Baltic Journal of Health and Physical Activity

Volume 1 | Issue 1 Article 7

2009

Quantitative and Qualitative Evaluation of Motor Coordination Abilities in Gymnast Girls Aged 7–9 Years

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Recommended Citation

Kochanowicz K, Boraczynska LB, Boraczynski T. Quantitative and Qualitative Evaluation of Motor Coordination Abilities in Gymnast Girls Aged 7–9 Years. Balt J Health Phys Act. 2009;1:62-69. doi: 10.2478/v10131-009-0007-8

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Abstract

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Keywords

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Authors' Contribution:
A – Study Design
B – Data Collection
C – Statistical Analysis
D – Data Interpretation
E – Manuscript Preparation
F – Literature Search
G – Funds Collection

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Word count: 3228
Tables: 5
Figures: -
References: 20

Received: May 2009
Accepted: July 2009
Published: September 2009

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Introduction

Guiding the competitors' training in a long-term training process is based on making use of objective evaluation of motor coordination abilities, physiological response to training loads, characteristics of mental processes, level of players' technique and preparation tactics [1, 2, 3, 4, 5, 6, 7]. Modern, computerised research tools and methods enable obtaining valid and reliable metric indices of physical fitness as well as genetic and environmental influences on athletes [1,8, 9,10]. For the sake of using many different indices, which are characterised/specified in various metric measures (centimeters, seconds, milimoles, etc.), the results of measurements are often hard to compare between one another and they are of independent nature. In this connection, a question arises: what is the level of validity and reliability of control indices applied in the evaluation of competitors' special abilities.

In literature, there are notes on using a large number of control indices, which, on the one hand, creates the possibility to diversify a group of subjects, but on the other hand, does not give reasons to create an objective, integral assessment of competitors' fitness. Attitudes which are targeted at competitors' physical fitness assessment have various metric conditions, directly connected with specific aims of control in specific conditions of research organization and measurement methods [8, 11, 12]. But in most cases they are targeted at creating quantitative and qualitative assessment of the development level of various physical and mental competitors' abilities. In everyday pedagogical practice, control organisation of every metrological attitude is realised in the following sequence: – at the first stage test results or original control measurements are statistically analysed in order to determine their validity and reliability, in accordance with aims, control tasks and specificity of the examined group (sex, age, training, sport level); – at the second stage measurement results are used to create quantitative evaluation scales (in metric units) and qualitative (in points); – at the third stage, the final assessment of examined fitness is characterized on the basis of points sum from the whole control indices system; – at the last, fourth stage there is time to formulate final competitors' fitness assesments on the basis of obtained points sum and drawn up qualitative norms comparison. A similar stance is also presented by Sawczyn [3], Sozański [5], Sozański, Zaporozanow [6], Prusik [13] specialising in guiding and controlling grounds of a training process in professional athletics and physical education.

On the basis of the above presented grounds of training management, research aimed at widening the empirical knowledge and improvement of control process of selected gymnasts' motor coordination abilities was started, on the basis of logically chosen set of indices.

In the research, the following tasks were assigned:

– to determine the validity and reliability of every selected index in order to characterize motor coordination abilities referring to the requirements of gymnastics, the subject's age and qualifications,

– to draw up quantitative evaluation norms on the basis of objective, metric measurements for every control used,

– to draw up qualitative evaluation norms.

Material and Methods

18 girls aged 7–9, training gymnastics at the initial stage of sports practice in the Sports School in Olsztyn participated in the study.

In this research quantitative and qualitative methods were used to evaluate individual factors of motor coordination abilities:

1. Static-dynamic balance. Ellipsis test

The Ellipsis test was taken on a dynamometric platform PLA2-4P, integrated with a tensometric amplifier WTM5 and computer software KKD v. 1.1 (JBA, Poland). This test is based on controlling the position of the centre of body mass using a dynamometric platform. The tested person had to keep the cursor (the centre of body mass) at the point moving along a prefect ellipsis on the screen. The gymnasts performed the test four times, two before and two after labyrinth function stimulation (10 revolutions in a rotation chair for 10 seconds with opened eyes). Mean error was recorded (DB) – absolute value of integral in time function from the difference between the model curve course and the course of the imaging curve. The mean error value was calculated as the quotient of the error value and the time of continuation of the test. In the data analysis mean error before 10 revolutions round the vertical body axis (DB_1) and after revolutions (DB_2) was taken.

