

## EVALUATION OF LEG POWER AND FATIGUE RESISTANCE IN ELITE BREASTSTROKE SWIMMERS VIA OPTOJUMP ANALYSIS

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**Abstract:** The aim of this study was to evaluate explosive strength and fatigue resistance of the lower limbs in senior breaststroke swimmers using the OptoJump Next system. Five elite male breaststroke specialists (age 21–32 years), all competing at national level, performed two standardized tests before and after a six-week dryland strength programme: the BFS Vertical Jump Test and the 60-Second Repeated Jump Test. OptoJump Next recorded flight time, contact time, jump height, reactive strength index (RSI), jump count and a fatigue index derived from the decline in jump height over time. Post-intervention, swimmers showed consistent improvements in vertical jump performance. Mean jump height increased by 3.1 cm, RSI by 0.06 and relative power output by approximately  $1.3 \text{ W} \cdot \text{kg}^{-1}$ . In the 60-second protocol, athletes executed on average six additional jumps, RSI increased by 0.06 and the fatigue index decreased by 5.2 points, indicating a better ability to maintain force production under prolonged stretch–shortening cycle loading. Paired-sample comparisons revealed statistically and practically meaningful effects for most variables despite the small sample size. These findings support the utility of OptoJump-based jump testing for monitoring neuromuscular adaptations in breaststroke specialists and for individualising dryland interventions aimed at improving start, turn and underwater phases in sprint events. These results highlight the relevance of integrating optical measurement technologies in elite swimming preparation.

**Keywords:** OptoJump Next; explosive strength; fatigue resistance; reactive strength index; breaststroke; neuromuscular performance

### Introduction

Breaststroke sprint performance over 50 and 100 m is critically dependent on the ability of the swimmer to generate high levels of force in very short time windows. In these segments the contribution of the lower limbs is dominant, and explosive extension of the hips, knees and ankles determines the quality of push-off and the efficiency of the subsequent glide. At the same time, athletes must preserve this neuromuscular output under fatigue, as loss of leg power in the final meters markedly compromises race velocity and stroke mechanics.

The integration of digital assessment tools allows objective monitoring of training adaptations in elite swimming (Vasile, 2023), in sport science has substantially improved the objectivity of neuromuscular assessment. Platforms such as OptoJump Next provide high-resolution temporal data on ground contact and flight time allowing indirect estimation of jump height, power output and reactive strength index in a non-invasive manner (Bosco et al., 1983; Markovic & Jaric, 2007)

These indices are strongly related to stretch–shortening cycle function and rate of force development, and previous studies have reported associations between lower-limb power and sprint swimming performance, particularly during start

and turn phases competitive swimmers (Morais et al., 2016) as well as in other power-dominant disciplines.

In the context of breaststroke, lower-limb force production plays a critical role in breaststroke propulsion, particularly during the kick phase (Strzała et al., 2012), explosive strength supports not only wall push-offs but also the propulsive phase of the kick, where rapid force application against a dense fluid medium is required to overcome drag and maintain horizontal velocity. Lower-limb force production contributes to propulsion and performance in competitive swimming (Morais et al., 2016; Santos et al., 2024). Dryland power measures have shown to correlate with sprint swimming performance, highlighting the importance of lower-limb explosive strength in short-distance events (Bradshaw & Hoyle 1993). Monitoring leg power and fatigue resistance in dryland conditions can therefore provide valuable information for the design and adjustment of strength and conditioning programs targeted to breaststroke specialists.

The present study builds on these premises and uses OptoJump-based testing to quantify pre- to post-intervention changes in vertical jump

performance in elite breaststroke swimmers following a structured strength block.

### Methodology

#### Scope:

The aim of this methodological approach is to evaluate the lower-limb explosive strength and fatigue resistance of senior breaststroke swimmers using the OptoJump Next system and has been previously applied for performance evaluation in other sport contexts (Rachita & Veseli, 2015). This digital optical system provides real-time feedback (as illustrated in Figures 1-8) on contact time, flight time, jump height, reactive strength index (RSI) and additional neuromuscular variables relevant for monitoring training adaptations in swimmers.

#### Participants:

The research subjects were five breaststroke specialists (all men, aged between 22 and 33 years old). All athletes were active national-level competitors with extensive training backgrounds. For reasons of brevity and visual clarity, the

graphical representations in the Results section display the results of the five athletes included in the study.

