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Original Article

Effectiveness of the conjugate influence method in improving static and dynamic balance in rhythmic gymnastics gymnasts

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Abstract:
The object of this study was to assess the effectiveness of the conjugate influence method in developing specific static and dynamic balance skills in rhythmic gymnastics (RG) gymnasts in the juvenile and adult categories in the city of Fortaleza, Ceará, Brazil. Sixty female gymnasts in the juvenile and adult categories were selected. The gymnasts were divided at random into an experimental group (training by the conjugate influence method) and a control group (normal training). A pre-test was performed on both groups at the start of the experiment and a post-test after four months. Four tests were applied to assess the gymnasts' balance: Balance test in the high leg backward with hand support position; Balance test in the arabesque position; Balance test in the heel stretch position; Movement from the arabesque to the passé position. Both groups presented improvements in static and dynamic balance, however the gymnasts in the experimental group presented significantly higher mean scores in all the tests than those in the control group. The conjugate influence method developed better control of postural responses by RG gymnasts, resulting in better balance during the execution of static positions and better dynamic balance during the transition from one position to another.
Key words: rhythmic gymnastics, static balance, dynamic balance, conjugate influence method

Introduction

Rhythmic gymnastics (RG) is a mixture of gymnastics, dance and manipulation of apparatus, an impressive combination of motor structures characterised by beauty, elegance and harmony in movement with a constant effort to achieve perfectly coordinated, coherently connected and precisely executed movements (Ivančević, 1976). Gymnasts need a low percentage of body fat and high flexibility and strength (Alexander, 1991). This type of gymnastics is based on the precision, grace and originality of the movements performed (Karloh et al. 2009), and requires a high degree of development of certain physical qualities, with the object of achieving technical perfection in the execution of the compulsory elements and handling of the apparatus (Laffranchi, 2001; Zetaruk et al., 2006).

Balance is essential in RG for executing static positions and dynamic technical elements, such as jumps, turns and acrobatic movements (Shahheidari et al., 2012). Balance depends basically on muscular synergies and consists in maintaining a stable support during a balance exercise (Bresselet al., 2007). Lisitskaia(1982) shows that many balance positions in RG demand the maximum development of active flexibility, as well as isometric strength and optimum perception of muscular coordination with a very small point of support. RG requires complex skills and develops a variety of motor skills such as whole-body coordination, dynamic balance, static balance, kinaesthetic sensitivity, timing of movements using the whole body, anticipation of coincidence and perception of depth (Kioumourtzoglou, et al., 1997; Pavlova, 2011).

A range of proposals exists for high performance training; of these, the conjugate influence method has been quite extensively used to develop the specific skills needed for RG (Rumba & Karpenko, 2014). This method aims to take into account the particularities (physiological, kinetic and structural) of the sport to obtain

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the high levels of flexibility that gymnasts develop over the years, in training and competition, which are of primary importance for executing the motor pattern of balance-related difficulties (Tsepelevitch, 2007).

The object of this study was to assess the effectiveness of the conjugate influence method in developing specific static and dynamic balance skills in rhythmic gymnastics gymnasts in the juvenile and adult categories in the city of Fortaleza, Ceará, Brazil.

Methods& methods

The whole study was carried out in accordance with the Helsinki Declaration. All the procedures were carefully explained to the parents/guardians of each gymnast. The gymnasts signed an informed consent expressing their free participation in the study; they were informed that they would be subjected to tests classified as being of minimum risk, as per resolution 466/12 of the National Health Council of Brazil.

The population was intentionally chosen and consisted of 60 female gymnasts in the juvenile and adult categories in a team which participated in regional and national tournaments, based in the city of Fortaleza, Brazil. The gymnasts were divided at random into a control group (mean age 15.2 ± 1.5 years; years of experience 7.5 ± 1.6 years, height 1.65 ± 0.07 metres and daily training time 4 ± 0.2 hours), and an experimental group (mean age 15.4 ± 1.2 years; years of experience 7.5 ± 1.8 years and daily training time 4 ± 0.2 hours). The control group maintained their normal training. A pre-test was performed in both groups at the start of the experiment and a post-test after four months. Both groups carried out 6 hours training per day.

