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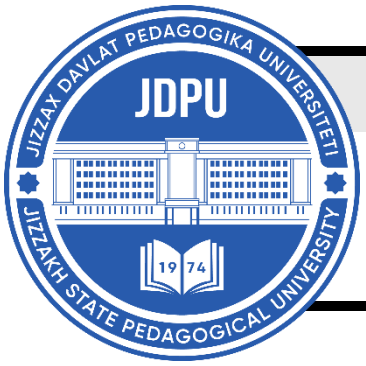

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SPECIAL PERFORMANCE INDICATORS OF HIGHLY SKILLED BOXERS BY USING MOBILE LABORATORY

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ABOUT ARTICLE

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Abstract: The "Hardware and Software Complex for Measuring Martial Artists' Strikes" enables precise evaluation of the physical and psych functional capabilities of highly skilled boxers. The equipment, utilizing the "TABO-STAR" software, provides critical data on various performance metrics through 8-second and 40-second tests, focusing on explosive and speed endurance. This study highlights the special performance indicators of boxers, including metrics such as Coefficient of Explosive Endurance (CEE), Index of Explosive Endurance (IEE), and Creatine Phosphate Index (CPI). The analysis of these results allows for deeper insights into the athletes' work power, endurance, and overall performance in combat

sports. The research offers significant advances over traditional pedagogical methods, particularly in enhancing the training and assessment of high-level boxers.

INTRODUCTION

In combat sports, assessing athletes' physical and functional capabilities is vital for optimizing performance. Traditional methods of evaluating explosive power, endurance, and other critical parameters often fall short in providing precise, repeatable data. Modern advancements in sports technology, such as the "Hardware and Software Complex for Measuring Martial Artists' Strikes," offer a more sophisticated approach to analyzing performance in boxing. This study utilizes this complex, equipped with "TABO-STAR" software, to assess the work ability of highly skilled boxers, capturing key metrics during short (8 seconds) and extended (40 seconds) tests.

Boxing requires a unique blend of explosive power, speed endurance, and technical skill. Traditional methods of assessment, such as manual recording and observation, have limitations in accuracy. Recent advancements in dynamometric and motion-capture systems now allow for precise, quantifiable measurements. This review explores the role of modern technologies in evaluating boxing performance, focusing on key metrics like explosive endurance, speed endurance, and energy system efficiency.

Explosive endurance refers to the capacity to sustain high-intensity efforts over short durations. Bompa and Haff (2009) emphasized its importance in delivering powerful punches in rapid succession. Traditional tests like punch bag drills and shuttle runs have been qualitative, but the introduction of dynamometric tools has enabled more accurate measurements. Kravitz & Martin (2012) used force platforms to evaluate power output during explosive actions, showing the value of precise technology in sports assessment.

The Coefficient of Explosive Endurance (CEE), introduced by Kiselev (2006), has become a key metric in modern boxing. It helps assess an athlete’s ability to maintain high power output during explosive actions. Boxers with higher CEE values tend to perform better in competition, as they can sustain powerful punches throughout a match.

Speed endurance is critical in maintaining high punch frequency without losing force. This ability is closely tied to the efficiency of the glycolytic energy system, which fuels high-

intensity efforts lasting 10 to 90 seconds (Powers & Howley, 2012). The Glycolytic Endurance Index (GLEI) measures a boxer's ability to sustain high-intensity activity during rounds.

Johnson & Lee (2018) highlighted the importance of glycolytic endurance in combat sports, showing that athletes with higher GLEI values could deliver more effective punches in later rounds. Boxers with superior speed endurance also recovered better between rounds, maintaining higher performance levels throughout a match.

The Coefficient of Speed Endurance (CSE) evaluates a boxer's ability to sustain punch frequency and power over 40 seconds. Jones & Carter (2015) emphasized the importance of CSE, finding that boxers with higher CSE values dominated in the later stages of a match when opponents fatigued. This metric provides coaches with objective data to refine training strategies.