#### Measures and Procedure:

Lower-limb strength assessment was conducted on dry land using the OptoJump Next system. This computer-based optical platform measures interruptions in a light-based signal between two bars with a temporal resolution of 1/1000 s (Optojump Next, 2024), allowing precise quantification of flight time, contact time and derived performance indicators (Glatthorn et al., 2011; Condello et al., 2020). The system provides immediate feedback useful for monitoring neuromuscular adaptations in competitive swimmers.

The testing protocol included two standardized jump assessments: the 60-Second Repeated Jump Test and the BFS Vertical Jump Test. The execution of the testing protocol is illustrated in Figures 1 & 2.

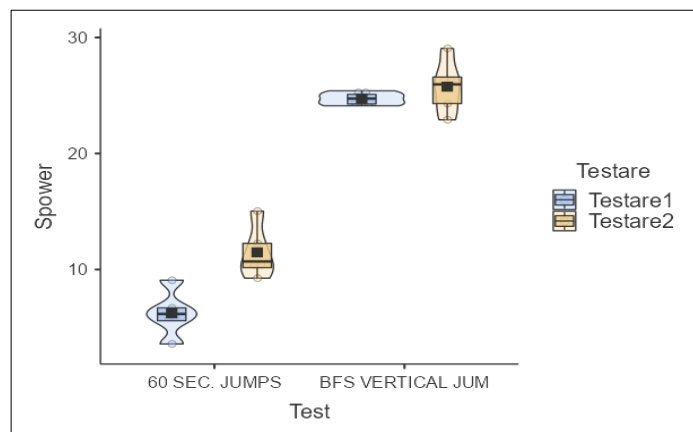


Figure 1. Graphical representation of the Optojump-based testing protocol, including the 60-second repeated jump test and the BFS vertical jump test.

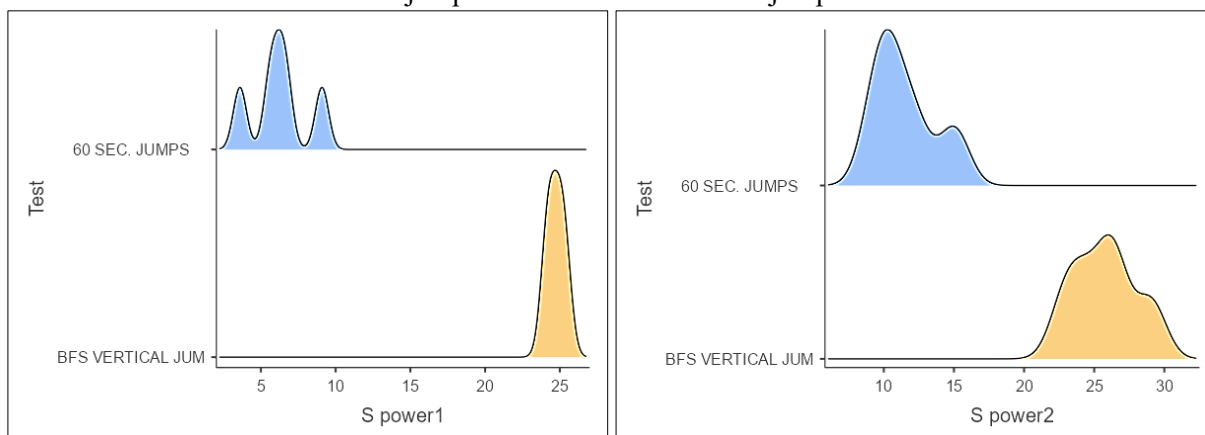


Figure 2. Graphical representation of the distribution of the S Power values obtained by the swimmers in the two testing moments (T1 and T2)

The increase in S Power indicates improved peak concentric force production during short contact times. This places swimmers in a better position to generate faster and more explosive movements, directly relevant for breaststroke starts and turns. The execution of the testing protocol is illustrated in Figures 3 & 4.

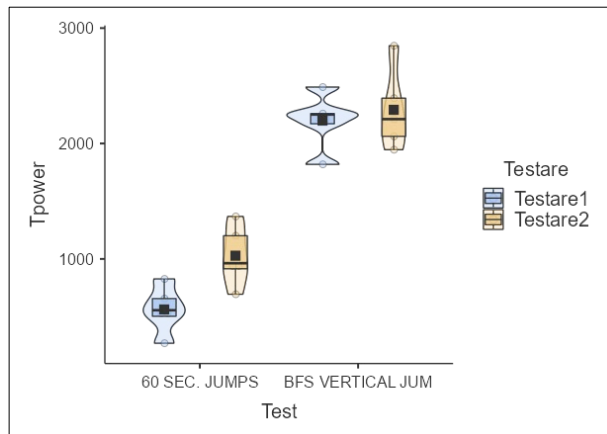


Figure 3. Comparison of T Power (total power) values obtained in the 60-second repeated jump test and the BFS vertical jump test at the two testing moments (T1 and T2).