The control group's training consisted of a daily warm-up for 20 minutes alternating rope-skipping with various forms of running. Solo physical preparation was carried out 3 times per week for 1 hour. Choreographed physical preparation emphasising strength was carried out 2 times per week for 1 hour (ballet and modern dance). Solo physical preparation was carried out for 1 hour 30 minutes of training time on the other days, alternating with the choreographed physical preparation days. Technical preparation for apparatus handling (basic handling of 2 pieces per day, control and throwing) and running through routines were carried out in the 4 hours training. Running through routines involvesrepetition of the competition routine, in which the gymnasts execute the routine; on completion, the trainer corrects them individually, and they repeat the routine, for 4 hours consecutively.

The experimental group started to use the conjugate influence method in training sessions for four months, in the preparation period for annual periodization, in which the gymnasts carry out 4 complexes each day. The training consisted of 7 complexes of exercises of 10-20 minutes each:3 complexes for training active flexibility and balance; 3 complexes for training power and strength and 1 complex of acrobatic exercises which include the exercises of the competition routines. On three alternate days the gymnasts carried out 3 complexes for training active flexibility and balance + acrobatic complex. On the three intervening days, the gymnasts carried out 3 complexes for training power and strength + acrobatic complex. The acrobatic complex was carried out every day. Total time used per day: 1 hour 20 minutes to 1 hour 30 minutes.

The tests used were Balance test in the arabesque position (Fig. 1), Balance test in the backgrab position (Fig. 2), Balance test in the heel stretch position (Fig. 3), Movement from the arabesque to the passé position (Fig. 4) (Rumba & Karpenko, 2014).

Test 1- Balance test in the Arabesque position

The gymnast adopts the arabesque position, with one leg extended behind at 90º and hands alongside the body. Once steady in the position, she raises her heel (to the mid-point position) and the time that she maintains the position is recorded.

Test 2- Balance test in Backgrabposition

The gymnast adopts the backgrab position with the active leg pointing upwards, supported by the hands. Once steady in the position, she raises her heel (to the mid-point position) and the time that she maintains the position is recorded.

Test 3- Balance test in the Heel stretch position

The gymnast adopts the heel stretch position, with the active leg above the line of the head and the foot pointing upwards. One arm holds the active leg and the other is extended. The gymnast must raise her heel 10 times to the mid-point and return, holding the position after the 10th repetition. The time that the position is held is recorded.

Test 4: Movement from the Arabesque to the Passé position

Keeping her heel raised, the gymnast must move from the arabesque to the passé position and then to the forward leg extension position, and back. The number of repetitions without falling is recorded.

Statistical analysis

Descriptive statistical and normality tests were done using SPSS V20, Minitab 16. Paired Student's t tests were used to compare the results between the pre-test and the post-test; ANOVA was used to compare the group results in the two tests. The magnitude of the effect was analysed by Cohen's *d* and classified as very small (0.01), small (0.29), medium (0.50), large (0.80), very large (1.20) and enormous (2.00), according to

Sawilowsky(Sawilowsky, 2009). The significance level used in testing the hypotheses developed in this work was 5%.

Results

When the pre- and post-test results were analysed, it was found that after 4 months of training all the gymnasts presented better performance in the 4 tests (Tables 1-4), except in the “Balance in the heel stretch” test in which the gymnasts in the control group presented no differences on the right side (Table 3). The size of the effect was big or very big for the "Movement from the arabesque to the passé position" for both groups (Table 1). In the “Balance in the arabesque position” test the size of the effect was medium for the EG and small for the CG (Table 2). In the “Balance in the heel stretch position” test the size of the effect was big for the EG and CG (left side) and small for the CG (right side) (Table 3). In the “Balance in the backgrabposition” test the size of the effect was big or very big for the EG and big for the CG (Table 4).

When the control group was compared with the experimental group we observed that the two groups presented no differences in performance in the pre-test, except in the “Backgrab” test on the right side where the CG presented slightly better performance. After 4 months' training the experimental group presented better performance than the control group in all the tests (Tables 5-8).

"Movement from the Arabesque to the Passé position” test

In the "Movement from the arabesque to the passé position” test we observed that both groups presented better performance after 4 months from the start of training, however the EG presented better performance than the CG, with higher mean scores. The size of the effect was big for both the right and left sides (Table 5).

“Balance in the Arabesque position” test

In the “Balance in the arabesque position” test we observed that after 4 months' training the EG presented better performance than the CG, with higher mean scores in the test and a medium effect (Table 6).

“Balance in the Heel stretch position" test

In the “Balance in the heel stretch position” test we observed that after 4 months' training the EG presented better performance than the CG, with significantly higher mean scores and a big or very big effect (Table 7).

