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The influence of a lifeguard training course on the specialized skills and motor performance in young females

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Abstract:

Abstract: Introduction: Individual variation in training adaptation among female lifeguard candidates remains poorly understood. Therefore, the aim of this study was to evaluate changes following of lifeguard training on body composition, lower limb strength, and specialized swimming performance in women. Furthermore, the study examined the associations between changes in lower limb explosive strength and swimming performance and explored potential adaptation profiles. Methods: : Nineteen women (body mass: 63.86 ± 9.32 kg; BMI: 22.91 ± 2.58 kg·m^{-2}; body fat: 26.49 ± 5.26%) participating in a Water Rescue Volunteer Service (WOPR) lifeguard course were enrolled in this study. The training program lasted from March to June 2025 and comprised 63 h of theoretical and practical instruction, including pool and open-water rescue training. Assessments were performed before and after course completion and included body composition analysis, countermovement jump (CMJ) performance, and four swimming performance tests, including freestyle swimming, rescue crawl swimming, backstroke breaststroke kick swimming, and a 50-m two-handed manikin towing test. Body composition was measured using bioelectrical impedance analysis, whereas lower-limb explosive power was assessed with a BTS G-Sensor inertial measurement unit during CMJ testing. Swimming performance was evaluated on a certified 25 m swimming pool. Results: Following completion of the training course, participants demonstrated a significant reduction in body fat percentage ($p = 0.031$) without significant changes in body mass, BMI, or fat-free mass. Significant improvements were observed in CMJ performance (jump height, propulsive power, and maximal concentric power; $p < 0.05$) and in all swimming and rescue performance tests ($p < 0.05$). No significant correlations were found between changes in CMJ performance and improvements in freestyle swimming performance. Conclusions: The lifeguard training course was associated with improvements in body composition, lower-limb explosive power, and swimming performance in young women.

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INTRODUCTION

Water rescue is a physically demanding activity that combines high physiological demands with the need to perform specialized rescue procedures rapidly and effectively in the aquatic environment. Lifeguards are required to possess a high level of both aerobic and anaerobic fitness, efficient swimming technique, and the ability to generate substantial force and power while performing rescue tasks such as towing drowning victims, swimming with rescue equipment, or transporting casualties to safety [1–3]. Consequently, lifeguard education should develop both endurance capacity and strength- and power-related physical qualities. Previous research has demonstrated that systematic swimming training induces significant anthropometric adaptations and physiological changes that enhance performance in aquatic environments [4]. Depending on the country, several organizations may be responsible for water safety education and lifeguard certification [5]. For example, the Royal Life Saving Society (RLSS) in the United Kingdom places strong emphasis on rescuer self-protection, whereas in France organizations such as the Fédération Française de Sauvetage et de Secourisme (FFSS) and the Brevet National de Sécurité et de Sauvetage Aquatique (BNSSA) prioritize the preservation of the drowning victim's life [6]. Consequently, the success of a rescue operation depends largely on the quality of the lifeguard's training. Other researchers have likewise emphasized the importance of well-designed aquatic education programs and standardized competency requirements for professionals operating in aquatic environments [7]. Professional competence in water rescue extends beyond physical fitness and includes tactical decision-making skills, such as rapidly assessing the emergency situation, controlling the victim, and continuously evaluating the effectiveness of rescue actions. The sequence of actions undertaken during a rescue is commonly referred to as the drowning chain of survival [8]. This process involves the early recognition of life-threatening situations, prompt intervention to interrupt the drowning process, safe transportation of the victim to shore or another secure location, and, when necessary, the initiation of cardiopulmonary resuscitation (CPR) [9]. Previous studies have demonstrated that swimming performance depends not only on physiological capacity and swimming technique but also on the ability of the lower limbs to generate effective propulsion [10]. Lower-limb explosive power plays an important role in swimming starts, turns, and the maintenance of swimming velocity, particularly during high-intensity efforts [11]. These capabilities are likely to be equally important during water rescue operations, where rescuers must perform powerful and dynamic movements while overcoming substantial water resistance. To date, research on water rescue has focused primarily on physical fitness, anthropometric characteristics, and the technical execution of rescue-specific tasks [6]. Considerably less attention has been devoted to investigating how lifeguard training influences lower-limb explosive power or how improvements in neuromuscular performance may relate to swimming performance. Furthermore, relatively little is known about individual differences in training adaptations among lifeguard trainees, particularly among women. Modern approaches to exercise science increasingly recognize that individuals respond differently to identical training stimuli [12]. However, exploratory approaches—including responder/non-responder analyses and k-means cluster analysis—have rarely been applied in studies of lifeguard training. Consequently, it remains unclear whether female lifeguard trainees exhibit distinct functional and motor adaptation profiles following course completion. Applying these analytical methods may provide valuable insights into different patterns of adaptation resulting from lifeguard education.