The creatine phosphate system supports short-duration, high-intensity efforts like those in boxing. The Creatine Phosphate Index (CPI) measures an athlete's ability to utilize this energy system effectively. Smith (2010) demonstrated that athletes optimizing their creatine phosphate stores could deliver more powerful punches in rapid succession, leading to higher CPI scores.

CPI is typically measured in short-duration tests like the 8-second punch test. Bompa & Haff (2009) argued that CPI testing helps coaches tailor training programs to improve athletes' ability to replenish creatine phosphate stores during recovery, enhancing performance in high-intensity bouts. CPI is a critical determinant of success in boxing, as athletes often rely on short bursts of power to score points.

Comprehensive performance assessments integrate multiple metrics into composite indices like the Integral Index of Work Power (IWP) and the Integral Index of Speed-Strength Preparation (ISSPI). These indices provide a holistic view of a boxer's capabilities. The IWP, introduced by Kiselev (2006), evaluates a boxer's ability to sustain high power output over different time frames, incorporating data from both 8-second and 40-second tests.

Kravitz & Martin (2012) found that IWP strongly predicts overall performance in combat sports, as it reflects an athlete's ability to perform both explosive and sustained actions. ISSPI measures an athlete's ability to combine speed and strength in combat, with higher values indicating a better ability to deliver fast, powerful punches. Jones & Carter

(2015) noted that boxers with higher ISSPI values were more dominant in matches, combining endurance and power effectively.

The advent of advanced technologies like the "Hardware and Software Complex for Measuring Martial Artists' Strikes" has revolutionized performance evaluation. This technology offers real-time data on punch force, frequency, and endurance, providing detailed insights for coaches. Smith (2010) noted the unparalleled accuracy of these technologies, which have enabled more tailored training interventions focused on improving explosive power and endurance.

Mobile laboratories equipped with such technology provide flexibility for testing athletes in various environments, from training camps to competitions. This allows for ongoing monitoring of progress. Dynamometric sensors and motion-capture systems also offer significant improvements in the reliability of performance assessments. Kravitz & Martin (2012) found that force sensors provided more consistent data than manual assessments, enhancing training precision.

The assessment of physical performance in combat sports has evolved significantly with the introduction of modern technologies. Metrics such as CEE, CPI, GLEI, IWP, and ISSPI offer comprehensive insights into a boxer's abilities, allowing for more effective training and competition strategies. Explosive endurance, speed endurance, and efficient energy system utilization are key determinants of success in boxing. As technology continues to advance, the ability to monitor and enhance athlete performance will only improve.

Aim: The primary aim of this study is to evaluate the special work capacity of highly skilled boxers using a mobile laboratory setup that includes the "Hardware and Software Complex for Measuring Martial Artists' Strikes" and "TABO-STAR" software.

Tasks:

1. To determine the Coefficient of Explosive Endurance (CEE) in highly skilled boxers by conducting 8-second tests using the hardware and software complex.

2. To calculate the Index of Explosive Endurance (IEE) by analyzing the punch data obtained from the 8-second test.

3. To measure the Creatine Phosphate Index (CPI) and Glycolytic Endurance Index (GLEI) during the 40-second endurance test, focusing on speed and energy system utilization.

4. To assess the Integral Index of Work Power (IWP) and Integral Index of Speed-Strength Preparation (ISSPI), providing a comprehensive analysis of the boxers' physical capabilities.

5. To compare the results of the mobile laboratory setup with traditional testing methods, highlighting the advantages of using advanced technologies for monitoring athlete performance.

The method of determining the special work ability of highly qualified boxers

The "Hardware and Software Complex for Measuring Martial Artists' Strikes" is used to monitor the development of physical, psychofunctional, and special movements in taekwondo athletes during the initial training stage. It is capable of measuring and calculating the strikes of individual fighters, equipped with the "TABO-STAR" software.