“Balance in the backgrabposition” test

In the “Balance in the backgrab” test we observed that after 4 months' training the EG presented better performance than the CG, with significantly higher mean scores and a big effect (Table 8).

Discussion

The postural control system depends on interaction of the visual, vestibular and somatosensory systems. Postural stability is essential in RG both in balance positions and in pirouettes and jumps (Massion, 1994). RG gymnasts are trained to hold a stable position for no more than 2s during a very dynamic performance (Calavalle et al., 2008). In an earlier study, Kioumourtzoglou et al. (1997) compared the motor and perceptual skills of novice and elite RG gymnasts, showing that elite gymnasts presented better dynamic and static balance than novices. Calavalle et al. (2008) found that RG has a direct effect on the ability to hold a bipedal posture, confirming the hypothesis of a "transfer" of expertise from RG to bipedal postural sway, especially in mediolateral displacements.

The principal physical abilities for the physical preparation work in RG are: flexibility, strength, coordination, rhythm, balance, resistance and agility (Laffranchi, 2001). Training experiences which improve neuromuscular coordination, joint strength and range of movement act as mechanisms to improve balance (Di Cagno et al., 2014). Previous studies showed that RG gymnasts present better qualitative and quantitative performance when they are trained with other methods in addition to traditional training (Agostini et al., 2017). In the present study, all the gymnasts presented better performance after 4 months' training, however the gymnasts trained with the conjugate influence method presented better results than those who underwent traditional training, with better static and dynamic balance. It should be noted that the two groups presented quite similar performance before the study training programme, but after 4 months' training the group trained with the conjugate influence method presented higher mean scores in all the tests (Movement from the Arabesque to the Passé position, Balance in Arabesque, Balance in Heel stretch, Balance in backgrabposition).

Shigaki et al. (2013) carried out a comparative analysis distinguishing dominance in the postural control of RG gymnasts. These authors observed that asymmetries exist in muscular actions in the hip region in movements performed in a mediolateral direction, since the non-dominant lower limb presented greater stability than the dominant (Shigaki et al., 2013). In the present study, no comparative analysis was done between the dominant and non-dominant limbs, however we observed that gymnasts in the experimental group presented markedly higher scores for both legs in all tests, showing that the conjugate influence method effectively improved static and dynamic balance in both the dominant and non-dominant lower limb. We also observed that normal training (control group) likewise improved the mean scores obtained for all the tests in both legs, except

in the "Balance in the arabesque position" test; however the improvement in performance was not as marked as in the experimental group.

The ability of gymnasts to hold well-defined balance positions and maintain them for a minimum period to allow the judges to assess their difficulty are determining factors for success in this sport. The nature of cortical commitment in postural responses is known to depend on prior experience, allowing the organism to act with speed and flexibility to modify environmentally appropriate responses to loss of balance (Jacobs & Horak, 2007). According to Gautier et al. (2008), experience in gymnastics may enable the plasticity of the cortex to bring about a functional reorganization of motor behaviour, making it more reactive. It is therefore necessary to train RG gymnasts using techniques which will contribute new experiences, to improve their dominion over their postural responses with greater balance and precision in movements during performance. The conjugate influence method proved effective in improving the postural response of RG gymnasts in the experimental group, presenting better results than the gymnasts who underwent normal training. The gymnasts in the experimental group managed to hold a balance position for longer during the static balance tests; in the dynamic balance tests they were able to move between postures with fewer falls than the gymnasts who underwent normal training.

Conclusions

The conjugate influence method developed better control in postural responses by RG gymnasts, resulting in better balance during the execution of static positions and better dynamic balance during the transition from one position to another.

Conflicts of interest. The authors have no conflicts of interest.