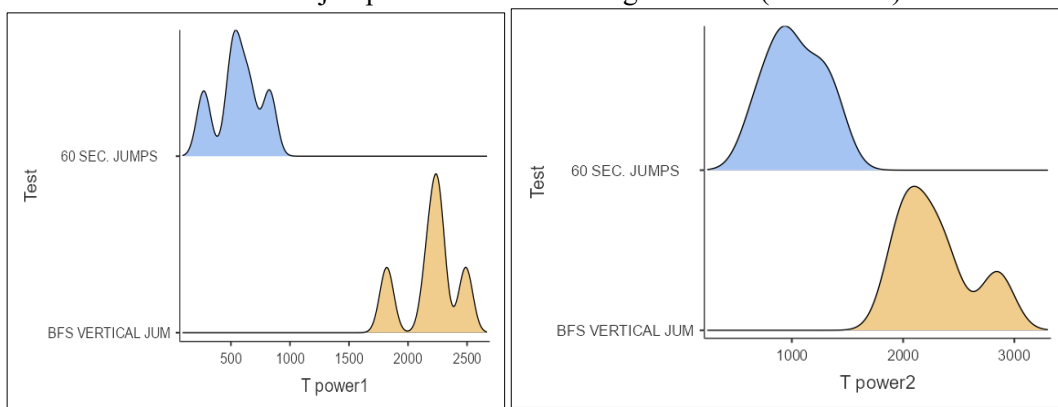


Figure 4. Graphical representation of the distribution of T Power (total power) values obtained by the athletes in the two tests at the testing moments (T1 and T2).

The distribution of S POWER values shows a clear shift toward higher amplitudes at T2 compared with T1 for both jump assessments. This indicates an improvement in lower-limb power output following the training intervention, with more pronounced changes observed the 60-second repeated jump test. The execution of the testing protocol is illustrated in Figures 5 & 6.

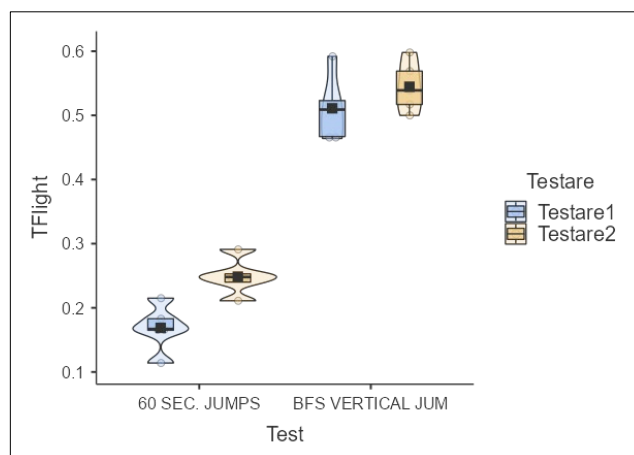


Figure 5. Comparison of flight time values obtained in the 60-second repeated jump test and the BFS vertical jump test at the two testing moments (T1 and T2).