The testing was conducted in the fifth mode of the dynamometer. The length of the working segments is programmed for 4 seconds, with a total working duration of 8 seconds. After pressing the "Start" button (a buzzer sounds), the device is ready for testing. The recording of the number of punches, working time, and total workload is automatically activated with the athlete's first punch.

The athlete stands at an optimal distance from the dynamometric bag, which is held by an assistant. When ready, the athlete begins delivering continuous straight punches with maximum strength and frequency. Punches are alternated between the left and right hands. After 4 seconds, a buzzer sounds, indicating that half of the test is complete. Simultaneously, the display shows information about the current working segment.

After the second buzzer, signaling the end of the second 4-second segment, the information about the second half of the test appears on the display, followed by the total workload completed in 8 seconds. The protocol records the number of punches and the total workload for both halves of the test, as well as their cumulative values.

Based on the recorded data, the following performance indicators are calculated:

1. Work power in the 8-second test (W8 sec), calculated per kilogram of the athlete's body weight per second:

(W8 \, \text{sec} = S8 / P / 8 \), where \ (P \) is the athlete's body weight and \ (S8 \) is the total workload during the test.

2. Coefficient of Explosive Endurance (CEE): (CEE = (S2 \times N2) / (S1 \times N1) \), where \ (S1 \) and \ (S2 \) are the workloads for the first and second halves of the test, and \ (N1 \) and \(N2 \) are the number of punches in the first and second halves, respectively.

3.Index of Explosive Endurance (IEE): (IEE = W8 \, \text{sec} \times CEE\).

4. Creatine Phosphate Index (CPI): (CPI = IEE \times N8 \), where \(N8 \) is the total number of punches in the 8-second test.

The testing was conducted in the fifth mode of the dynamometer. The length of the working segments is programmed for 20 seconds, with a total test duration of 40 seconds. The athlete is instructed to deliver medium-strength straight punches with maximum frequency over the course of 40 seconds. During testing, punch strength can be adjusted, and the force of the last punch is displayed at the bottom of the screen, updating with each punch.

At the end of the test, the results are mathematically calculated in a manner similar to the previous test. The following indicators are calculated:

1. Work power in the 40-second test (W40 sec), calculated per kilogram of the athlete's body weight per second: (W40 \, \text{sec} = S40 / P / 40 \).

2. Coefficient of Speed Endurance (CSE): (CSE = (S2 \times N2) / (S1 \times N1) \), where \ (S2 \) and \ (N2 \) are the workload and number of punches in the second half of the test, and \(S1 \) and \(N1 \) are the workload and number of punches in the first half.

3. Index of Speed Endurance (ISE): (ISE = W40 \, \text{sec} \times CSE \).

4. Glycolytic Endurance Index (GLEI): (GLEI = ISE \times N40 / 2.2 \), where 2.2 is a constant.

5. Integral Index of Work Power (IWP): (IWP = IEE + ISE \).

6. Integral Index of Speed-Strength Preparation (ISSPI): (ISSPI = CPI + GLEI).

In the calculations of the last two indices, IWP and ISSPI, the values for IEE and CPI are taken from the 8-second test. The interpretation of all these indices and coefficients remains the same as in the previous test: the higher the values, the better the athlete's performance. Typically, in the 40-second test, only one valid attempt is recorded (Kiselev, 2006).

Result and discussion: The highest CEE is recorded by J-ev E (3.95), indicating superior explosive power. The lowest is seen in X-ov A (1.14), suggesting difficulties in sustaining high-intensity efforts (Table-1).

Table-1

Special performance indicators of highly skilled boxers.