Therefore, the primary aim of the present study was to evaluate the effects of a lifeguard training course on body composition, lower-limb explosive power, and

specialized swimming performance in women. An additional objective was to determine the relationships between changes in lower-limb explosive power and swimming performance. Accordingly, the study addressed the following research questions: (1) Does completion of a lifeguard training course influence body composition, lower-limb explosive power, and specialized swimming performance in women? (2) Are changes in lower-limb explosive power associated with changes in swimming performance following completion of the course?

MATERIAL AND METHODS

Participants

The study included 19 women (age: 18.6 ± 5.96 years; body mass: 63.86 ± 8.98 kg; body height 167.17 ± 5.93 cm; body mass index [BMI]: 22.91 ± 2.58 $kg \cdot m^{-2}$; body fat percentage: 26.49 ± 5.26%; fat-free mass [FFM]: 46.45 ± 4.08 kg) who participated in a Water Volunteer Rescue Service (WOPR) Lifeguard Course conducted at four training centres located in the Silesian Voivodeship, Poland (Rybnik, Jastrzębie-Zdrój, Wodzisław Śląski, and Racibórz). Each participant included in the study met the following criteria:

Possess a current medical certificate entitling them to participate in the training.

Possess Junior Lifeguard Qualifications, confirming basic water rescue skills.

Successfully pass the entrance exam for the current lifeguard course, which included: swimming 100 m front crawl in less than 1 min 40 s; swimming 25 m underwater from a surface-water start; towing a partner over 50 m in a supine position using the breaststroke kick; swimming 400 m freestyle in less than 8 min.

Ethical Approval

The study was conducted in accordance with the principles of the Declaration of Helsinki. Prior to participation, all individuals received detailed information regarding the purpose and procedures of the study and provided written informed consent. The study protocol was approved by the Research Ethics Committee of Jan Długosz University in Częstochowa (Approval No. KE-U/90/2025).

Lifeguard Training Course

The Water Volunteer Rescue Service (WOPR) Lifeguard Course was conducted between March and June 2025 and comprised 63 instructional hours, including 20 hours of theoretical instruction and 43 hours of practical training. Practical sessions were carried out both in a 25-m indoor swimming pool accredited by the Polish Swimming Federation (PZP) and in open-water environments. Swimming-pool water temperature was maintained between 26 and 27°C. Swimming sessions were conducted three times per week, each lasting 1 hour, whereas open-water training took place once per week for 3 hours. For both training and testing procedures, standardized PITET rescue manikins approved by the International Life Saving Federation (ILS) were used. These adult torso manikins are red in colour, feature a high-contrast face, shortened arm segments, and filling ports that allow them to be filled with water to achieve standardized buoyancy and weight.

Theoretical instruction was delivered through classroom-based teaching.

All participants completed the full curriculum in accordance with the Regulation of the Polish Minister of Internal Affairs of 21 June 2012 concerning water rescue training (Journal of Laws, 2012, Item 747). According to these regulations, participants must be at least 16 years of age; hold a Junior Lifeguard qualification; possess at least one additional certification relevant to water rescue, such as: motorboat operator, yacht sailor, scuba diver or swimming instructor.

The present study was conducted during the same Water Volunteer Rescue Service (WOPR) lifeguard training course as our previous investigation [13]. However, unlike the previous study, which included only male participants and focused on body composition and manikin towing performance, the present study was performed exclusively in women and addressed different research questions related to lower-limb explosive power and swimming performance. Therefore, the participant cohort and dataset analysed in this study are independent of those reported previously.

Study Protocol

Testing was performed twice for all participants: immediately before the beginning of the course and immediately after completion of the course.

Anthropometric Measurements

Body mass and height were measured using a WPT 150.0 scale with an integrated stadiometer (RadWag, Radom, Poland) with measurement accuracies of 0.1 kg and 0.5 cm, respectively. Measurements were performed in the medical laboratory of the Municipal Sports and Recreation Centre in Racibórz. Body mass index (BMI) was subsequently calculated.

