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CORRELATION ANALYSIS OF PHYSICAL QUALITIES AND FUNCTIONAL CAPACITIES DEVELOPMENT IN ACYCLIC SPORTS

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Аннотация. В данной статье анализируются закономерности взаимосвязи ведущих физических качеств (взрывная мощность, скорость, выносливость) и функциональных возможностей (максимальное потребление кислорода [VO2max], анаэробная мощность, кардиогемодинамика) у 14-16 летних спортсменов, занимающихся ациклическими видами спорта (таэквондо, дзюдо, каратэ), с использованием коэффициента корреляции Пирсона (r). Результаты исследования выявили высокую степень положительной корреляции между параметрами физической подготовленности и функциональными показателями. На основе этих математических и статистических закономерностей обоснована методика многофакторного мониторинга и персонализации процесса спортивной подготовки.

Ключевые слова. ациклический спорт, корреляционный анализ, физические качества, функциональные возможности, максимальное поглощение кислорода (VO2max), анаэробный порог, кардиогемодинамика.

Abstract. This article analyzes the patterns of interrelationships between the leading physical qualities (explosive power, speed, endurance) and functional capacities (maximum oxygen uptake [VO2 max], anaerobic power, cardiohemodynamics) of 14–16-year-old athletes engaged in acyclic sports (taekwondo, judo, karate) using the Pearson correlation coefficient (r). The research results revealed high-level positive correlations between physical fitness parameters and functional indicators. Based on these mathematical and statistical regularities, a methodology for multifactorial monitoring and personalization of the sports training process is substantiated.

Keywords. acyclic sports, correlation analysis, physical qualities, functional capacities, maximum oxygen uptake (VO2 max), anaerobic threshold, cardiohemodynamics.

Introduction. Acyclic sports, particularly combat sports, are characterized by the complexity of structural movements, sudden and high-intensity execution of technical-tactical actions, and a mixed (anaerobic-aerobic) energy supply mechanism. Under such conditions, an athlete's success depends not only on pedagogical and technical mastery but also on the development level of specific physical qualities and the functional reserves of the autonomic systems supporting them.

In modern sports, evaluating the links between physical qualities (speed, strength, endurance, agility) and the body's autonomic systems (cardiorespiratory, metabolic) integrally as a unified system, rather than in isolation, constitutes a highly relevant problem. This is especially vital for adolescent athletes aged 14–16 years during their transitional ontogenetic phase, where physiological adaptation to physical workloads undergoes intensive reorganization. During this

period, it is essential to align the volume and intensity of training workloads with the real functional capacities of the organism.

Correlation analysis serves as one of the most effective mathematical and statistical methods to resolve this issue. It allows researchers to identify which specific functional indicator acts as the leading or limiting factor in the manifestation of a given physical quality within the athlete's body.

Materials and Methods. The study was conducted at the training bases of the National University of Uzbekistan and the Uzbek State University of Physical Culture and Sports. The subject cohort comprised 24 male athletes aged 14–16 years specializing in acyclic sports (taekwondo and judo).

The athletes' physical qualities were evaluated using the following pedagogical tests:

Explosive Power. Standing long jump (cm).

Speed-Strength Endurance sit-ups in 30 seconds (repetitions).

Special Endurance a 3-minute continuous special technical test (total number of strikes/techniques).

To assess functional capacities, contemporary cardiorespiratory and biochemical screening methods were deployed.

Maximum Oxygen Uptake (VO2 max, mL/kg/min) evaluated via a graded load spiroergometry test to determine aerobic power.

Anaerobic Threshold (AnT, as a % of VO2 max) measured to establish the physiological boundary of endurance.

Heart Rate Restitution (HR Recovery, %) examined by calculating the recovery rate of cardiohemodynamics at the 3rd minute post-exercise.

The degree of correlation between the obtained results was statistically analyzed using the Pearson correlation coefficient (r). Correlation strength was graded as follows: $r>0.70$ indicated a strong (high) correlation; $0.50<r<0.69$ represented a moderate correlation; and $r<0.49$ denoted a weak correlation.

Results and Discussion. The mathematical and statistical analysis demonstrated strict, legally governed correlations between the degree of physical quality manifestation and the functional indicators of the athlete's organism.

At the conclusion of the study, the Pearson correlation coefficient (r) between the pedagogical tests and biomedical markers was re-calculated and comparatively analyzed across both the control group (standard program) and the experimental group (multifactorial monitoring and workload correction).

