0.01	0.22	0.24		
TCont. R[s]	Open	0.23; $\pm$ 0.02	10.92	0.01	0.21	0.24	-0.72	0.48
	Closed	0.23; $\pm$ 0.03	11.18	0.01	0.22	0.24		
TFlight L[s]	Open	0.53; $\pm$ 0.08	14.32	0.04	0.49	0.58	-0.35	0.73
	Closed	0.54; $\pm$ 0.08	15.28	0.05	0.49	0.58		
TFlight R[s]	Open	0.42; $\pm$ 0.04	9.89	0.02	0.39	0.45	-0.58	0.57
	Closed	0.43; $\pm$ 0.04	8.60	0.02	0.40	0.45		
Pace L [step/m]	Open	186.79; $\pm$ 14.24	7.63	8.22	178.6	195.02	0.89	0.39
	Closed	184.15; $\pm$ 13.69	7.43	7.91	176.2	192.06		
Pace R[step/m]	Open	188.07; $\pm$ 14.25	7.58	8.23	179.8	196.3	1.62	0.13
	Closed	183.38; $\pm$ 13.63	7.43	7.87	175.5	191.25		
Pace L[cycles/s]	Open	1.56; $\pm$ 0.12	7.73	0.07	1.49	1.63	0.93	0.37
	Closed	1.53; $\pm$ 0.11	7.41	0.06	1.47	1.60		
Pace R[cycles/s]	Open	1.57; $\pm$ 0.12	7.68	0.07	1.49	1.63	1.57	0.14
	Closed	1.53; $\pm$ 0.11	7.41	0.06	1.46	1.59		

Variables	Open /closed eyes	Mean $\pm$ SD	CV (%)	Confidence Level of Mean (0.95)	Confidence Limit of Mean		t- Test	
					Lower	Upper	t	P
Cycle L[s]	Open	0.65; $\pm$ 0.04	6.49	0.02	0.62	0.67	-1.11	0.29
	Closed	0.66; $\pm$ 0.04	6.57	0.02	0.63	0.68		
Cycle R[s]	Open	0.65; $\pm$ 0.04	6.47	0.02	0.62	0.67	-1.02	0.33
	Closed	0.66; $\pm$ 0.04	6.73	0.03	0.63	0.68		
Jumping Point L[cm]	Open	4.4; $\pm$ 8.40	90.9	4.85	-0.45	9.25	2.39*	0.03
	Closed	-4.46; $\pm$ 9.03	93.3	5.21	-9.89	0.54		
Jumping Point R[cm]	Open	4.35; $\pm$ 8.14	96.9	4.69	-0.34	9.05	2.37*	0.03
	Closed	-4.46; $\pm$ 8.96	96.9	5.17	-9.63	0.71		
Tendency L[cm]	Open	0.25; $\pm$ 0.40	60.5	0.23	0.02	0.48	2.55*	0.02
	Closed	-0.32; $\pm$ 0.72	74.2	0.41	-0.73	0.09		
Tendency R[cm]	Open	0.25; $\pm$ 0.56	61.3	0.33	-0.08	0.58	1.94	0.07
	Closed	-0.28; $\pm$ 0.73	54.2	0.42	-0.71	0.13		
Used Area L[cm]	Open	8.94; $\pm$ 3.16	35.39	1.82	7.11	10.76	-1.52	0.15
	Closed	10.11; $\pm$ 2.39	23.73	1.38	8.72	11.49		
Used Area R[cm]	Open	9.36; $\pm$ 3.95	42.16	2.28	7.08	11.64	-0.05	0.96
	Closed	9.40; $\pm$ 2.39	25.46	1.38	8.02	10.78		

The results of the mean differences in Group A show higher values in Jumping Point (L, R), while in Group B higher values are observed in number of steps, pace (L, R), Tendency, and Used Area. Comparative analysis between test parameters highlights non-significant differences in Group A at $p>0.05$ (17.6% are negative). In contrast, in Group B there are significant differences at $p<0.05$ (Jumping point L and R, Tendency L) and 47.06% negative differences.

The comparative analysis revealed non-significant differences both between age groups and among measured parameters, presenting better symmetry between legs in Group A and a proportion of 82.4% in Group B.

4. Discussions

The results of this research focus on the characteristics of vestibular ability in 6-10-year-old gymnasts. Comparative analysis between Group A and Group B (Tables 1 and 2) reveals significant differences in test performance. In Group A, higher values were observed in Jumping Point, while in Group B significant differences were identified in number of steps, pace, Tendency, and Used Area. These findings underline the variability in measured abilities between the two groups. Comparing test parameters between the two groups, it was found that the mean differences were non-significant in Group A, whereas significant differences were observed in Group B as for Jumping Point

and Tendency, as well as a higher proportion of negative differences. These results highlight notable variation in test performance between Groups A and B.

Conducting the comparative analysis revealed the absence of important differences between age groups and between measured parameters, except for better symmetry of legs in Group A and a higher number of negative differences in Group B. These findings reveal the importance of comparative analysis in highlighting the specific characteristics of each group regarding tests performance.

The literature analysis on the development of coordinative capacity, especially vestibular ability, in children aged 6-10, identifies some studies assessing somatic development and physical aptitudes in artistic gymnastics among children aged 7-10 [2]. Comparison of postural control between young gymnasts and their untrained peers studied the effect of a whole-body exercise intervention program on postural control in young gymnasts [3]. Examination of the influence of visual and somatosensory information on the performance of gymnasts determined the connections between perceptual characteristics and performance in artistic gymnastics [4]. There were also investigated the development characteristics of coordination abilities in students from grades 2-4 and the impact of biomechanical factors on balance [7]. The study on the integration of theoretical and practical aspects of balance into the national curriculum for second-grade students provides solid data for teaching and assessment in physical education. Specific balance assessment tests for 7-year-old children are suggested [8]. The

effectiveness and importance of a coordination training program for gymnastics-specialized athletes was demonstrated. It was found out a remarkable improvement in sensorimotor coordination thanks to the application of the exercise program [12]. Other specialists studied the level of bilateral coordination and balance in girls practicing gymnastics. They also made a comparison based on age and type of gymnastics practiced [14].

Therefore, each of these studies makes significant contributions to understanding and improving performance and physical development in artistic gymnastics and physical education in general. They provide valuable information for coaches, educators and also to health and fitness specialists.

5. Conclusions

Comparative analysis between Group A and Group B indicates important differences in test performance. Group A showed higher values in Jumping Point, while Group B had significant differences in number of steps, pace, Tendency and Used Area, highlighting variation in measured abilities between the two groups.

When comparing test parameters between groups, it was found that while mean differences were non-significant in Group A, significant differences were observed in Jumping Point and Tendency in Group B, along with a higher proportion of negative differences. These findings reveal significant variation in test performance between Groups A and B.

Furthermore, the comparative analysis revealed a lack of significant differences between age groups and among measured

parameters. There is an exception regarding the better symmetry between legs in Group A and a higher number of negative differences in Group B. These observations emphasize the importance of comparative analysis in highlighting the specific characteristics of each group in terms of tested performance.

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