Body Composition Assessment

Body composition was assessed using a Selvas Healthcare Accuniq BC310 bioelectrical impedance analyser (SELVAS Healthcare Inc., Daejeon, Republic of Korea). The following variables were recorded: body fat percentage (FAT%); total fat mass (FAT MASS); fat-free mass (FFM); total body water (TBW).

Swimming Tests

Each participant completed 4 swimming tests where time was measured:

- 50 m freestyle
- 50 m rescue front crawl
- 50 m backstroke - only legwork, performed on the back, arms along the body
- Two-handed mannequin towing - on back, using both hands with Underarm Grip. The Official ILS rescue mannequin used in lifesaving competitions according to the ILS Competition Rulebook 2025 (Revised May 2026) [13].

All swimming tests were conducted in a 25-m competition - standard swimming pool with a water temperature of 27.2°C. Swimming time was measured manually using a FINIS 3 × 300 m certified stopwatch (FINIS, Inc., Livermore, CA, USA). To minimize fatigue, the 50-m two-handed manikin towing test was performed on two consecutive days. Participants completed one trial on each day, separated by approximately 24 hours, and the better performance was included in the statistical analysis.

Countermovement Jump Assessment

Motor performance was evaluated using the Countermovement Jump (CMJ) test. The following variables were analysed: jump height; take-off power and maximal concentric power. Kinematic and kinetic data were collected using the BTS G-Sensor (BTS Bioengineering S.p.A., Garbagnate Milanese, Italy), a wireless inertial measurement unit (IMU). The device weighs 37 g and measures 70 × 40 × 18 mm. It integrates: a three-axis accelerometer (16-bit; ±16 g), a three-axis gyroscope (16-bit; ±2000°·s^{-1}), a three-axis magnetometer (13-bit; ±1200 µT). The sensor was securely attached over the lumbar region using a semi-elastic belt, enabling non-invasive monitoring of trunk motion during vertical jumping. Data were sampled at 100 Hz and transmitted wirelessly via Bluetooth® to

dedicated BTS software for real-time visualization, storage, and subsequent analysis. All testing sessions were performed under standardized environmental conditions and at approximately the same time of day using identical testing procedures. To reduce measurement variability, all pre- and post-course assessments were performed by the same experienced laboratory technician from the Medical Laboratory of Jan Długosz University in Częstochowa.

Statistical Analysis

Data are presented as mean ± standard deviation (SD). The normality of data distribution was assessed using the Shapiro–Wilk test. Differences between pre- and post-course measurements were evaluated using paired Student's t-tests. Additionally, absolute change (Δ = Post − Pre) and Cohen's d effect size for paired samples were calculated. Effect sizes were interpreted as: small: $d \geq 0.20$; moderate: $d \geq 0.50$; large: $d \geq 0.80$.

Pearson correlation coefficients were calculated to examine the relationships between changes in lower-limb explosive power and swimming performance. The dependent variable was the change in 50-m freestyle swimming time, whereas predictor variables included change in jump height and change in maximal concentric power.

A sensitivity analysis was performed using G*Power for the paired-samples *t*-test. Assuming $\alpha = 0.05$, statistical power = 0.80, and a sample size of 19 participants, the minimum detectable effect size was estimated at Cohen's $d = 0.67$. Statistical significance was accepted at $p < 0.05$. All analyses were performed using Python (Python Software Foundation, Wilmington, USA) with the SciPy, Statsmodels, and Scikit-learn libraries.

RESULTS

Table 1 presents the pre- and post-course comparisons of body composition, lower-limb explosive power, and swimming performance. Following completion of the lifeguard training course, a statistically significant reduction in body fat percentage was observed (Δ = −1.51%, $p = 0.031$, $d = -0.54$), whereas no significant changes were found in body mass, fat-free mass, or total body water ($p > 0.05$).

Significant improvements were also observed in countermovement jump performance. Jump height increased by 1.71 cm ($p = 0.008$, $d = 0.68$), propulsive power increased by 0.17 kW ($p = 0.006$, $d = 0.72$), and maximal concentric power increased by 0.20 kW ($p = 0.047$, $d = 0.49$).

