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The Interrelation Between Psychomotor And Cognitive Abilities In Aerobic Gymnastics

Elizaveta Panfilova

Federal Scientific Center for Psychological and Interdisciplinary Research, Moscow, Russian Federation
*Corresponding author: ea.panfilova@ihna.ru

Abstract: *The performance of athletes of aerobic gymnastics, depends on their physical abilities and mental strength. The present study explored the connections between characteristics of nervous system and cognitive skills of aerobic gymnasts to understand how these parameters affect their focus and performance. Twenty-four female aerobic gymnasts participated in tapping test using "NS-Psychotest" (E.P. Ilyin's method, 1972) to evaluate strength, efficiency and endurance of gymnasts' nervous system. Mental and coping-skills were assessed using the Russian version of the ACSI-28 and the OMSAT questionaries. Aerobic gymnasts mainly had medium-weak and weak nervous systems. Both groups significantly differed in the frequency difference of tapping test ($p < 0.05$). Strong correlations were found between the frequency difference and OMSAT test for "Focus" and "Goal-setting" subscales, and for "Confidence" subscale of ACSI-28 ($p < 0.05$). The decline indicator positively correlated with the OMSAT subscales ($p < 0.01$). Linear regression showed the decline indicator significantly predicts scores of "Focus" subscale ($p < 0.05$). Gymnasts with stronger nervous system demonstrated better attention focus, goal-setting and confidence, which is crucial in challenging situations in aerobic gymnastics. However, weaker nervous system may help athletes prepare themselves better for unwilling situations. These results underscore the crucial role of the nervous system in cognitive abilities and its significant influence on athletic performance.*

Keywords: *Cognitive Skills, Performance In Sport, Psychomotor Abilities, Tapping Test*

1. INTRODUCTION

Aerobic gymnastics is a complex coordination kind of sport, that is recognized by the International Gymnastics Federation (FIG). It is an aesthetic-technical discipline, originating from traditional aerobics but having its own structure unlike the other types of gymnastics [1]. The competition program in aerobic gymnastics is a styled high-intensity composition to music, involving elements from gymnastics, acrobatics, and dance movements. "Routines are evaluated by judges who consider three different aspects: difficulty, artistic value and execution" [1]. The highest scores are earned by the gymnasts who perform the choreography with proper technique, high accuracy and emotionally expressive approach. Each competition is unique, and unexpected situations are always possible before the start. Thus, well-planned training program is crucial for aerobic gymnasts in order to be able to find "the optimal solution to the problem in the shortest possible time" [3].

To succeed on competitions, aerobic gymnasts are constantly working on their motor abilities [2] and improving the routine in terms of both coherent and difficult performing [3]. In addition to proper physical state, there is a strong demand for the psychological training [4], as the preparation for competitions is characterized with high psycho-emotional stress and interval physical loads. Since the synergy of psychology and physiology of athletes determine athletic performance [5], the psychophysiological control is at the most importance for preparing for competitions at the highest level.

There are a few articles about psychophysiological features of gymnasts. In particular, Chayun [3] described the effectiveness of psychophysiological diagnostics of elite gymnasts before the main competitions and described the qualimety of psychophysiological parameters of younger athletes [6]. Tóth-Hosnyanszki [7]

found significant differences in psychological state of competitors in aerobic gymnastics and gymnastics. Kadir's [8] research is of the greatest interest in terms of the present study. There has been shown the positive effect of aerobic gymnastics exercise both on cognitive a motor ability in children [8]. Although, those works described both cognitive and motor abilities of athletes, there were no evidence of the relationship between psychology and physiology of gymnasts. The interconnection of cognitive and motor skills has been described for other sports, such as handball and soccer [9] – [11], however, there is no such studies for aerobic gymnastics.