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Apendix

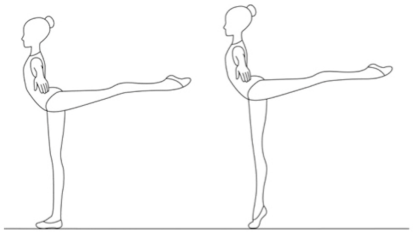

Figure 1 – Illustration of the arabesque position

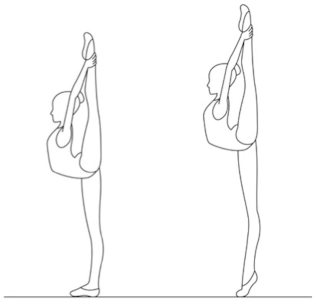

Figure 2 – Illustration of Backgrabpositio

Figure 3 – Illustration of Heel stretch position

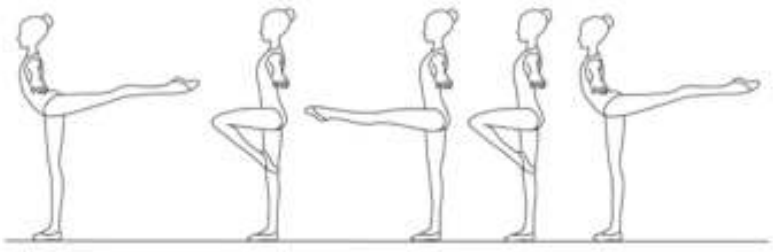

Figure 4 – Illustration of movement from arabesque to passé

Table 1. Movement from Arabesque to Passé comparing balance on the left and right sides in experimental and control groups, before and after the study training period.

Movement from arabesque to passé			Mean	Median	SD	CV	Min	Max	N	CI	Cohend	P-value
Experimental	R	l	2.935.87	36	1.171.81	40%31%	12	59	30	0.420.65	1.953	<0.001
	L	l	2.634.50	2.54	1.221.36	46%30%	12	57	30	0.440.49	1.472	<0.001
Control	R	l	2.534.20	2.54	1.251.61	49%38%	12	59	30	0.450.57	1.177	<0.001
	L	A l	2.233.23	23	1.141.07	51%33%	11	55	30	0.410.38	0.921	0.001

SD: Standard deviation; CV: Coefficient of variance; N: number of individuals in sample; CI: Confidence interval

Table 2. Balance in arabesque test comparing balance on the left and right sides in experimental and control groups, before and after the study training period.

Balance in arabesque			Mean	Median	SD	CV	Min	Max	N	CI	Cohen d	P-value
Experimental	l	l	6.909.23	7.59.5	4.294.26	62%46%	12	1921	30	1.541.52	0.555	<0.001
	l	l	3.504.83	24	3.574.0	102%83%	11	2023	30	1.281.4	0.356	<0.001

					4					4		
Control		l ı	6. 20 6. 60	6 6	2 . 8 6 2 . 7 7	46 % 42 %	2 3	1 4 1 4	(((	1 . 0 2 0 . 9 9	0.14 4	<0. 001
		l ı	2. 20 2. 57	2 2	1 . 1 3 1 . 4 1	51 % 55 %	1 1	6 7	(((	0 . 4 0 0 . 5 0	0.29 3	0.00 1

SD: Standard deviation; CV: Coefficient of variance; N: number of individuals in sample; CI: Confidence interval; R: right, L: left; B: before, A: after.

Table 3. Balance in heel stretch comparing balance on the left and right sides in experimental and control groups, before and after the study training period.

Balance in heel stretch			Mean	Median	SD	CV	Min	Max	N	CI	Cohend	P-value
Experimental	R	l ı	8.47	8	3.78	45%	2	20	30	1.351 1.87	1.838	<0.001
			16.70	17	5.22	31%	9	30	30			
	L	l ı	6.50 12.27	6.511	3.01 3.52	46% 29%	28	13 20	30 30	1.081 1.26	1.789	<0.001
Control	R	l ı	9.73 10.20	11 10	3.20 2.68	33% 26%	25	15 17	30 30	1.150 .96	0.161	0.547
	L	l ı	7.03 4.03	83	2.95 2.06	42% 51%	11	12 9	30 30	1.060 .74	1.199	<0.001

SD: Standard deviation; CV: Coefficient of variance; N: number of individuals in sample; CI: Confidence interval; R: right, L: left; B: before, A: after.

Table 4. Balance in backgrab position comparing balance on the left and right sides in experimental and control groups, before and after the study training period.

Backgrab			Mean	Median	SD	CV	Min	Max	N	CI	Cohend	P-value
Experimental	R	BA	2.63 6.17	2 6	1.191 1.74	45% 28%	1 2	5 9	30 30	0.430 0.62	2.408	<0.001
	L	B	2.63	2.5	1.221	46%	1	5	30	0.440	1.785	<0.001
		A	4.83	5	1.29	27%	2	7	30	0.466		
Control	R	BA	2.33 4.27	2 4	1.090 .98	47% 23%	1 2	5 6	30 30	0.390 .35	1.894	<0.001
	L	B	2.00	2	1.140	57%	1	5	30	0.410	1.395	<0.001
		A	3.43	3.5	.944	27%	1	5	30	0.333		

SD: Standard deviation; CV: Coefficient of variance; N: number of individuals in sample; CI: Confidence interval; R: right, L: left; B: before, A: after.