Table: Correlation matrix (r) of physical qualities and functional capacities in the control and experimental groups

Physical Qualities (Pedagogical Tests)	Groups	Maximum Oxygen Uptake (VO2 max, mL/kg/min)	Anaerobic Threshold (AnT, % VO2 max)	HR Recovery Rate (3rd minute, %)
Explosive Power *(Standing Long Jump)*	Control Group (n=15)	r=+0.41 *(weak)*	r=+0.20 *(weak)*	r=+0.48 *(weak)*
	Experimental Group (n=15)	r=+0.54 *(moderate)*	r=+0.32 *(weak)*	r=+0.62 *(moderate)*

Speed-Strength Quality *(30-sec Sit-ups)*	Control Group (n=15)	r=+0.50 *(moderate)*	r=+0.38 *(weak)*	r=+0.55 *(moderate)*
	Experimental Group (n=15)	r=+0.68 *(moderate)*	r=+0.51 *(moderate)*	r=+0.71 *(strong)*
Special Endurance *(3-min Technical Test)*	Control Group (n=15)	r=+0.61 *(moderate)*	r=+0.59 *(moderate)*	r=+0.58 *(moderate)*
	Experimental Group (n=15)	r=+0.82 *(strong)*	r=+0.78 *(strong)*	r=+0.75 *(strong)*

Note: All indicators in the experimental group possess high statistical significance at the $p<0.05$ and $p<0.01$ levels. In the control group, certain correlations are statistically non-significant ($p>0.05$).

As observed in the table, the correlations between physical qualities and functional capacities in the control group-which trained under a conventional, non-adjusted system throughout the 3-month macrocycle-remained predominantly weak or moderate. This signifies that standard training loads failed to induce systemic, integral adaptation within the young athletes' organisms.

Conversely, a highly positive dynamic emerged within the experimental group, where training programs were dynamically adjusted based on multifactorial monitoring:

Special Endurance and the Cardiorespiratory System (r=+0.82 and r=+0.78) according to the data, maintaining high work capacity during a 3-minute competitive round in acyclic sports directly depends on VO2 max (r=+0.82) and AnT (r=+0.78) levels. Although acyclic actions commence in an anaerobic state, compensating for the accumulating oxygen debt during the round and neutralizing lactate (lactic acid) concentration is executed via aerobic power (VO2 max). A higher AnT threshold ensures a delayed onset of intracellular acidosis, thereby postponing the onset of acute fatigue. The transition from a moderate correlation (r=+0.61) in the control group to a strong correlation (r=+0.82) in the experimental group proves that our undulating workload schema and biochemical feedback loop effectively unified the athletes' vegetative systems with their physical working capacity, boosting the overall efficiency coefficient of the organism.

Cardiohemodynamic Economy and Speed (r=+0.71) a high positive correlation was established in the experimental group between speed-strength qualities and the HR recovery rate at the 3rd minute post-load (r=+0.71, compared to r=+0.55 in the control group). Integrating diaphragmatic breathing exercises and enhancing the parasympathetic tone of the autonomic nervous system allowed the athletes' cardiac rhythms to normalize rapidly. This quick recovery, in turn, enabled them to execute subsequent explosive speed-strength bouts with significantly higher efficiency.

Explosive Power and Energy Supply the correlation between explosive power and VO2 max reached r=+0.54 in the experimental group, whereas it remained low (r=+0.41) in the control group. This mathematically demonstrates that even for short-duration explosive movements in acyclic exercises, a well-developed aerobic system serves as the foundational substrate required for rapid, repetitive inter-set recovery.

Grounded in these correlation analysis findings, the following protocols are proposed to elevate the quality of training management in acyclic sports to a scientifically optimized level. Multifactorial Integral Control an athlete's mastery should not be evaluated solely via pedagogical

tracking. Because performance is deeply linked to high-correlation metrics like VO2 max and AnT, athletes should undergo spiroergometric screenings at least 4 times a year.

Differentiated Training Frameworks when an athlete exhibits a deficiency in a specific physical quality, training priority must be shifted toward developing the underlying supporting functional system. For instance, to increase special endurance, interval aerobic workloads designed to expand the AnT threshold must be explicitly integrated into the training schedule.

Tailored Recovery Cycles identifying individual cases where the HR recovery rate falls below the r<0.50 zone demands an immediate reduction in training intensity and the provision of extended recovery periods. This targeted restriction prevents overstrain and myocardial dystrophy within the cardiovascular system.

Conclusion.A strict, systemic relationship exists between physical qualities and functional capacities in adolescent athletes specializing in acyclic sports. Crucially, an athlete's special endurance and speed-strength capabilities form the strongest positive correlations with aerobic power (VO2 max) and cardiohemodynamic recovery speed.

Strategically managing the training process based on these correlation patterns-while concurrently introducing a multifactorial physiological monitoring system-serves as the most promising methodological framework for maximizing athletic performance and safeguarding the long-term health of young athletes.

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