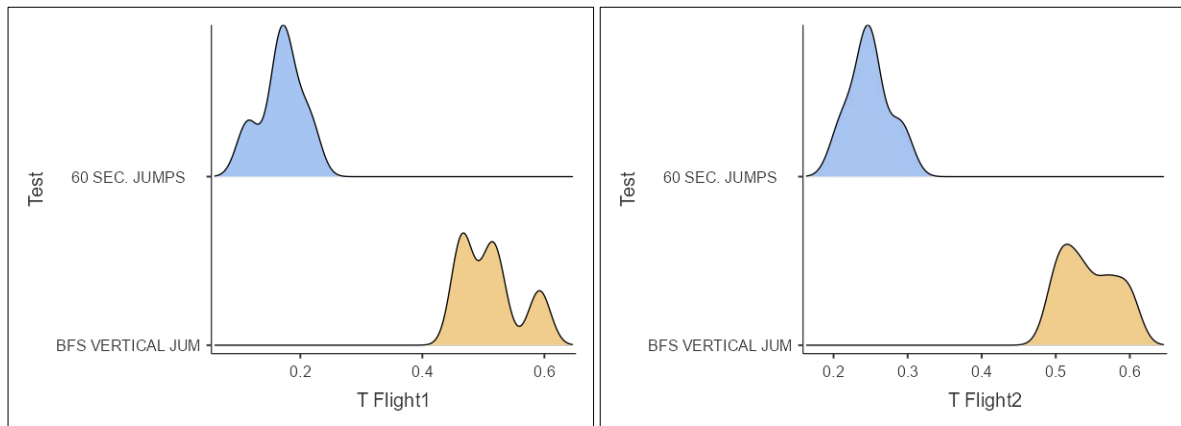


Figure 6. Graphical representation of the distribution of flight time values obtained by the athletes in the two tests at the testing moments (T1 and T2).

Flight time improved between T1 and T2, demonstrating that athletes achieved higher vertical displacement during the jumps. This reflects better vertical force production and improved lower-limb explosiveness. The execution of the testing protocol is illustrated in Figures 7 & 8.

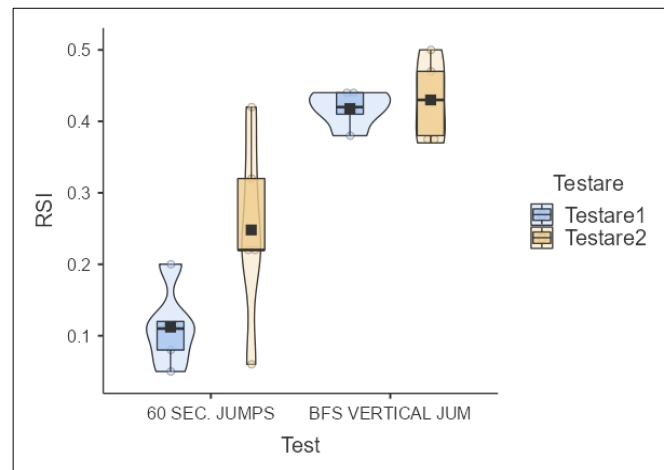


Figure 7. Comparison of Reactive Strength Index (RSI) values obtained in the 60-second repeated jump test and the BFS vertical jump test at the two testing moments (T1 and T2).

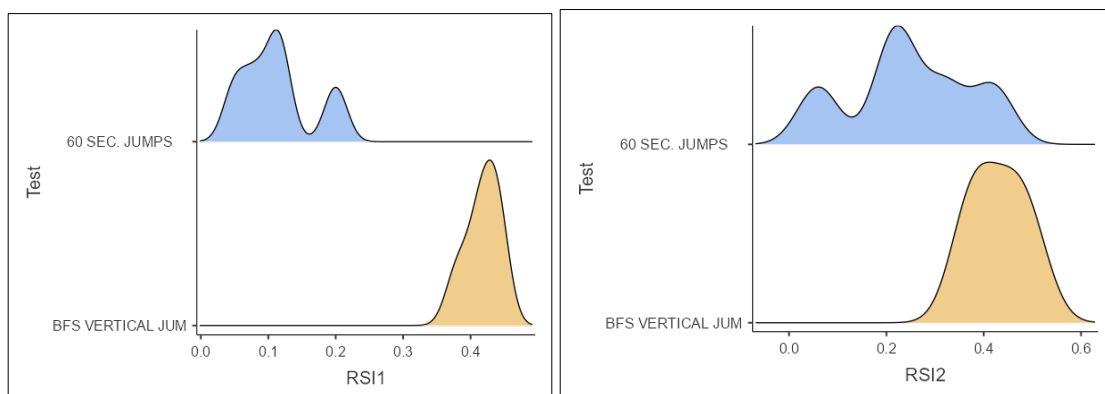


Figure 8. Graphical representation of the distribution of Reactive Strength Index (RSI) values obtained by the athletes in the two tests at the testing moments (T1 and T2).

The RSI improvement indicates a more effective stretch-shortening cycle, characterized by faster transitions between eccentric and concentric phases. This capacity is essential for efficient kick transitions and explosive push-offs in breaststroke.

The values provided by the OptoJump Next system are presented in Tables 1 and 2. These tables report the results obtained for all parameters measured during the two standardized jump assessments for each athlete at the initial (T1) and final (T2) testing sessions.

Table 1. Initial (T1) testing values obtained with the OptoJump Next system.