2. Static balance. Flamingo balance test (FLB)

In this test, the subject had to keep balance for 1 minute standing on a 3-cm-wide slat along its axis, handling the other foot of the leg bended in knee joint. The result of the test was a number of steppings on slat, needed to keep balance in standing on the batten/slat for 1 minute.

3. Global coordination test (GC) according to Starosta [14, 15].

Subjects were obliged to do a maximal revolution round the longitudinal body axis with both feet jump. 3 rehearsals were performed with revolutions to the right side and 3 rehearsals with revolutions to the left side. The result of the test was a sum (S) of the best result of revolution to the right side (P) and to the left side (L). The sum was treated as a measure of the global motion coordination level.

The results were statistically analysed by ANOVA method, making use of software Statistica 7.1 (StatSoft, USA) packet. To characterize the links between the obtained results Spearman rank correlation analysis – R_s was used. In order to draw up profiles, quantitative and qualitative criteria as well as the T scale were made on the basis of sport metrologic requirements [8, 16, 17]. Correlation links were specified, which allowed us to quantitatively determine validity measure of every index. The quantity of Spearman rank correlation coefficient (R_s) for every index in the total/global correlation matrix constituted the validity criterion (Tab. 3).

Results and Discussion

General research methodology consisted in an empirical presentation of possibilities of making use of individual indices to evaluate motor coordination abilities in women's gymnastics.

The initial analysis of results enabled statistical methods for next operations in the progress of solving consecutive research tasks. Table 1 shows that in each of the five control indices there was high diversity in results; variation coefficient values were situated in a range of V%=13.0–61.3. This presents a very high variation in the level of coordination abilities in the group of examined gymnasts. Diversed calendary age of examined gymnasts, which was situated in a range 7–9 years of age, undoubtedly affected high variation results. Moreover, it has to be considered that the examined gymnasts were in the period of dynamic biological development. The other causes of high diversity in the results in the examined group could result from time training difference, motor predispositions and technique skills. In the index defining reaction to labyrinth functions stimulation in the test evaluating the level of abilities controlling body balance (DB_2–DB_1) the obtained results, indicated the usefulness of that test only in groups of similar age, time training and level of sport advance.

Tab. 1. The results of coordination tests and rankings of gymnasts aged 7–9 years (n=18)

Sub	Age yrs	DB_1 mm/s	R1	DB_2 mm/s	R2	DB_2-DB_1 mm/s	R3	FLB 1/60s	R4	GC (°)	R5	ΣR	FR
EM	9.8	29.5	6	41.0	10	11.6	13	3	1	680	9	39	8
JE	9.8	22.3	2	25.6	1	3.3	8	4	3	670	10	24	1
MK	9.5	26.6	4	34.5	8	7.9	11	4	4	710	4.5	31.5	4
SM	9.5	31.9	10	31.3	5	-0.6	4	5	5	710	4.5	28.5	2
RS	9.2	65.2	18	87.5	18	22.3	17	8	8	625	13	74	16.5
SN	9.2	29.8	7	45.1	11	15.3	15	8	8	705	6	47	11
SM	9.2	19.4	1	29.7	4	10.4	12	6	6	630	12	35	6.5
SM	9.0	39.0	14	45.9	12	7.0	9	3	2	695	7	44	10
JG	8.6	31.8	9	32.3	7	0.5	5	9	10,5	720	3	34.5	5
PK	8.3	30.3	8	31.4	6	1.1	6	13	14	690	8	42	9
PA	7.8	42.1	15	55.0	15	12.9	14	11	13	740	1	58	13
BA	7.5	25.5	3	28.5	3	3.0	7	15	15	725	2	30	3
KS	7.5	34.3	12	26.5	2	-7.9	2	8	8	655	11	35	6.5
BN	7.5	60.4	16	52.2	13	-8.3	1	23	18	555	15	63	15
RZ	7.4	60.9	17	53.3	14	-7.6	3	9	10,5	550	16	60.5	14
FA	7.3	27.6	5	35.2	9	7.6	10	21	17	590	14	55	12
JD	7.3	31.9	11	63.1	17	31.2	18	19	16	435	18	80	18
MK	7.0	36.7	13	56.1	16	19.4	16	10	12	525	17	74	16.5
M	**8.4**	**35.8**		**43.0**		**7.2**		**9.9**		**645.0**			
SD	**1.0**	**13.3**		**16.1**		**10.7**		**6.1**		**83.6**			
min	**7.0**	**19.4**		**25.6**		**-8.3**		**3.0**		**435.0**			
max	**9.8**	**65.2**		**87.5**		**31.2**		**23.0**		**740.0**			
V %	**11.8**	**37.2**		**37.4**		**149.2**		**61.3**		**13.0**			