Swimming performance improved significantly following the course. Participants achieved faster times in the 50-m freestyle swim (Δ = −1.64 s, $p = 0.0016$, $d = -0.85$), 50-m rescue crawl (Δ = −1.89 s, $p = 0.0125$, $d = -0.64$), backstroke breaststroke kick swimming (Δ = −4.27 s, $p < 0.001$, $d = -1.16$), and the 50-m two-handed back manikin towing test (Δ = −7.68 s, $p = 0.0044$, $d = -0.75$). Overall, these findings indicate significant improvements in several measures of lower-limb explosive performance and rescue-specific swimming performance following completion of the training course. However, because the study did not include a control group, these changes should not be interpreted as definitive evidence of training-induced effects.

Table 1. Changes in body composition, lower-limb explosive power, and swimming performance following completion of the lifeguard training course in women (mean ± SD).

Variable	Pre (Mean ± SD)	Post (Mean ± SD)	Δ (Post–Pre)	t	p	Cohen's d
Body mass (kg)	63.68 ± 9.09	64.04 ± 9.12	+0.36	0.71	0.485	0.16
FAT (%)	26.49 ± 5.26	24.98 ± 6.22	−1.51	−2.34	0.031	−0.54
FFM (kg)	46.45 ± 4.08	46.29 ± 9.50	−0.16	−0.08	0.939	−0.02
TBW (kg)	34.48 ± 3.67	33.88 ± 2.90	−0.60	−0.91	0.375	−0.21
Jump height (cm)	20.14 ± 2.35	21.85 ± 3.46	+1.71	2.99	0.008	0.68
Propulsive power (kW)	0.71 ± 0.23	0.88 ± 0.36	+0.17	3.14	0.006	0.72
Maximum concentric power (kW)	2.28 ± 0.48	2.47 ± 0.44	+0.20	2.13	0.047	0.49
50-m freestyle (s)	39.15 ± 6.17	37.51 ± 5.93	−1.64	−3.72	0.0016	−0.85
50-m rescue crawl (s)	44.84 ± 7.17	42.95 ± 6.42	−1.89	−2.77	0.0125	−0.64
Backstroke breaststroke kick (s)	77.92 ± 10.88	73.65 ± 10.70	−4.27	−5.06	<0.001	−1.16
Two-handed back towing (s)	105.18 ± 25.63	97.51 ± 20.83	−7.68	−3.25	0.0044	−0.75

Table 2. Correlations between changes in lower-limb explosive power and changes in 50-m freestyle swimming performance following completion of the lifeguard training course.

Variable	r	p
Δ vertical jump height vs. Δ 50-m freestyle swim time	−0,227	0,357
Δ maximum concentric power vs. Δ 50-m freestyle swim time	0,249	0,304

Correlation analysis revealed no statistically significant associations between changes in lower-limb explosive power and changes in 50-m freestyle swimming performance. A weak negative correlation was observed between changes in countermovement jump height and swimming time ($r = −0.227$, $p = 0.351$), whereas maximal concentric power showed a weak positive correlation with swimming performance ($r = 0.249$, $p = 0.304$). These findings indicate that improvements in lower-limb explosive power were not significantly associated with changes in freestyle swimming performance following the lifeguard training course.

DISCUSSION

The aim of the present study was to evaluate the effects of a lifeguard training course on body composition, lower-limb explosive power, and performance in specialized swimming tasks among young women. Following completion of the training programme, participants demonstrated a significant reduction in body fat percentage, significant improvements in countermovement jump performance (jump height, propulsive power, and maximum concentric power), and significantly faster times in all swimming and rescue-specific performance tests. Although these findings suggest that the course was accompanied by favorable changes in physical performance, the absence of a control group precludes attributing these improvements exclusively to the training intervention. Consequently, the observed changes should be interpreted with appropriate caution, as they may also have been influenced by participants' habitual physical activity, previous sporting experience, or other uncontrolled factors.

The present findings are partially consistent with previous studies investigating adaptations to lifeguard training. Makar et al. reported that an eight-week lifeguard training programme produced limited changes in swimming kinematics, while emphasizing that rescue performance depends largely on movement economy and mastery of rescue-specific techniques rather than on physical fitness alone [14–16]. In the present study, however, significant improvements were observed not only in rescue-specific swimming

tasks but also in measures of lower-limb explosive power. These findings suggest that regular participation in practical lifeguard training may provide a sufficient neuromuscular stimulus to improve explosive performance despite the programme not being specifically designed as a strength-training intervention.