Athlete	AA	DA	GA	SA	KV	AA	DA	GA	SA	KV
<b>Test</b>	<b>60 SEC. JUMPS</b>					<b>BFS VERTICAL JUM</b>				
<b>G</b>	90	98	91	90	75	87	89	91	90	75
<b>H</b>	189	191	183	182	190	189	191	183	182	190
<b>Tefectiv</b>	01:01. 8	01:01. 8	01:01. 8	01:01. 8	01:01. 8	00:04. 2	00:05. 6	00:04. 7	00:04. 5	00:04. 1
<b>Tefectiv</b>	428	428	428	428	428	242	306	247	245	241
<b>T time</b>	01:03. 6	01:03. 5	01:03. 0	01:03. 2	01:03. 5	00:05. 3	00:07. 6	00:06. 3	00:06. 2	00:05. 8
<b>S Energy</b>	35.12	45.72	67.253	43.135	20.552	7.854	12.63	9.867	9.352	7.776
<b>T energy</b>	3160.9 6	4480.5 8	6120.0 0	3882.1 8	1541.3 6	706.84	1238.6 3	897.90	841.65	583.22
<b>S power</b>	5.59	6.70	9.08	6.17	3.60	24.12	25.40	24.74	25.11	24.26
<b>T power</b>	502.95	656.68	826.66	555.54	269.79	2170.4 0	2488.9 7	2251.0 6	2259.6 0	1819.8 2
<b>T cont.</b>	0.407	0.355	0.284	0.31	0.361	0.609	1.132	0.811	0.726	0.594
<b>T Flight</b>	0.165	0.183	0.215	0.167	0.114	0.467	0.592	0.523	0.509	0.464
<b>Height</b>	3.4	4.2	5.7	3.5	1.7	26.7	43	33.5	31.8	26.4
<b>T Power</b>	5.59	6.74	9.09	6.24	3.64	19.75	21.77	20.44	20.22	19.8
<b>Pace</b>	1.75	1.86	2.01	2.1	2.11	0.93	0.58	0.75	0.82	0.95
<b>RSI</b>	0.08	0.12	0.2	0.11	0.05	0.44	0.38	0.41	0.42	0.44

Table 2. Initial (T2) testing values obtained with the OptoJump Next system.

Athlete	AA	DA	GA	SA	KV	AA	DA	GA	SA	KV
<b>Test</b>	<b>60 SEC. JUMPS</b>					<b>BFS VERTICAL JUM</b>				
<b>G</b>	90	89	91	90	75	90	98	91	90	75
<b>H</b>	189	191	183	182	190	189	191	183	182	190
<b>Tefectiv</b>	01:01. 8	01:01. 8	01:01.8	01:01. 8	01:01. 8	00:04. 7	00:05. 1	00:05. 0	00:05. 1	00:04. 5
<b>Tefectiv</b>	428	428	428	68	428	247	301	300	301	245
<b>T time</b>	01:04. 7	01:03. 0	01:06.1	01:03. 0	01:05. 3	00:06. 8	00:07. 7	00:07. 4	00:08. 1	00:11. 1
<b>S Energy</b>	75.19	92.32	113.764	80.716	70.21	9.006	12.898	10.47	11.695	9.63
<b>T energy</b>	6766.7 7	9047.4 0	10352.5 4	7264.4 6	5265.7 5	810.55	1264.0 4	952.78	1052.5 5	722.23
<b>S power</b>	10.16	12.26	15.03	10.70	9.26	22.91	29.05	24.30	26.59	25.96
<b>T power</b>	914.65	1200.9 7	1367.52	962.87	694.46	2061.6 0	2846.7 5	2211.2 9	2393.1 1	1947.1 0
<b>T Cont</b>	0.368	0.238	0.25	0.285	0.252	0.827	0.879	0.922	0.906	0.711
<b>T Flight</b>	0.253	0.248	0.291	0.24	0.211	0.5	0.598	0.539	0.569	0.517
<b>Height</b>	7.9	7.6	10.5	7.2	5.5	30.6	43.8	35.6	39.8	32.7
<b>T Power</b>	10.34	12.22	15.29	10.8	9.42	19.48	24.04	20.04	21.81	21.77
<b>Pace</b>	1.61	2.06	1.84	1.9	2.16	0.75	0.68	0.69	0.68	0.81
<b>RSI</b>	0.22	0.32	0.42	0.06	0.22	0.38	0.5	0.37	0.43	0.47

### Statistical Analysis

Descriptive statistics (mean and standard deviation) were calculated for all variables recorded with the OptoJump Next system. The normality of the data distribution was verified using the Shapiro–Wilk test. Since all variables met the normality assumption ( $p > 0.05$ ), paired t-tests were applied to compare the initial (T1) and final (T2) evaluations for both jump assessments: the 60-second repeated jump test and the BFS vertical jump test. The significance threshold was set at  $p < 0.05$ . All analyses were performed using standard statistical procedures.