Thus, the aim of current study was addressed at exploring the relationship between cognitive and psychomotor skills in athletes, involved in aerobic gymnastics. Since Bastik [9] and Koparan [12] works described the interplay of finger tapping test performance on cognitive abilities of athletes, we decided to use this method as a tool of evaluating the psychomotor state of aerobic gymnasts. Though The Finger Tapping Test shows only the speed and coordination status of a respondent [12], we suggested using instead the tapping test, described by Ilyin E.P. in 1972 [13], which measures speed of motor movements and allows to indirectly evaluate such psychomotor parameters as efficiency, endurance and strength of nervous processes [13]. All athletes are characterized by a typological complex of psychomotor features, based on the strength, mobility and balance, that forms the type of behaviour corresponding to the specific requirements of the kind of sport [13]. So, our hypothesis was that aerobic gymnasts had a characteristic psychomotor status of nervous system, assessed by tapping test and correlated with their cognitive skills.

2. METHODS

A. Sample

Twenty-four female athletes aged from 12 to 17 years old (14.5 ± 1.74 years old) took part in our study. All participants engaged in aerobic gymnastics for at least 2 years (8.04 ± 2.88 years old).

The tapping test (E.P. Ilyin's method [13]) was applied to assess individual typological psychomotor features of strength, efficiency and endurance of athletes' nervous system using the diagnostic complex "NS-Psychotest" [14].

To study cognitive skills of athletes we assessed their skills to cope with stress, keep motivation and self-esteem at the competitions, as well as the state of their skills to maintain the concentration, commitment and setting to the goal during sport career of athletes. We used Russian version of the Athletic Coping Skills Inventory questionary (ACSI-28) [15] to assess the coping-skills and The Ottawa Mental Skills Assessment Tool questionary (OMSAT) [16] to assess the mental skills of athletes.

B. Procedure

The diagnostics was conducted two weeks after the last competition of the season from May to June 2024. Athletes' parents were aware of the aims of the study and signed the informed consent. The study was conducted in a sports school 30 minutes before the start of the training. Athletes were invited individually into a room isolated from external noise and distractions. Firstly, participants filled in two questionaries. After that, they conducted tapping test via "pencil" (contact pointer) and a rubber electrode. Participants were required to tap the electrode with a pointer as fast as possible for 30 second.

C. Data analysis

The "NS-Psychotest" software calculated tapping frequency every five seconds. Consequently, collected data consisted of six five-second intervals. The strength of nervous system was assessed by the type of the curve graph, constructed on the basis of five points of tapping frequency [17].

The software "NS-Psychotest" also allows to calculate the main psychomotor indicators of the efficiency, strength and the endurance of nervous system. The outcome results were the following: tapping frequency (Hz), total number of taps, initial work frequency level (Hz), frequency difference of tapping [Hz], average inter-tap interval (ms), decline indicator, power of nervous system, lability and endurance level. Since the endurance level is assessed for individuals over the age of 16, this indicator was excluded from the analysis of the current research. Frequency difference of tapping was calculated as the average value of the frequency difference within five-second intervals. The decline indicator shows the level of the performance curve decline from the initial value. It is calculated as the sum of deviations of frequency values for each subsequent five-second interval in relation to the first five-second interval. According to the decline indicator we can conclude about the level of the strength of nervous system: positive values refer to the strong nervous system, whereas negative values – to the weak one. The results of the questionnaires were analyzed for each subscale, and the overall scores were calculated.

Statistical analysis was carried out via Jamovi program 2.6.44. The differences between the types of nervous system were examined using Independent Sample T-Test. The relationship between psychomotor abilities and cognitive (mental and coping) skills was estimated by Pearson correlation coefficients. The predictive power of that relationship was assessed by creating a simple linear regression model.

3. RESULTS

Comparing the curve graphs of athletes in aerobic gymnastics with the reference curves [17], we defined the nervous system type of all athletes. Aerobic gymnasts in our research had three types of nervous system: 11 participants with weak type, 11 ones with medium-weak and 2 athletes with medium type (Fig. 1).