Sub – subject; DB_1 – dynamic balance before rotation; DB_2 – dynamic balance after rotation; FLB – flamingo balance; GC – global coordination; R1,2,3,4,5 – ranking…; ΣR – sum of rankings; FR – final ranking.

Tab. 2. Coordination tests results of motor coordination abilities of gymnasts aged 9.3 (n=9) and 7.5 y. (n=9)

	Age yrs	DB_1 mm/s	R1	DB_2 mm/s	R2	DB_2-DB_1 mm/s	R3	FLB 1/60s	R4	GC (°)	R5	ΣR	FR
M	9.3	32.8	7.9	41.4	8.4	8.6	10.4	5.6	5.3	682.8	7.7	39.7	7.1
SD	0.4	13.4	5.6	18.6	5.0	7.3	4.4	2.3	3.1	35.0	3.5	14.7	4.9
min	8.6	19.4	1.0	25.6	1.0	-0.6	4.0	3.0	1.0	625.0	3.0	24.0	1.0
max	9.8	65.2	18.0	87.5	18.0	22.3	17.0	9.0	10.5	720.0	13.0	74.0	16.5
V%	4.1	40.9	70.4	45.0	59.5	84.8	41.8	41.4	59.4	5.1	46.0	37.1	68.6
M	7.5	38.8	11.1	44.5	10.6	5.7	8.6	14.3	13.7	607.2	11.3	55.3	11.9
SD	0.4	13.3	4.9	14.0	5.7	13.6	6.3	5.5	3.2	102.1	6.4	16.9	4.9
min	7.0	25.5	3.0	26.5	2.0	-8.3	1.0	8.0	8.0	435.0	1.0	30.0	3.0
max	8.3	60.9	17.0	63.1	17.0	31.2	18.0	23.0	18.0	740.0	18.0	80.0	18.0
V%	4.9	34.2	44.0	31.4	54.2	237.9	73.5	38.4	23.4	16.8	56.2	30.6	41.0

Stimulation by revolutions round the vertical axis of the labyrinth body function led to a decrease in the dynamic balance index in subjects to 16.7% (M1=35.8; M2=43.0 mm/s), but high standard deviation values (SD1=13.3; SD2=16.1 mm/s) and high variation in measures at rest and after stimulation (V%=37.2; 37.4) did not reveal statistically significant influence of the applied load on the level of abilities controlling body balance on the basis of the t criterion (t=1.33, p>0.05).

A similar link took place also in the Flamingo test (FLB). Statistical parameters of the entire group (n=18) showed clear deviation from general Gauss requirements. The results presented in Table 2 showed that mean values of older gymnasts (M=5.6; SD=2.3) and the younger ones (M=14.3; SD=5.5) were spread on a logically specified scale in extreme ranges. It follows that in the Flamingo test distinct diversity in gymnasts' results being in various calendar age took place. Older gymnasts made from 3 to 9 errors, the younger ones from 11 to 16 errors.

In the remaining tests a link between results of measurements and subjects' age was affirmed. One should take a note of a fact that in the global ranking classification (n=18), some of the younger gymnasts achieved 2, 5, 6, 8 position, others from among the older gymnasts achieved 9, 10, 16 position. It proves a diversed level of motor coordination abilities both of the older and the younger gymnasts.