№	Surname/ First Name	Year of Birth	Weight	MaxId	Date and Time	CEE	IEE	CPI	CSE	ISE	GLEI	IWP	ISSPI
1	M-ev A	2001	71	117	4/2/2024 16:43	3.89	26.52	795.64	0.82	1.91	45.26	28.43	840.90
2	A-ev A	2003	75	120	4/2/2024 16:46	2.38	11.82	343.05	0.90	2.35	67.36	14.18	410.41
3	X-ov A	2001	57	119	4/2/2024 16:45	1.14	10.31	371.45	0.72	1.49	26.59	11.81	398.04
4	J-ev E	2004	92	121	4/2/2024 16:48	3.95	18.98	550.46	0.99	2.71	86.36	21.69	636.83
5	D-ov F	2004	51	122	4/2/2024 16:49	1.96	15.97	495.22	1.19	2.34	42.56	18.31	537.78
6	M-ov A	2002	63	124	4/2/2024 16:51	1.66	6.17	117.32	1.10	3.36	125.30	9.53	242.63
7	T-ov G'	2003	71	125	4/2/2024 16:53	1.62	9.29	269.58	0.79	1.42	27.84	10.72	297.42

Note: 1. CEE - Coefficient of Explosive Endurance. 2. IEE - Index of Explosive Endurance. 3. CPI - Creatine Phosphate Index. 4. CSE - Coefficient of Speed Endurance. 5. ISE -Index of Speed Endurance. 6. GLEI - Glycolytic Endurance Index. 7. IWP - Integral Index of Work Power. 8. ISSPI - Integral Index of Speed-Strength Preparation.

CEE is indicative of fast-twitch muscle fiber efficiency and anaerobic power. High CEE values, like those of J-ev E and M-ev A (3.89), suggest excellent anaerobic conditioning, vital for powerful strikes in boxing (Smith et al., 2009).

M-ev A leads with an IEE of 26.52, demonstrating top-tier power adjusted for body weight. Lower values in T-ov G' (9.29) highlight potential areas for improvement. IEE reflects not only raw power but also how effectively this power is utilized relative to body weight. High IEE scores are crucial for maintaining competitive advantages in weight-class sports (Stone et al., 2006).

With a CPI of 795.64, M-ev A shows the most efficient use of the phosphagen energy system. This is contrasted by M-ov A's lower score of 117.32. CPI assesses the boxer's ability to rapidly regenerate ATP for short, intense efforts. High CPI values are associated with quick recovery between high-energy bursts, essential in boxing (Gastin, 2001).

D-ov F displays the highest CSE (1.19), indicating sustained high-speed capabilities. Similarly, M-ov A excels in ISE (3.36), suggesting excellent endurance at maintaining high-speed actions. Both CSE and ISE are linked to a boxer's aerobic and anaerobic conditioning, impacting their ability to perform prolonged activities at high intensities. These traits are vital for endurance during longer rounds (Laursen & Jenkins, 2002).

M-ov A achieves the highest GLEI at 125.30, showing great capacity in glycolytic energy system utilization, essential for sustained high-intensity efforts. GLEI relates to a boxer's ability to handle longer periods of high-intensity work by efficiently managing energy production and lactate accumulation. High values indicate better endurance and recovery during fights (Smith, 2006).

M-ev A stands out with the highest IWP (28.43) and ISSPI (840.90), indicating a well-rounded athletic profile with optimal integration of speed, strength, and endurance. IWP and ISSPI represent comprehensive measures of a boxer's overall conditioning and readiness for competition. High scores in these indices reflect a boxer's preparedness to engage effectively across the full spectrum of physical demands in the sport (Baker, 2010).

CONCLUSION

The detailed examination of various performance metrics (CEE, IEE, CPI, CSE, ISE, GLEI, IWP, and ISSPI) reveals significant insights into the athletic capabilities of highly skilled boxers. These indices collectively provide a nuanced understanding of each athlete's strengths and areas for improvement, correlating physical prowess with the physiological demands of boxing. Athletes like M-ev A, who score highly across several metrics, exemplify well-rounded physical attributes conducive to competitive success. In contrast, athletes with lower scores in certain

indices might be at a tactical disadvantage unless specific training interventions are employed.

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