Table 5. Movement from Arabesque to Passé comparing the experimental and control groups on left and right sides, before and after the study training period.

Movement from arabesque to passé		Mean	Median	SD	CV	Min	Max	N	CI	Cohen d	P-value
R	Experimental	2.932	3 2.5	1.171	40% 49%	1 1	5 5	30 30	0.420	0.335	0.207
	Control	2.53		.25					.45		
	Experimental	5.87	6	1.811	31%	2	9	30	0.65	0.989	<0.001
	Control	4.	4	1.	38	2	9	30	0.		

		20		61	%			57			
L	Experimental	2.63	2.5	1.22	46%	1	5	30	0.440	0.346	0.193
	Control	2.23	2	1.14	51%	1	5	30	0.441		
	Experimental	4.503	4	1.361	30%	2	7	30	0.490	1.053	<0.001
	Control	3.23	3	1.07	33%	1	5	30	0.38		

SD: Standard deviation; CV: Coefficient of variance; N: number of individuals in sample; CI: Confidence interval; R: right, L: left; B: before, A: after.

Table 6. Balance in arabesque test comparing the experimental and control groups on left and right sides, before and after the study training period.

Balance in arabesque		Mean	Median	SD	CV	Min	Max	N	CI	Cohend	P-value
l	Experimental	6.90	7.5	4.292	62%	1	19	30	1.541	0.195	0.460
	Control	6.20	6	2.86	46%	2	14	30	1.02		
ı	Experimental	9.23	9.56	4.262	46%	23	21	30	1.520	0.746	0.006
	Control	6.60		2.77	42%		14	30	0.99		
l	Experimental	3.50	2	3.571	102%	1	20	30	1.280	0.500	0.062
	Control	2.20	2	1.13	51%	1	6	30	0.40		
ı	Experimental	4.83	4	4.041	83%	1	23	30	1.440	0.763	0.005
	Control	2.57	2	1.41	55%	1	7	30	0.50		

SD: Standard deviation; CV: Coefficient of variance; N: number of individuals in sample; CI: Confidence interval; R: right, L: left; B: before, A: after.

Table 7. Balance in heel stretch comparing the experimental and control groups on left and right sides, before and after the study training period.

Balance in heel stretch			Mean	Median	SD	CV	Min	Max	N	CI	Cohen d	P-value
R	B	Experimental Control	8.479.73	8 11	3.783.20	45%33%	2 2	20 15	30 30	1.351.15	0.368	0.167
	A	Experimental Control	16.70 10.20	17 10	5.222.68	31%26%	9 5	30 17	30 30	1.870.96	1.593	<0.001
L	B	Experimental Control	6.507.03	6.58	3.012.95	46%42%	2 1	13 12	30 30	1.081.06	0.182	0.492
	A	Experimental Control	12.274.03	11 3	3.522.06	29%51%	8 1	20 09	30 30	1.260.74	2.902	<0.001

SD: Standard deviation; CV: Coefficient of variance; N: number of individuals in sample; CI: Confidence interval; R: right, L: left; B: before, A: after.

Table 8. Balance in backgrab position comparing the experimental and control groups on left and right sides, before and after the study training period.

Backgrab			Mean	Median	SD	CV	Min	Max	N	CI	Cohen d	P-value
R	B	Experimental Control	2.632.33	2 2	1.191.09	45%47%	1 1	5 5	30 30	0.430.39	0.267	0.313
	A	Experimental Control	6.17	6 4	1.741	28%2	2 2	9 6	30 30	0.62	1.366	<0.001

		4.27		0.98	3%			0.35			
l	Experimental Control	2.63	2.52	1.21	46%	11	55	0.44	0.545	0.042	
		2.00		1.14	57%			0.41			
L	Experimental Control	4.83	5	1.29	27%	21	75	0.46	1.265	<0.001	
		3.33	3.5	0.90	27%			0.33			
		4.43		0.94				0.33			

SD: Standard deviation; CV: Coefficient of variance; N: number of individuals in sample; CI: Confidence interval; R: right, L: left; B: before, A: after.