The significant reduction in body fat percentage without concurrent changes in body mass or fat-free mass indicates that the training volume may have been sufficient to induce modest improvements in body composition while maintaining overall body weight. Similar observations have been reported in physically active populations, where regular swimming and rescue-related activities contribute to improved body composition without substantial alterations in lean body mass [17]. From a practical perspective, even relatively small reductions in adiposity may contribute to greater movement efficiency during repeated rescue tasks performed in aquatic environments.

The greatest performance improvements were observed in rescue-specific tasks, particularly in the two-handed back manikin tow and rescue crawl swimming. These tests closely reflect the physical and technical demands encountered during real rescue operations. Therefore, the observed improvements may reflect from the repeated practice of rescue-specific skills throughout the course, leading to enhanced movement coordination, technical proficiency, and swimming efficiency. Such task-specific adaptations are highly relevant in lifeguarding, where successful rescue performance depends on the integration of physical capacity with efficient execution of rescue techniques under demanding environmental conditions [18].

The significant improvements in countermovement jump height, propulsive power, and maximum concentric power further suggest that repeated jumping, water-entry drills, and dynamic rescue activities performed during the course may be related to neuromuscular adaptations. Similar improvements in lower-limb explosive strength have also been investigated in young female athletes, highlighting the importance of neuromuscular performance in physically demanding sporting activities [19]. Previous research indicates that improvements in explosive performance during the early stages of training are often mediated primarily by enhanced neural activation and motor-unit recruitment rather than by increases in muscle mass [20]. Because fat-free mass remained unchanged in the present study, the observed enhancement in lower-limb power is could be explained by to improved neuromuscular function rather than morphological adaptations.

Despite the significant improvements observed in both lower-limb explosive power and swimming performance, correlation analysis did not demonstrate significant associations between individual changes in these variables. This finding suggests that improvements in sprint swimming performance during the lifeguard course cannot be explained solely by gains in explosive power. Swimming and rescue performance are multifactorial and are influenced by technical proficiency, coordination, movement economy, and task-specific motor skills in addition to physical fitness [21,22]. Previous research has also highlighted the importance of technical training in improving swimming effectiveness, particularly during the initial stages of swimming development in girls and boys [23]. It is therefore plausible that improvements in swimming performance primarily reflected enhanced technical competence acquired during the course rather than isolated increases in lower-limb power. The relatively small sample size may also have limited the ability to detect weak-to-moderate associations between variables.

Study Limitations

The present study has several limitations that should be considered when interpreting the findings. First, the relatively small sample size limits statistical precision and the generalizability of the results. Second, only women participating in a single

lifeguard training course were included; therefore, the findings may not be applicable to other populations or training systems. Most importantly, the study did not include a control group, making it impossible to determine whether the observed improvements resulted exclusively from the training programme or from other concurrent factors. Finally, the assessment was limited to body composition, explosive power, and swimming performance, without detailed biomechanical or physiological analyses that could provide greater insight into the mechanisms underlying the observed adaptations. The authors did not take into account the course participants' diet, hydration and other physical activity. Future studies should include larger cohorts, appropriate control groups, and more comprehensive biomechanical and physiological assessments.

Practical Implications

The present findings suggest that participation in a standardized lifeguard training course may be accompanied by improvements in lower-limb explosive power, swimming performance, rescue-specific performance, and body fat percentage in young women. Although causal conclusions cannot be drawn because of the absence of a control group, the results indicate that regular practical rescue training may support physical preparedness in addition to developing technical competence. The testing protocol used in this study may also be useful for monitoring physical preparedness and training adaptations during lifeguard education.

CONCLUSION

Participation in the lifeguard training course was associated with significant improvements in lower-limb explosive power, swimming performance, and rescue-specific swimming tasks, accompanied by a reduction in body fat percentage in young women. However, because the study did not include a control group, these findings should not be interpreted as definitive evidence of a causal effect of the training programme.

No significant relationships were found between individual changes in lower-limb explosive power and improvements in 50-m freestyle swimming performance, suggesting that gains in swimming performance during the course were likely influenced by multiple factors, including technical proficiency and task-specific motor skills.

Overall, the findings indicate that standardized lifeguard training may contribute to improvements in physical and rescue-specific performance while simultaneously developing technical competence. Future randomized controlled studies involving larger and more diverse cohorts are needed to confirm these findings and to identify the mechanisms responsible for the observed adaptations.

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