The results of the static-dynamic balance test (Ellipsis test) confirms a high diversity in control values of indices regardless of the age of the examined gymnasts. For instance, in DB_2 indice results of dynamic balance after labyrinth function stimulation in the older gymnasts were situated in ranges 25.6 – 87.5 mm/s, and in the younger ones 26.5-63.1 mm/s.

Different conclusions come from the analysis of results in the global motor coordination test (GC test). Older gymnasts obtained a definitely better result, and the variation coefficient of the value was definitely lower coming only to 5.1%, while in the younger group it came to 16.8%. This proves a distinct impact of age on results obtained in this test. The level of coordination abilities in two age groups specified in individual tests was a basis to draw up logical criteria and evaluation norms. The next step in the analysis of results was to determine the purposefulness of using individual indices to objectively assess the gymnasts' coordination abilities. A method of research correlation links between results in individual indices was used, and global gymnasts' ranking was drawn up on the basis of obtained points sum (Tab.3).

Tab. 3. Correlation link between indices of coordination abilities in gymnasts aged 7-9 years (n=18)

		1	2	3	4	5
	Indicators	DB_1	DB_2	DB_2-DB_1	FLB	GC
1	Dynamic balance (DB_1)	X				
2	Dynamic balance after 10 revolutions (DB_2)	**0.717*** **	X			
3	Stability index (DB_2 - DB_1)	0.055	**0.540***	X		
4	Flamingo balance (FLB)	0.237	0.285	0.077	X	
5	Global coordination (GC)	0.297	0.415	0.145	0.283	X
6	Final ranking (FR)	**0.685*** **	**0.904*** **	0.441	**0.505***	**0.646****

Simultaneously, it was considered that in connection with little number of subjects and high results diversity between subjects in every index, correlation analysis results should be treated cautiously. For this reason, the research results showed statistically significant correlations between dynamic balance indices at rest (DB_1) and dynamic balance after stimulation by revolutions round the vertical body axis (DB_2) (R_s=0.717). They characterise the same ability to

control location of the whole body in space in dynamic conditions. That coordination ability has been confirmed by a statistically significant link with the measurements stability index after labyrinth function – DB_2-DB_1 (R_s=0.540). It follows that in the structure of indices characterising body balance control, index DB_2 can be considered as valid and specific to gymnastics conditions, where competitors perform a lot of exercises having a crucial impact on labyrinth function stimulation. The ability to control balance in dynamic conditions after stimulation impacts the most essentially the other coordination abilities, which shows a very high value of the correlation coefficient with global ranking drawn up on the basis of ranking points sum obtained in five indices (R_s=0.904).

It is worth emphasizing correlation links of the global rank (GR), the Flamingo test (FLB) results and the global motor coordination test (GC). Starosta's test results depend on various, important mechanisms of the sensorimotor system, which clearly impacts complex coordination abilities qualification of subjects (R_s=0.646), like the ability to keep balance in the static Flamingo test (FLB) conditions (R_s=0.505). Table 3 shows the gymnasts' results in FLB and GC tests, which turned out to be weakly dependent on one another, as was the case with other indices of the dynamic balance at rest and after stimulation. Coefficients correlation values between these indices were situated in ranges 0.055-0.415 and were not statistically significant ($p>0.05$).

On the basis of the results of correlation analysis, it can be affirmed that in gymnasts aged 9.3 and 7.5 the structure of coordination abilities was characterised by complex links of sensorimotor system mechanisms, which impact the validity and efficiency of free motions in every test used in the study. The research results presented in objective metric quantities and correlation coefficients gives the basis to state that objective evaluation of motor coordination abilities in gymnasts aged 7-9 is possible by complex evaluation taking into consideration a static and dynamic character of indices in resistance and non-resistance conditions (body contact with ground – support phase as well as air phase). On the basis of results presented in Tables 1–3, and also data from literature on biological characteristics and individual development pace of children, quantitative and qualitative norms of coordination abilities evaluation of gymnasts in two age categories – 9.3 and 7.5 were drawn up (Tab. 4 and 5).