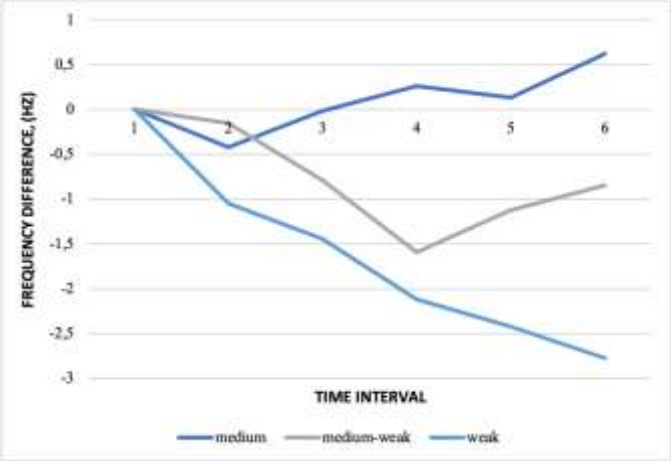

Fig. 1. Types of curves of maximum tapping frequency change in five-second intervals of aerobic gymnasts in the present study.

*The figure represents average curves of all athletes for each type. Frequency difference (Hz) is the difference of the tapping frequency relative to the frequency in the first time interval

The Independent Sample T-Test was performed to evaluate whether type of nervous system differed by psychomotor indicators of tapping test. The results revealed that athletes with weak nervous system had significantly greater frequency difference ($p < 0.05$) than athletes with medium-weak type. The decline indicator differed between both groups on the level of tendency ($p < 0.1$). Full statistical results are provided in the Table 1.

Table 1. Descriptive Statistic of Athletes According to the Nervous System Type.

Indicator	Strength type		t	df	p-value
	medium-weak (n = 11)	weak (n = 11)			
frequency difference	-0.22±0.22	-0.55±0.41	2.43	20	0.02
decline indicator	-23.27±20.91	-48.9±38.15	1.95	20	0.06

*df – degrees of freedom

To assess the relationship between nervous system strength and the level of cognitive skills we calculated a Pearson correlation for the whole group, including two athletes with medium strength nervous system. Pearson correlation coefficients showed a significant positive correlation between strength indicators of tapping test and cognitive skills. There was a positive correlation between frequency difference and OMSAT subscales for "Goal-setting" ($r = 0.43$, $p < 0.05$) and "Focus" ($r = 0.48$, $p < 0.05$), as well as between frequency difference and "Confidence" subscale of ACSI-28 ($r = 0.42$, $p < 0.05$). Power indicator also positively correlated with the subscales to the level $p < 0.05$ for "Confidence", $p < 0.01$ for "Focus", and to the level $p < 0.01$ for "Goal-setting". Decline indicator had a positive correlation with "Confidence" subscale ($r = 0.45$, $p < 0.05$) and "Focus" subscale ($r = 0.58$, $p < 0.01$)

The predictive relationship between psychomotor indicators and cognitive skills was examined using a simple linear regression model. The linear regression analysis revealed a statistically significant model for the decline indicator and the "Focus" subscale of OMSAT ($F(2,21) = 6.11$, $p < 0.01$), with an adjusted $R2$ of 0.36. The regression coefficient for the decline indicator was found to be 0.11, with a standard error of 0.04. This indicates that for each point of curve decline, there is an average increase of 0.11 score units in "Focus" subscale of OMSAT questionary. This positive relationship between decline indicator of nervous system strength and "Focus" subscale was found to be significant ($t(21) = 2.42$, $p < 0.05$), affirming the predictive power of nervous system strength on cognitive skills.

4. DISCUSSION

During the present research, we measured nervous system strength as a psychomotor ability of 24 female gymnasts using the tapping test (by E.P. Ilyin, 1972). To evaluate cognitive skills, we asked athletes to complete two questionaries, assessing their mental skills (OMSAT) and ability to cope with stress (ACSI).

Tapping test allows to measure several psychomotor indicators, indirectly reflecting the state of efficiency, endurance and strength abilities of nervous system. The present study revealed significant results only for strength ability. Aerobic gymnasts had diverse types of nervous system according to Ilyin's classification: 46% of athletes with medium-weak type, 46% with weak type and two participants, which is 8%, had medium type of nervous system. The previous studies support our result suggesting a weak or medium type of nervous system in complex coordination sports such as artistic gymnastics and acrobatics [18]. Korolkov [19] found the difference in tapping frequency between athletes of coordination and game sports. Gymnasts in complex coordination sports performed the test with less variation in the frequency of tapping movements and with a lower maximum frequency in the first time interval [19], which is typical for weaker nervous system.