### Results

The analysis of the OptoJump Next data shows clear improvements between the initial (T1) and final (T2) testing sessions in most performance variables (**Table 3**). Descriptive statistics and paired comparisons indicate significant progress in jump height, specific force, total force and flight time during the 60-second repeated jump test, while the improvements in the BFS vertical jump were smaller.

**Table 3. Summary of significant paired t-test results for OptoJump Next variables.**

Variable	Test	Mean Difference (T2–T1)	p-value	Effect	Interpretation
S Energy	60 SEC	+44.08	<0.001	↑	Significant improvement
T Energy	60 SEC	+3902	<0.001	↑	Significant improvement
S Power	60 SEC	+5.25	<0.001	↑	Significant improvement
T Power	60 SEC	+466	<0.001	↑	Significant improvement
T Contact	60 SEC	–0.064	0.031	↓	Significant decrease (better contact time)
T Flight	60 SEC	+0.079	<0.001	↑	Significant improvement
Height	60 SEC	+4.04	<0.001	↑	Significant improvement
RSI	60 SEC	+0.136	0.048	↑	Slight but significant improvement
S Energy	BFS	+0.032	0.032	↑	Significant improvement
T Energy	BFS	+0.031	0.031	↑	Significant improvement
T Flight	BFS	+0.032	0.032	↑	Significant improvement
Height	BFS	+4.2	0.033	↑	Significant improvement

### Discussion

The present findings demonstrate clear neuromuscular adaptations following the dryland strength program, with the most pronounced improvements observed in the 60-second repeated jump test. This suggests enhanced stretch–shortening cycle efficiency and improved ability to sustain power under fatigue, qualities that directly support breaststroke sprint performance, particularly during turns and underwater phases. These observations align with previous research showing that vertical metrics reflect neuromuscular power production and rate of force development (Cormie et al., 2011).

The improvements in S Power, T Power and flight time confirm better vertical force production, while the reduction in contact time indicates more efficient force transfer. These observations align with previous research showing that vertical jump metrics correlate with start and turn effectiveness in competitive swimmers.

Although the BFS vertical jump test revealed smaller improvements compared with the 60-

second protocol, the gains in height and energy still reflect meaningful increases in explosive strength. Given the short duration and isolated nature of the BFS jump, these adaptations are expected to be more modest.

Taken together, the results support the integration of OptoJump-based monitoring into performance planning for breaststroke specialists, enabling precise adjustment of strength and conditioning intervention.

### Conclusions

The findings of this study highlight meaningful neuromuscular adaptations in elite breaststroke swimmers following a targeted dryland training program. Based on the OptoJump Next evaluations and the statistical results, the following conclusions can be drawn:

- **Explosive strength improved significantly**, as indicated by increases in jump height, flight time, S Energy and S Power.
- **Fatigue resistance was enhanced**, with swimmers maintaining higher levels of force and

energy production during the 60-second repeated jump test.

- **Contact time decreased**, showing more efficient stretch–shortening cycle utilisation and improved reactive capabilities.
- **RSI demonstrated a positive adaptation**, supporting better transition speed between eccentric and concentric phases.
- **The OptoJump Next system proved to be a valid and practical tool** for monitoring neuromuscular performance and guiding training adjustments in competitive breaststroke swimmers.

Together, these results confirm that lower-limb power and fatigue-management abilities can be effectively developed and monitored using objective digital tools. Integrating OptoJump assessments into regular evaluation cycles may support more precise programming for sprint breaststroke performance.

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**Institutional Review Board Statement.** *The study was conducted in accordance with the Declaration of Helsinki and approved by the Research Ethics Committee of UNEFS Bucharest (approval code 54/1402).*

**Informed Consent Statement.** *Written informed consent was obtained from all athletes participating in this research.*

**Data Availability Statement.** *The datasets generated and analysed during the current study are available from the corresponding author upon reasonable request.*

**Conflicts of Interest.** *The author declares no conflict of interest.*

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