Tab. 4. Quantitative and qualitative criteria of coordination abilities in gymnasts aged 9.3 (n=9)

Level	Points	DB_2		GC		FLB
High	10	-5.1	4.2	770.3	752.8	0
	9	4.2	13.5	752.8	735.3	1
Above average	8	13.5	22.8	735.3	717.8	2
	7	22.8	32.1	717.8	700.3	3
Average	6	32.1	41.4	700.3	682.8	4
	5	41.4	50.7	682.8	665.3	5
Below average	4	50.7	60	665.3	647.8	6
	3	60	69.3	647.8	630.3	7
Low	2	69.3	78.6	630.3	612.8	8
	1	78.6	87.9	612.8	595.3	9

Tab. 5. Quantitative and qualitative criterions of coordination abilities in gymnasts aged 7.5 (n=9)

Level	Points	DB_2		GC		FLB	
High	10	9.5	16.5	862.5	811.4	0.6	3.3
	9	16.5	23.5	811.4	760.4	3.3	6.1
Above average	8	23.5	30.5	760.4	709.3	6.1	8.8
	7	30.5	37.5	709.3	658.3	8.8	11.6
Average	6	37.5	44.5	658.3	607.2	11.6	14.3
	5	44.5	51.5	607.2	556.2	14.3	17.1
Below average	4	51.5	58.5	556.2	505.1	17.1	19.8
	3	58.5	65.5	505.1	454.1	19.8	22.6
Low	2	65.5	72.5	454.1	403.0	22.6	25.3
	1	72.5	79.5	403.0	352.0	25.3	28.1

Tables 4 and 5 present qualitative criteria of the assessment of gymnasts' coordination evaluation in terms a "high", "average" and "low" level on the basis of results from quantitative measurements in five control indices. For instance, in order to obtain a "high" result in DB_2 indice, a younger age gymnast – 7.5±0.4 has to obtain a result below 23.5 mm/s; a gymnast at the age of 9.3±0.4 to obtain the same qualitative assessment has to obtain a result below 13.5 mm/s.

Analogously, quantitative and qualitative norms of evaluation for two age groups were drawn up with reference to the remaining two tests used to evaluate coordination abilities of the examined gymnasts. The analysis of quantitative, metric measurements, presented in the above-mentioned tables shows that every single index reflects a specific feature of the sensorimotor system, individually developed in every gymnast.

That assumption allows affirming the purposefulness of using a complex attitude to evaluate gymnasts' coordination abilities on the basis of an average number of points obtained in the three control tests (DB_2+GC+FLB)/3. Total points obtained on the basis of the above-mentioned algorithm create the possibility of an objective, complex evaluation of coordination abilities in quantitative units of measurements, while the average points number with reference to qualitative criteria presented in Tables 4 and 5 creates the possibility of a complex, quantitatively-qualitative evaluation of coordination abilities in gymnasts aged 7–9.

Conclusions

In many scientific studies a heterogenous and complex character of motor coordination abilities is pointed out [2, 13, 19, 20]. They disclose its direct impact on the efficiency in various kinds of activities displayed in everyday actions, specialist activity and sport activity. That complexity, as well as the distinctness of the exploration aims, make it difficult to apply valid and reliable research methods and procedures. Distinctness of control indices and differences in software often do not give possibilities of obtaining results comparison in various centers. But they allow presenting certain tendencies in individual development or correlations between indices. The above-mentioned research showed some conformities with research results presented by Kochanowicz [2], Sawczyn [3], Prusik [13], Starosta [14] and others; still, they show a high diversity among examined gymnasts and age groups. On the basis of objective quantitative and qualitative information obtained in the research, a valid and reliable selection of indices useful for objective evaluation of coordination abilities in gymnasts at an initial stage of general preparation was made.

Making use of the obtained results gives the basics to evaluate far-reaching possibilities of gymnasts at that age.

Drawn up norms of evaluating coordination abilities creates the basis for gymnasts's training individualisation process at the initial stage of general preparation, according to modern requirements of the training theory.

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