Moreover, the current result is in accordance with the literature findings describing a various type of nervous system within one group of athletes. Kovalenko and Lyapin [20] showed a wide distribution of types of karate athletes from weak to strong nervous system. Specifically, athletes with higher qualification had strong or medium-strong nervous system in general. However, articles, that would describe individual features of psychomotor abilities using specific qualitative coefficients and indicators, are hardly to find. Our study revealed significant differences in strength indicators such as frequency difference, and tendency

to differences in the decline and the power indicators. These parameters reflect the strength of nervous system: the more positive values, the stronger nervous system of an athlete [13]. Thus, our research bonds individual curve graphs of tapping test with qualitative indicators of the test, that supports the graphical division of participants into the strength type of nervous system.

Once we stated the qualitative difference between strength type, we evaluated how strength of nervous system influence the cognitive skills of athletes. Correlation analysis showed a significant positive connection of strength indicators such as decline indicator, frequency difference, and power indicator, with goal-setting, attention concentration and self-confidence skills. The same interconnection was found in Scharfen and Memmert [10] study. In particular, authors stated that attention parameters and working memory were positively associated with dribbling skills and ball control, which is thought to enable soccer players to execute early reactions in their sensorimotor system to make their performance more efficient [10]. Moreover, Muntianu [11] found a strong relationship of 83% between psychomotor abilities and psychological aspects of handball players, using a linear regression model. This finding is in line with our observations, highlighting the strong bond between strength of nervous system and attention concentration of aerobic gymnasts.

According to the results of current research, we suppose that gymnasts with stronger nervous system were able to hold better the attention focus, set clear and realistic goals more efficiently and maintain self-motivation, which eventually has an effect on self-esteem. Although, there is no similar studies on aerobic gymnastics, our hypothesis of interplay of physical and cognitive abilities supported by a study where motor abilities, performance level and psychological characteristics of junior rhythmic gymnasts were explored [21]. There was found the association of cognitive skills with the level of performance of athletes, while the difference in motor skills were revealed but not significant. Collaboration of these abilities is crucial in aerobic gymnastics, where athletes must perform complex routines within a short time constraints. Performance programs demand simultaneous applying strong physical skills with emotional storytelling. Hence, the ability to concentrate on the target goals and stay self-esteemed can help meet these requirements.

As it was stated above athletes of various kinds of sport are characterized with different combination of psychomotor and cognitive abilities, which best suits the requirements of a particular sport. These observations are also supported by theory of typological features of nervous processes in different occupations [13]. For example, people with strong nervous system are able to quickly mobilize under high stressful conditions, whereas actions of people with weaker nervous system are more effective in preventing unwilling situations. The results of linear regression affirmed predictive power of the strength of nervous system on the focus skills, which are essential in the ability to prepare oneself for various scenarios during competitions. Athletes in aerobic gymnastics from our sample have a weak or medium-weak nervous system in the majority of respondents. Taking into account the above we suppose that medium-weak type of strength may be a characteristic feature of successful aerobic gymnastics, where athletes have to be prepared for unexpected occasions and perform under the high emotional and cognitive load.

5. CONCLUSIONS

In conclusion, our study described several crucial insights into the psychomotor abilities that influence cognitive skills of aerobic gymnastics athletes. Gymnasts in aerobic gymnastics had weak and medium-weak nervous system, which was confirmed by qualitative indicators such as the frequency difference and the decline indicator. Also, we showed that the strength of nervous system had a positive influence on attention concentration, self-confidence and task setting. A shift to the weaker type of nervous system may be a unique ability of athletes in aerobic gymnastics. We hypothesize, that the balance between strength of nervous system and good mental skills tend to help athletes cope with competition stress.

Our findings have emphasized the importance of integrating nervous system assessments into training programs. We believe that knowing typological features of nervous system of athletes may help to form the professional profile of aerobic gymnasts. It will encourage coaches and athletes to develop more effective training strategies that enhance motor-cognitive interaction, reduce stress and burnout, better mental toughness, and improve overall performance.

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